BRONCHOPLEURAL FISTULAS :

An Overview of the Problem With Special Focus on Endoscopic Management

Definition and Incidence

- **Bronchopleural fistula (BPF) :**

  communication between the pleural space and the bronchial tree

- **Incidence : 1.5 - 28% after pulmonary resection**

- **Depends on :**
  - **etiology**
  - **surgical technique**
  - **experience of the surgeon**

- **The incidence is lower for benign conditions compared to malignant ones**

Classification of BPF

Postoperative

Associated with resection :

- **Malignancy**
- **Trauma**
- **Infectious - removal of pneumatocele**
  - tuberculosis
  - abscess
  - fungus ball

Classification of BPF

Postoperative

Associated with pleuroparenchymal disease

- **Empyema**
- **Thoracic trauma**
- **Other infections**

  - *Pneumocystis carinii*

  - liver abscess opening into chest

Classification of BPF

Postoperative

Others

- **Tracheal or esophageal perforation repairs**
- **Gastroesophageal reflux disease**
- **Boerhaave syndrome**

Classification of BPF

Nonpostoperative

- After procedures
  - line placement
  - pleural biopsy
  - bronchoscopy
  - lung biopsy
- Idiopathic
- Infections
- Persistent spontaneous pneumothorax
- Thoracic trauma
- Necrotizing lung disease associated with radiation or chemotherapy
- ARDS

Etiologies

- Most common cause:

  postoperative complication for pulmonary resection

- Postoperative BPF *
  - 7.8% cases of inflammatory diseases
  - 4% cases of lung cancer

- The incidence is highest in patients who undergo right pneumonectomy & right lower lobectomy

* Sato et al. Nippon Kyobu Geka Gekkai Zasshi 1989;37:498–503

Etiologies

- **Preoperative risk factors :**
  - **advanced case (main & intermediate bronchus)**
  - **previous ipsilateral thoracotomy**
  - **preoperative chemotherapy and/or radiation**
  - **fever**
  - **steroid use**
  - ***H influenzae* in sputum**
  - **elevated ESR and anemia**

- **Perioperative risk factors :**
  - **residual tumor on stump**
  - **excessive peribronchial & paratracheal dissection**
  - **long bronchial stump**
  - **intrathoracic use of chemotherapy**
  - **tightness of the individual sutures**

Etiologies

- **Postoperative risk factors :**
  - **fever**
  - **steroid use**
  - **leukocytosis**
  - **tracheostomy & bronchoscopy for mucus plugging**
  - **postoperative mechanical ventilation**

- ***Risk of* dehiscence[*] :**
  - ***1.8% : manual suture***
  - ***5.0% : stapling device***
  - ***1.9% : reinforcement suture at distal side***
  - ***1.0% : reinforcement suture at proximal side***

[*] Sonobe et al. Eur J Cardiothorac Surg 2000; 18:519–523

Clinical Presentation

- **Acute**

Due to tension pneumothorax or asphyxiation from pulmonary flooding following dehiscence

A life-threatening condition characterized by:

-- sudden dyspnoea
-- hypotension
-- subcutaneous emphysema
-- cough with purulent expectoration
-- shifting of trachea and mediastinum
-- persistence of air leak
-- ↓ / disappearance of pleural effusion on chest X ray

Clinical Presentation

- **Sub acute**

  More insidious

  Characterized by :

  - **wasting**
  - **malaise**
  - **fever**
  - **minimally productive cough**

- **Chronic**

  Associated with :

  An infectious process

  Fibrosis of the pleural space and mediastinum preventing mediastinal shift

Diagnosis

- **Instillation of methylene blue into pleural space & its detection in chest tube**
- **Bronchography**
- **^{133}Xe, ^{81m}Kr and ^{99m}Tc diethylenetriamine pentaacetic acid ventilation scintigraphy**
- **CT scan : useful in detecting the etiology of BPF & select potential candidates for surgery**
- **Bronchoscopic exploration : evaluation of stump, localize fistula, exclude TB & other infections, introduction of sealants into fistulous tract**

Treatment

- No optimal therapy

- Treatment should be individualized

- Options include:
  - surgical procedures
  - medical therapy
  - bronchoscopy & different glues, coils, & sealant

Treatment

- **Initial non operative management:**
  - **-- ↓ gradient between airway pressures & pleural space by minimizing mean airway pressure**
  - **-- minimizing suction on pleural tubes if lung remains fully inflated**

- **Aggressive management of underlying comorbidities and conditions that led to the BPF**

Treatment

- **Control any life threatening conditions:**
  - **tension pneumothorax:**
    emergent drainage
  - **pulmonary flooding:**
    airway control & postural drainage
  - **major bronchial stump dehiscence:**
    immediate resuture & reinforcement
- **Proper nutrition**

Treatment

Successful treatment of chronic BPF

- Aggressive control of infection
- Adequate drainage of the chest cavity
- Closure of the fistula with vascularized tissue
- Obliteration of the chest cavity

Chest tubes

- **Indications**

  -- high flow BPF
  -- drainage of empyema

- **Complications**

  -- negative effects during mechanical ventilation
  loss of tidal volume
  abnormal gas exchange
  appearance of ventilator cycling

  -- negative pressure to chest tube can ↑ flow through tract & interfere with closure and healing

  -- tube itself can function as a foreign body and predispose infection both at the insertion site & in pleural space

Chest Tubes

- **Patients receiving MV :**
  chest tube used to add positive intrapleural pressure during expiratory phase (↓ air leak during expiration in order to maintain PEEP) or occlusion during inspiratory phase (to ↓ BPF flow)

- **These maneuvers have also been used in combination in patients in which PEEP is required to maintain` oxygenation (eg. ARDS)**

- **Chest tube should be of large diameter to allow drainage of air leak**
  flow $\propto$ (radius of tube)^5 (Fanning equation)

- **Chest tube can be used to apply sclerosing agents to promote pleurodesis (talc, bleomycin)**

Mechanical Ventilation

- An independent risk factor for development of BPF in postsurgical patients or in the patients ARDS, COPD
- Air escaping through BPF delays healing of fistulous tract, causes significant loss of tidal volume, jeopardizing minute ventilation & oxygenation
- Flow through tract is limited by ↓ airway pressure accomplished by limiting PEEP, limiting effective tidal volume, ↓ inspiratory time, & ↓ respiratory rate
- Use of :
  - selective intubation of unaffected lung
  - double-lumen intubation with differential ventilation
  - independent lung ventilation & patient positioning

Mechanical Ventilation

- High frequency ventilation (HFV) to overcome limitations of conventional ventilation
- Useful in patients with normal lung parenchyma and proximal BPF
- HFV more applicable in massive air leak due to BPF: difficult to manage by conventional modes
- Adjunctive interventions: combining mechanical ventilation and chest tube manipulation

Surgery

- Success rate of surgical closure between 80% and 95%

- Risk : open thoracotomy
  reported mortality as low as 0%

- Surgical closure includes
  -- chronic open drainage
  -- direct closure with intercostal muscle reinforcement
  -- omental flap
  -- trans sternal bronchial closure
  -- thoracoplasty with/without extrathoracic
  chest wall muscle transposition

- Video-assisted thoracoscopy also been used

Surgery

- **Turk et al * - a staged closure of complicated BPF**

First stage:

Eloesser procedure for chest cavity drainage consisting of muscle flap operation

Second stage:

After aggressive nutritional & physical rehabilitation, second procedure for chest cavity obliteration with an omental flap is performed

* Turk et al. Plastic Surg 2000; 45:560–564

Bronchoscopy

- **A diagnostic & therapeutic modality**
- **Successfully used percutaneously to visualize the track of a bronchopleurocutaneous fistula**
- **Regel et al* reported use of Swan-Ganz catheter in management of distal fistulas**
- **Balloon used to localize fistula, & with balloon inflated sealant is passed through distal port into tract**

*Regel et al. J Trauma 1989; 29:223–226

Bronchoscopy

- **Success of sealing : most leaks are peripheral / alveolar**
- **An alternative to otherwise poor surgical candidates**
- **No controlled studies so far : those reported are anecdotal or limited to a few patients**
- ***Lead Shots:***

1977 -- Ratliff et al pioneered endoscopic management of BPF by using a lead shot. Guidewire passed into affected bronchus after its location with a balloon catheter. A fishing weight attached to a suture was passed over guidewire & advanced with bronchoscope until leak stopped

BRONCHOSCOPY- Sealing compounds

- ***Ethanol :*** **injecting absolute ethanol directly into submucosal layer of a fistula is first-line therapy for patients with a postoperative central BPF with an orifice < 3 mm**

- ***Polyethylene Glycol :***

water-soluble polyethylene glycol-based gel, comes as a polymer and sealant activated by a xenon-generated light in the spectrum of 440 to 550 nm. The light probe is to be held for 45 s, 2 cm from area leading to cross-linking of compounds

BRONCHOSCOPY- Sealing compounds

- ***Cyanoacrylate Glue :***

  most common (along with fibrin)
  seal by acting as a plug, and later inducing an inflammatory response leading to fibrosis, mucosal proliferation & permanently sealing

- ***Fibrin Glue :*** **successful in small BPFs and patients with multiple postresection bronchial stumps**
  1mL of concentrated fibrinogen is injected followed immediately by 1 mL of topical thrombin (1,000 UI/mL)
  A fibrin clot forms over the fistula, sealing the leak, eventually it is reabsorbed, preventing foreign body reaction

BRONCHOSCOPY- Sealing compounds

Kinoshita et al* used fibrin glue to perform pleurodesis in 40 high-risk patients with intractable pneumothorax and in 13 postthoracotomy patients with persistent air leakage

air leaks stopped in both groups

In follow-up period, a recurrence rate of 12.5% was observed in former group which also were successfully treated by glue administration with no further recurrence

In the 13 postthoracotomy cases, there was no recurrence

Side effects: Pyrexia (12.5%) & chest discomfort (4.1%)

* Kinoshita et al. Chest 2000; 17:790–795

BRONCHOSCOPY- Sealing compounds

- ***Blood Clot :*** **based on a similar principle of fibrin glue**

- ***Antibiotics :*** **successful fistula closure was obtained by endoscopic instillation of tetracycline/ doxycycline into the fistula using a balloon catheter and blood clot occlusion**

BRONCHOSCOPY- Sealing compounds

- ***Albumin-Glutaraldehyde Tissue Adhesive:***

  Potaris et al* concluded that the use of BioGlue proved to be safe and effective in the sealing of lung lacerations and in preventing air leakage from suture or staple lines in emphysematous lungs. It was also successful in sealing BPFs when applied either intrabronchially through the rigid bronchoscope or during thoracotomy

* Potaris et al Med Sci Monit 2003; 9:P179–P183

BRONCHOSCOPY- Sealing compounds

- ***Gel Foam :***

  theoretical advantages of availability and being totally reabsorbed

- ***Coils:*** **alone or in conjunction with other sealants**

  Angiographic occlusion coils placed endobronchially under fluoroscopic guidance succeeded in controlling a large parenchymal BPF after failure of surgical treatment and transbronchoscopic fibrin glue application

BRONCHOSCOPY- Sealing compounds

- ***Balloon Catheter Occlusion :***

  method of choice to detect the site of air leak and place the sealant, has also been used in BPF management

- ***Calf Bone :***

  calf bone used along with fibrin glue to seal

  The bone is shaped to the form of fistula & sprayed with fibrin after insertion

BRONCHOSCOPY- Sealing compounds

- ***Stents :***

  mostly for management of esophageal-to-airway fistulas

  also indicated for sealing of stump fistulas after pneumonectomy & dehiscence after bronchoplasty

  provide tight seal to prevent aspiration pneumonias

  selection of a stent depends upon the type of lesion, its location, characteristics of the stent, and its potential short-term and long-term complications

BRONCHOSCOPY- Sealing compounds

- ***Others:***

  cellulose

  silver nitrate

  surgical sponges

  specially built endobronchial silicon spigots.

Discussion

- **No controlled studies comparing different sealants or comparing surgical and endoscopic therapy**

- **In general, endoscopic procedure is preferred in high-risk surgical candidates to avoid risk of anesthesia & surgery**

Discussion

- **A retrospective study of 45 patients with BPF after pneumonectomy (40 pt) or lobectomy (5 pt) seen over a 13-year period who had closure of stump performed with a mechanical stapler**

Procedures performed with rigid bronchoscopy :

Visible leaks < 3 mm :	**treated with fibrin sealant**
Fistulas > 3 mm :	**fibrin & spongy calf bone**
Fistulas > 8 mm :	**not suitable for endoscopic treatment, and were excluded**

* Hollaus et al. Ann Thorac Surg 1998; 66:923–927

Discussion

Weekly follow-up :
if occluding material was expectorated –
immediate bronchoscopy for reclosure

Surgical intervention (open window drainage or thoracoplasty) when fistula size increased with endoscopy, empyema developed, or there was progression to systemic sepsis

Overall rate of fistula closure was 35.6% (16 patients), and recurrence occurred in 2 patients (12.2%),

Average number of endoscopic interventions : 2.47

Discussion

Size, interval, and number of therapeutic interventions showed no significant differences between the surgical and endoscopic groups

Hospital mortality : 17.8%

Most died in endoscopically treated

Conclusion:

Bronchoscopic treatment of BPF was an efficient alternative, especially when surgery not possible because of the physical condition of the patient

ACCP recommendations for spontaneous pneumothorax

For patients with persistent air leak:

- **Observation for 4 days for spontaneous closure.**
- **If an air leak persists longer than 4 days, evaluate for surgery to close air leak & perform a pleurodesis to prevent recurrence. Thoracoscopy is preferred procedure (Very Good Consensus)**
- **Use of an additional chest tube or bronchoscopy is not indicated (Very Good Consensus)**
- **Where surgery is contraindicated or patient refuses surgery, chemical pleurodesis should not be used (Very Good Consensus)**
- **Doxycycline or talc slurry are preferred sclerosing agents (Good consensus)**

ACCP recommendations for spontaneous pneumothorax

Patients with secondary spontaneous pneumothorax and persistent air leaks :

for a patient with persistent air leaks & prolonged chest tube drainage who initially refuses surgery, continue observation for 5 days. After 5 days of observation, patient should be urged to accept surgical intervention. More prolonged delay may limit the effectiveness of thoracoscopy. Instillation of sclerosing agents through a chest tube to produce a pleural symphysis in managing persistent air leaks is acceptable for patients who are not surgical candidates (Good Consensus)

Conclusions

- **Further studies are required**

  -- to establish role of techniques
  -- patient selection for endoscopic procedures
  -- which technique / combination will be most valuable

- **No established guidelines in proper management of BPF**

Conclusions

A Possible Recommended Approach

-- to reduce BPF appearance : use manual sutures rather than mechanical stapling or a combination

-- detection of high-risk patients and possible delayed or alternative procedures until their condition is improved

-- once BPF has developed, early recognition, drainage of empyema, & management of infectious process are critical

-- prevention of complications : aspiration, sepsis

-- aggressive nutritional and rehabilitative support

Conclusions

-- diagnostic tools:

nuclear scans

CT scans

bronchoscopy

-- localization of fistula and apparently size may indicate potential benefits of surgery vs endoscopy

-- high-risk surgical patients, endoscopic procedure

-- BPF size important factor in predicting outcome

Conclusions

-- BPFs 8 mm not suitable for endoscopic management

-- Distal small BPFs 1 mm in size : highest success rate

-- the time of appearance of BPF a prognostic factor

-- large or central BPFs best managed with
surgery or stent placement

-- If appears early after surgery:
reclosure is mandatory

Conclusions

-- two-stage intervention best approach for
debilitated high-risk patients

-- In first stage, an attempt to close or decrease BPF
via endoscopy & patient receives aggressive
nutritional and rehabilitative support

-- once clinical condition stabilizes:
a definite surgical intervention

-- double stenting is best approach for
esophagotracheal fistulas

Conclusions

-- if MV required, HFV indicated in patients with otherwise normal lung parenchyma & proximal BPF
however, a trial of HFV tried in any case

-- “best sealant”
there is no evidence to support one vs another compound

-- experience of endoscopist with different compounds dictate choice

All the best..