

Bronchopleural Fistula

A bronchopleural fistula (BPF) is a communication between the bronchial tree and the pleural space; although rare, bronchopleural fistulas represent a challenging management problem and are associated with high morbidity and mortality; by far, BPF is most often the postoperative complication of pulmonary resection, followed by lung necrosis complicating infection, persistent spontaneous pneumothorax, chemotherapy or radiotherapy (for lung cancer), and tuberculosis

ANESTHETIC CONSIDERATIONS:

- Potentially life threatening emergency
 - Tension pneumothorax vs. pulmonary flooding
- High risk for inadequate ventilation and oxygenation
 - Due to air leak (lost ventilation with low Vt and alveolar hypoventilation), worsens with PPV
- Absolute indication for lung isolation and OLV
 - DLT preferred
 - Consider ventilatory strategies including HFV
- Co-morbid Illness / Etiology
 - Postoperative pneumonectomy / lung resection
 - Abscess / Empyema
 - Necrotizing pneumonia
 - Cancer
 - Spontaneous pneumothorax / bullous lung disease

ANESTHETIC GOALS:

- Optimize oxygenation and alveolar ventilation & minimize leak through BPF
 - Maintain spontaneous ventilation if possible
 - If PPV:
 - Short inspiratory time
 - Minimize inspiratory pressure and Vt
 - Avoid PEEP
- Avoid cross contamination of normal lung if BPF secondary to empyema/infection
 - Consider positioning bad lung down
- Anticipate possible tension pneumothorax with PPV and be prepared to manage cardio-respiratory collapse
- Facilitate early extubation

HISTORY

- Clinical presentation of BPF depends on the etiology (see background)
- **Etiology:** post pneumonectomy is most common but presentation can be acute, sub-acute, delayed or chronic
 - Acute BPF
 - Within the first 4 postoperative days, secondary to a mechanical failure of closure of the stump and requires re-exploration and re-closure
 - Potentially life threatening due to tension pneumothorax or asphyxiation from pulmonary flooding
 - Characterized by: sudden appearance of dyspnea, hypotension, subcutaneous emphysema, cough with expectoration of purulent material or fluid, shifting of the trachea and mediastinum, persistence of air leak in the absence of a technical problem, or decrease or disappearance of pleural effusion on the chest radiograph
 - Sub-Acute BPF
 - More insidious and is characterized by wasting, malaise, fever, and minimally productive cough
 - Chronic BPF
 - Usually associated with an infectious process
 - There is fibrosis of the pleural space and mediastinum preventing the mediastinal shift
- If postoperative, review anesthetic record, particularly for easy intubation and lung isolation
- Presence / absence of chest tube, and output / leak / function, +/- suction
- Need to assess **size of BPF** (can do this if chest tube in situ → BP cutaneous fistula)
 - Air leak during inspiration only (small)
 - Air leak (continuous) during both inspiration and expiration (large)
 - If intubated, can determine difference in inspired and exhaled tidal volumes
 - If not intubated, may do with a tight-fitting mask and a rapidly-responding spirometer

PHYSICAL

- **GENERAL** - Full Vital Signs / O₂ / FiO₂ / focused physical
- **HEENT** - A/W for patency & easy of intubation (DLT)
- **RESP**
 - If concern of tension pneumothorax, assess and manage pt emergently with needle decompression +/- CT drainage if no CT in situ
 - Respiratory distress, tracheal deviation, accessory muscle use, cyanosis, subcutaneous emphysema, CT function, air entry, wheezing
 - Assess loss of tidal volume through the bronchopleural fistula
 - Small leak – CT only bubbles intermittently
 - Large leak – CT bubbles during inspiration & expiration
 - Degree of Vt loss can be quantified by spirometry and measurement of inspired / expired volumes (via mask or ETT)
- **CVS** - Cardiac, volume status, JVP, peripheral pulses, HS

INVESTIGATIONS

- **Labs**
 - **CBC, Lytes, BUN, Cr, INR, PTT, Crossmatch** (looking for anemia, infection, coagulopathy, renal insufficiency)
 - **ABG** (assess adequacy of oxygenation and ventilation)
- **Imaging**
 - **CXR:** review pre & post op series, assess changes in air / fluid levels, ensure no mediastinal shift (Air and fluid are always apparent in the basilar zone of the hemithorax after a pneumonectomy, but hemithorax should fill with fluid between 3 weeks to 7 months)
 - +/- CT chest
- **Special**
 - **Bronchoscopy** (visualization of the stump, < 3 mm hole considered small and possibly amenable to endoscopic therapy)
 - **Bronchogram** (contrast into tracheobronchial tree, assess presence in hemithorax with CXR)
 - **Sinogram** (contrast study under fluoroscopy)
 - **Methylene Blue** (either into pleural cavity and assess sputum, vs. into stump via bronchoscope and assess CT drainage)
 - **Xe gas** (pt breathes radioactive gas, then washout lungs with normal ventilation, assess presence of Xe in pleural space by scintigraphy)

OPTIMIZATION

- Stability of patient determines urgency of case and time for optimization
 - Tension PTX – manage accordingly with chest tube
 - Chest tube to underwater seal (10-15 cmH₂O), unclamped, not to suction
 - Small BPF without hemodynamic or respiratory compromise
 - Consider pre-induction chest tube if not in situ but not required (but have equipment / thoracic surgeon available)
 - Large BPF
 - Chest tube to treat / prevent tension PTX
 - Remove from suction prior to induction (to minimize air-leak if PPV)
 - Degree of air-leak is determined by bronchial to pleural pressure gradient
 - Empyema
 - Chest tube drainage + underwater seal prior to surgery with local anesthesia
 - Drainage performed with pt sitting up and leaning forward
 - Possibility of loculations therefore single CT may be inadequate
 - Abx as appropriate to cover infection / sepsis
 - DLT (an absolute indication) should be chosen with EBT on side opposite empyema (so pus comes up tracheal lumen and protect good lung)
- Aspiration prophylaxis
- Antisialagogue - to decrease secretions to facilitate FOB
- Sepsis management – Abx, hemodynamic control & end organ perfusion, glycemic control etc.

ANESTHETIC OPTIONS

- Local – for chest tube placement preoperatively and drainage of empyema
- Preference for regional / local anesthetic if procedure can be done this way (maintains spontaneous ventilation)
- BPF returning to the OR, usually will require thoracotomy / thoracoscopy (VATS) under GA with lung isolation & OLV with DLT being preferred
- **Three options:**
 - AFOI with DLT placement in spontaneously breathing patient (ideal)
 - Spontaneously breathing GA (inhalational vs. TIVA)
 - RSI with rapid DLT placement vs. titrated induction +/- NMBs with immediate isolation and OLV
- If anticipated difficult DLT placement, other options of lung isolation are possible but less ideal due to inability to aspirate from contaminated side (e.g. blocker / mainstem intubation)
 - If known small fistula, single lumen tube with small tidal volume / low pressure vent is an option
 - Also consider HFV to help minimize air-leak if single lumen required
- **Lung isolation** is required before positioning pt in LDP to prevent contamination of good lung
- If unable to meet above goals due to patient anatomy / co-morbid illness discuss options of non-operative management with thoracic surgeon / respiratory / ICU
- If patient requires ventilation but unable to achieve lung isolation consider the following ventilation strategies (minimize air leak)
 - Maintain SV if possible (SV > PSV > controlled)
 - Goal = transalveolar pressures < BPF leak pressures:
 - Minimize Vt
 - Minimize inspired time
 - Avoid PEEP
 - Consider permissive hypercapnia
 - Titrate PPV to point where continuous bubbling through underwater seal of chest tube then decrease
 - Position patient with bad lung down to prevent contamination (if not a pneumonectomy may get worse V/Q matching)
 - Consider HFOV

ANESTHETIC SETUP

- **Drugs**
 - Emergency drugs (atropine, SCh, ephedrine, phenylephrine)
 - May need inotropes if septic (norepinephrine, dobutamine etc.)
- **Equipment**
 - CAS monitors +/- 5 lead EKG if needed
 - Art line (hemodynamic monitoring + assessment of oxygenation & ventilation)
 - Central Line – if concern of sepsis or possibility of HD instability requiring inotropic support
 - Thoracic epidural – often in situ if post-op, consider contraindication due to systemic infection
 - Bronchoscopy Cart + appropriate sized DLT

- If post pneumonectomy consider R vs. L sided tubes (ideally use opposite EBT to side of fistula, to avoid stump suture line / rupture, out of surgical field if required to revise stump etc.)
 - Chest tube tray
 - Thoracic surgeon in room

MANAGEMENT OF ANESTHESIA

- **Induction**
 - **Goal:** safe rapid lung isolation while avoiding increases in bronchopleural gradient and minimizing aspiration
 - Three common techniques of securing airway / lung isolation:
 - **Awake spontaneously breathing**
 - FOI vs. direct laryngoscopy + DLT
 - Ideal option in terms of anesthetic goals, but practically awake DLT is challenging and more stimulating than single lumen AFOI, requires cooperative patient + excellent topicalization
 - **GA spontaneously breathing**
 - Inhalational induction vs. TIVA
 - IH can take long time to get pt deep enough for DLT placement (hypoventilation)
 - Risk of apnea requiring BMV / PPV (if required minimize pressure and assess degree of air-leak via chest tube)
 - **GA without spontaneous vent (+/- NMBs)**
 - RSI with rapid lung isolation (DLT) vs. titrated induction with assisted BMV
 - Both have considerable pitfalls (failure to place DLT, unanticipated difficult airway becomes can't ventilate situation, tension PTX with PPV etc.)
 - Requires careful patient selection with known easy airway, expertise in lung isolation and confirmation of placement prior to PPV, or known small fistula
- **Maintenance**
 - Avoid N₂O due to PTX risk / bullae
- **Emergence**
 - Awake, Warm, Comfortable, Reversed, Goal of immediate extubation with no coughing

DISPOSITION & MONITORING

- **Pain control**
 - Thoracic epidural to facilitate optimized post-op pulmonary function (if not done preoperatively consider postoperative insertion)
 - Multimodal – acetaminophen, NSAIDS, local infiltration, regional (intercostals, paravertebral), PCA
- **Disposition** – high dependency unit

COMPLICATIONS

- Induction
 - Tension pneumothorax if PPV required and no CT
 - **Cannot Ventilate**, consider temporarily clamping chest tube to create positive pressure in hemithorax to decrease leak and allow BMV, hemithorax will need to be intermittently decompressed to avoid cardiovascular effects of tension pneumothorax
- Intraoperatively
 - Complications Related to DLT
 - Failure to place, trauma, malpositioning etc.
 - Complications with One lung Ventilation
 - Pulmonary complications include hypoxemia, hypercapnia, impaired hypoxic pulmonary vasoconstriction (HPV)
 - Barotrauma
 - Cross contamination
- Postoperatively
 - Persistent Air-leak
 - Sepsis
 - Pain

PATHOPHYSIOLOGY

- BPFs are communications between the pleural space and the bronchial tree
- Rare & represent a challenging management problem and are associated with an important morbidity
- After pulmonary resection, BPFs can be a life-threatening condition
- The incidence has been reported from 1.5 to 28% after pulmonary resection
 - Variability apparently depends on the etiology, surgical technique, and experience of the surgeon
 - Lower for benign conditions compared to malignancy
 - Cerfolio reported an incidence of 4.5 to 20% after pneumonectomy and 0.5% after lobectomy
 - Sirbu et al reported their experience with 490 patients with lung resection for non-small cell lung cancer w/ an incidence of 4.4% (22 of 490 patients)
 - Twenty-one patients (95%) were men, and 1 patient (4.5%) was a woman
 - Mean age was 57.8 years
 - BPF after pneumonectomy occurred in 12 patients (54.6%), in 9 patients (40.9%) after lobectomy, and in 1 patient (4.5%) after sleeve resection
- **Etiologies**
 - Postoperative complication of pulmonary resection is the most common cause
 - Other causes include necrotic lung complicating infection, chemotherapy or radiotherapy (for lung cancer), persistent spontaneous pneumothorax, and tuberculosis (less common)
 - Sato and colleagues reported their experience with postoperative BPF; they found BPF in 5 of 64 cases (7.8%) of inflammatory diseases and 19 of 481 cases (4%) of lung cancer

- **Risk Factors**
 - Preoperative
 - Fever
 - Steroid use
 - H. influenzae in sputum
 - Elevated ESR
 - Anemia
 - Postoperative
 - Fever
 - Steroid use
 - Leukocytosis
 - Tracheostomy
 - Bronchoscopy for sputum suction / mucus plugging
 - Postoperative ventilation
 - Right pneumonectomy
- **Management**
 - Management dependent on nature and etiology of fistula but aims to reduce the pleural space and seal the fistula
 - **Conservative management** (non surgical) usually tried first especially if small BPF:
 - Chest tube drainage ± Abx as indicated
 - Various ventilatory strategies to exclude the affected lung and / or to reduce airway pressures to minimize leak, optimize alveolar ventilation and to rest the BPF to allow healing
 - HFV - may be **non-surgical treatment of choice**
 - Can use as sole method of ventilation or as part of differential ventilation strategy
 - HFV refers to 3 major categories of delivery systems and respiratory rate ranges but generally uses small Vt (<2mL/kg) and high RR (60-2400/min) resulting in lower mean and peak airway pressures and thus improved alveolar ventilation in BPF and reduced driving pressure across BPF
 - **Surgical management** is warranted if failure of conservative management or as more urgent procedure in case of large BPF with respiratory compromise (e.g. bronchial stump disruption post pneumonectomy or traumatic tracheobronchial tree disruption)
 - Thoracoscopic procedure (resection blebs / bullae; pleurodesis)
 - Thoracotomy to repair stump (primary or via pedicled flaps); may require lobectomy / pneumonectomy

REFERENCES

- Barash et al. Clinical Anesthesiology 6th Ed. Chapter 40
- Miller et al. Anesthesia 6th Ed.
- Lois et al. Bronchopleural Fistulas: An Overview of the Problem With Special Focus on Endoscopic Management, Chest 126(6) 2005