# Non surgical management of hemoptysis and air leaks

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# Introduction

- Hemoptysis - expectorated blood arising from the pulmonary parenchyma or tracheobronchial tree
- Massive hemoptysis - widely used criterion is the production of 300–600 mL per day
- Surgical treatment a mortality rate of up to 40% in the emergent setting
  - *Woong Yoon et al. Radiographics 2002;22:1395-1409*

# Introduction

- The morbidity and mortality of this disease is due to asphyxiation in 80% of cases, and exsanguination in the remaining

# Sources of hemoptysis

- Bronchial circulation - 90%
- Pulmonary circulation – 5%
- Non-bronchial systemic collaterals – 5%

# Initial management

- Ensuring adequate airway protection, ventilation and cardiovascular function
- Airway protection – in patients with massive ongoing hemoptysis & respiratory failure, hemodynamic instability or inability to maintain patent airway
- Large bore oral endotracheal tube 8.0 or more

# Initial management

- Coagulation disorders and thrombocytopenia/platelet dysfunction Corrected aggresively

# Protecting the non-bleeding lung

- Ask the patient to lie on the side of bleeding – if bleeding side is known
- subjective sense of ‘‘a funny feeling’’ or ‘‘gurgling’’ in the chest is highly predictive of the site of bleeding[1,2]
- Intubating the main stem bronchus with single lumen endotracheal tube
- Double lumen endotracheal tube (DLT)


- *1)Brinson GM et al.Am J Respir Crit Care Med 1998;157:1951–1958*
  - *2)Najarian KE et al. J Thorac Imaging 1998;13(2):93–104*

# Double lumen endotracheal tube (DLT)

- Specially designed for selective intubation of the right or left mainstem bronchi
- 2 lumen – one tracheal lumen and bronchial lumen
- Left  DLT is preferable

# Double lumen endotracheal tube

# Double lumen endotracheal tube (DLT)

- Difficulties

-Difficult to place even by experienced anesthetists

-May move when the patient's position changes

-Lumen size is small - prohibit passage of a bronchoscope

-small ET lumen - predispose to intra-tube clot / airway obstruction

- Not recommended except in patients who are exsanguinating and/or asphyxiating from their bleeding

- *Strange C et al. Clin Chest Med 1991;12:497-506*

# Chest radiograph

- Quick, noninvasive, and widely available first step that can localize the site of abnormality in 19 to 83% of cases
- Can suggest etiology of hemoptysis

- *Woong Yoon et al. Radiographics 2002;22:1395-1409*

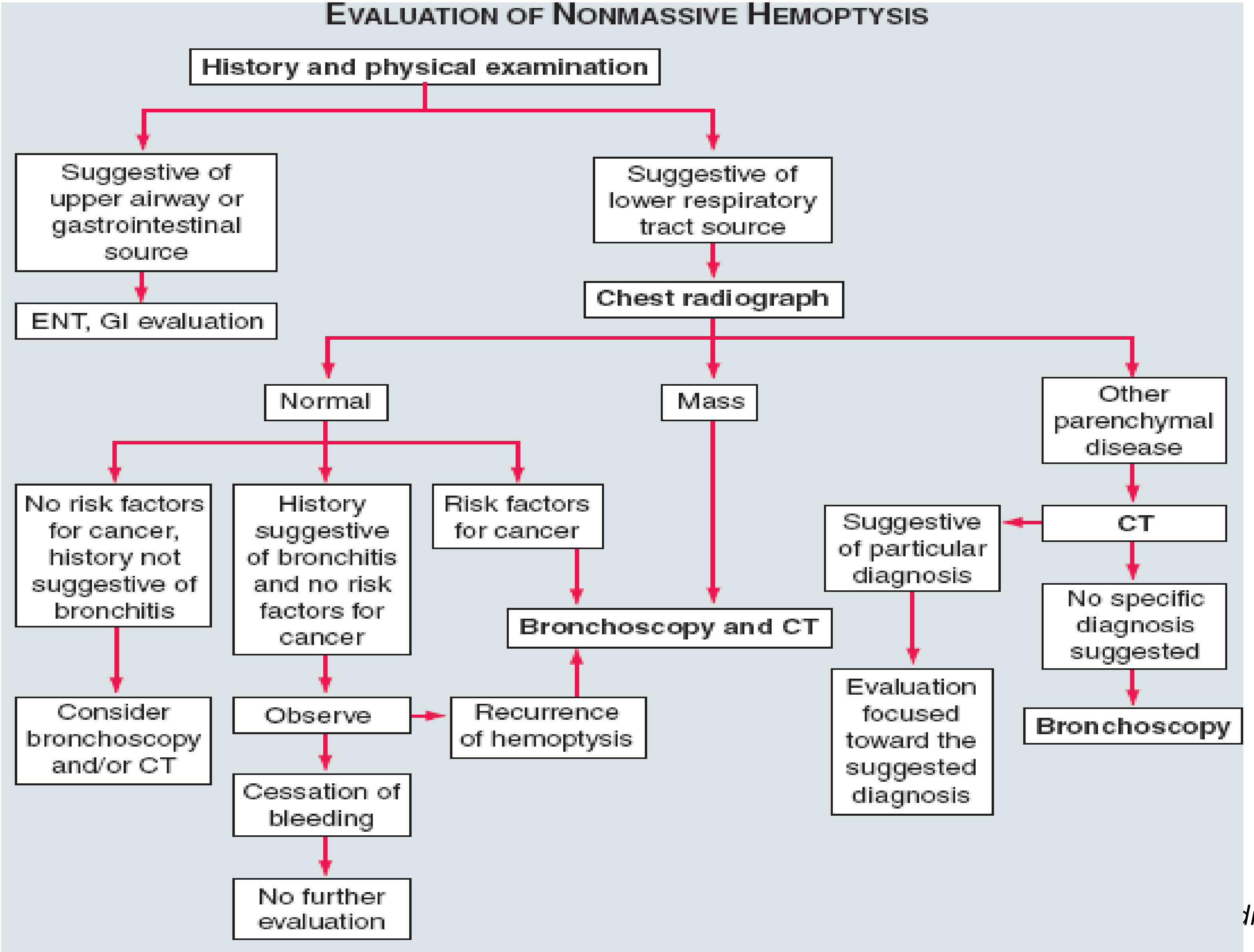
# chest computed tomography (CT) VS Bronchoscopy

- Earlier use of CT advocated
- Identifies parenchymal abnormalities, difficult to detect using other diagnostic modalities
- Detect systemic arterial supply - increased pleural thickness (>3 mm) adjacent a parenchymal lesion and/or enhanced vascular structures in extrapleural fat layer

# chest computed tomography (CT) VS Bronchoscopy

- Disadvantage  CT - requires temporary movement of an unstable patient out of ICU
- Modified HRCT and FOB - 57 consecutive patients – parenchymal and intrabronchial causes
- HRCT- bronchiectasis, aspergillomas, whereas FOB - endobronchial lesions and chronic bronchitis
- Higher diagnostic yield of HRCT


- *McGuinness G et al. Chest 1994;105:1155-62*


EVALUATION OF NONMASSIVE HEMOPTYSIS
History and physical examination
Suggestive of upper airway or gastrointestinal source
ENT, GI evaluation
Suggestive of lower respiratory tract source
Chest radiograph
Normal
Mass
Other parenchymal disease
No risk factors for cancer, history not suggestive of bronchitis
History suggestive of bronchitis and no risk factors for cancer
Risk factors for cancer
CT
Suggestive of particular diagnosis
Bronchoscopy and CT
No specific diagnosis suggested
Consider bronchoscopy and/or CT
Observe
Recurrence of hemoptysis
Evaluation focused toward the suggested diagnosis
Bronchoscopy
Cessation of bleeding
No further evaluation

*dition*

# chest computed tomography (CT) VS Bronchoscopy

- Complementary to each other
- Combined yield better than individual yield
- FOB – exact localization of bleeding segment, therapeutic application, initial choice in patients with high suspicion of lung cancer/clinically unstable

# Timing of Bronchoscopy

- performed acutely(during or within 48 after hemoptysis stopped) more likely to visualize active bleeding (41 vs 8 %)/site (34 vs 11%) than doing a dealyed bronchoscopy

- *Gong H  et al. Am Rev Respir Dis 1981;124:221-5*

# Role of bronchoscopy

- Protecting the non-bleeding lung - balloon tamponade of the bleeding site
- Segmental or subsegmental bronchus level - four French 100 cm Fogarty balloon catheter
- Balloon  left inflated for 24 to 48 hours
- After deflating balloon - observed for rebleeding for several hours


- *Lordan JL et al. Thorax 2003; 58:814*

# Role of bronchoscopy

- Bronchoscopic techniques to slow or stop bleeding
- Lavage with iced saline
- Topical epinephrine (1:20,000)
- Vasopressin,thrombin, or a fibrinogen-thrombin combination
- Not studied in RCT's
- Localized bleeding mucosal lesion - laser therapy / electrocautery

# Rigid vs fibreoptic bronchoscopy

- Advantages - better suctioning & greater variety of therapies during rigid bronchoscopy eg: direct cautery or packing of bronchial lesions
- visual range of inspection is limited
- FOB used in conjunction with the rigid bronchoscope – improves visual range
- Rigid bronchoscope used for patients with ongoing massive hemoptysis

# Anatomy of bronchial circulation

- Origin- descending thoracic aorta between levels of T5 and T6 vertebrae
- Bronchial arteries that originate outside the area between the T5 and T6 vertebrae at the levelof the major bronchi are considered – anomalous
- Adults – normal bronchial arteries measure < 1.5 mm at origin and 0.5 mm at entry into segment

- *Radiographics 2002;22:1395-1409*

# Anatomy of bronchial circulation

- 4 classic bronchial artery branching patterns
- Type I- 2 left &  1 right ICBT- 40%
- Type II- 1 left and 1 right ICBT -21.3%

# Anatomy of bronchial circulation

- Type III- 2 left and 2 right (1 ICBT and 1 bronchial artery) -20.6%
- Type IV- 1 left % 2 right (1 ICBT & 1 BA)

- *Woong Yoon et al. Radiographics 2002; 22:1395-1409*

# Angiographic embolisation

- Indications :
- Massive hemoptysis
- Lesser degrees of hemoptysis may also require treatment, depending on the patient's underlying pulmonary reserve and ability to maintain a patent airway
- Preparing the patient for elective surgery
- Unfit for surgery

# Indications

- Ongoing chronic but nonmassive hemoptysis that impairs a patient’s quality of life

# Contraindications

- Uncorrectable coagulopathy, renal failure, and severe contrast allergy
- Congenital pulmonary artery stenosis, the bronchial collateral vessels may provide an essential role in pulmonary parenchymal perfusion

# Complications

- Postembolization syndrome - retrosternal chest pain, intercostal pain, transient dysphagia, and fever - not uncommon
- Chest pain – most common
- Dysphagia due to embolization of esophageal branches
- Subintimal dissection of the aorta or the bronchial artery

# Complications

- Most disastrous complication of BAE - spinal cord ischemia due to the inadvertent occlusion of spinal arteries The prevalence of spinal cord ischemia after BAE is 1.4%–6.5%
- Anterior medullary artery (artery of Adamkiewicz)

# Complications

- Rare complications - include aortic and bronchial necrosis, broncho-esophageal fistula, non–target organ embolization (eg, ischemic colitis),
- pulmonary infarction, and transient cortical blindness

# Technique

- Preliminary descending thoracic aortogram – anatomy of arteries supplying lung
- Cobra-type curved catheters
- Microcatheter for selective BAE
- Bronchial angiography is performed with manual injection of contrast medium


- *Woong Yoon et al. Radiographics 2002; 22:1395-1409*

- Angiographic findings - hypertrophic and tortuous bronchial arteries, neovascularity, hypervascularity , shunting into the pulmonary artery or vein, extravasation of contrast medium, and bronchial artery aneurysm, parenchymal staining.
- Bronchial arteries larger than 2 to 2.5 mm in diameter are considered enlarged

- Absorbable gelatin sponge – widely used
- Polyvinyl alcohol particles are nonabsorbable embolic materials
- Size of particles - 350–500 µm in diameter

- Broncho-pulmonary anastomosis of 325 µm – pulmonary infarction and systemic arterial embolisation
- small particles – occlusion of distal braches leading to necrosis of bronchial, aortic, oesophageal wall

- Optimal approach - A widely accepted and relatively conservative approach is to treat ipsilaterally enlarged bronchial arteries at the first session
- Nonbronchial systemic arteries can be a significant source of massive hemoptysis, especially in patients with pleural involvement caused by an underlying disease

- Recurrent bleeding:

-Recanalization of embolized vessels

-Incomplete embolization

-Revascularization by the collateral circulation

-Inadequate treatment of the underlying disease

-Progression of basic lung disease

-Non-bronchial systemic arterial supply

- Pleural thickening of more than 3 mm and tortuous enhancing vascular structures within hypertrophic extrapleural fat seen at contrast enhanced CT are signs of nonbronchial systemic arterial supply in patients with massive hemoptysis

*Woong Yoon et al. Radiographics 2002; 22:1395-1409*

# NON SURGICAL MANAGEMENT OF AIR LEAKS

# Management of air leak

- Prolonged air leak is an important clinical problem
- Generally a consequence of spontaneous pneumothorax caused by underlying lung disease, chest trauma
- Lung biopsy, segmentectomy, lung volume reduction, or anatomic resections when there are incomplete fissures
  - *Douglas E. Wood et al . Clin Chest Med 2010; 31: 127–133*

- Prolonged air leaks are the most common complication after pulmonary resection
- Average incidence:
- Segmental or wedge resection - 8%,
- Lobectomy - 10%
- Lung volume reduction surgery (LVRS)- 45%
  - *Douglas E. Wood et al . Clin Chest Med 2010; 31: 127–133*

- Prolonged air leak – duration > 7 days or longer[1]
- Contribute directly to respiratory failure by increasing the work of breathing
- Complications – limited activity
- 3 major factors evaluating air leaks:
  1) Volume
  2) Duration
  3) Trend of the leakage

*1-McKenna RJ et al; J Thorac Cardiovasc Surg 2004;127:1350–60*

# Evaluating volume of air leak

- Simple obserevation of water seal chamber – mild, moderate and severe

- Cerfolio classification

- *Cerfolio RJ Ann Thorac Surg 2009;87:1690–6*

# Cerfolio's classification

**Four classifications of air leak in the Cerfolio System**

1. Continuous (C): present throughout the respiratory cycle
   - Tends to be in patients receiving positive pressure ventilation
2. Inspiratory (I): present during the inspiration phase of the respiratory cycle
   - Like continuous air leaks, patients with this pattern are often on a ventilator
3. Expiratory (E): present only during expiratory phase of the respiratory cycle
4. Forced Expiration (FE): present only when patient coughs or forces exhalation

# Volume of air leak

- Digital devices –

-Sahara S1100a Pleur-evac drainage system eg: E7, FE7

-AIRFIX

- Tube thoracostomy, the air in the pleural space can be rapidly evacuated
- Chest tube should be positioned in the uppermost part of the pleural space
- Chest tube - connected to a water seal device with or without suction
- Failure of the pneumothorax to resolve should prompt the initiation of suction if it was not initially applied

- Heimlich valve – alternative to water seal

Valve- rubber sleeve within a plastic case

- Prolonged airleak > 7 days

-Lung is less than 90 percent expanded- VATS(stapling of bleb, wedge resection) followed by pleurodesis

-Stable patients lung is at least 90 percent expanded but  persistent air leak - Heimlich valve to the chest tube and send the patient home

- Most spontaneous pneumothoraces are effectively managed with small chest tubes/catheters[1,2] /secondary spontaneous pneumothorax[3]

*1)Vedam H et al.* Intern Med J. 2003 Nov;33(11):495-9,
*2)Minami H* Am J Med Sci. 1992 Dec;304:345-7
*3)Am J Emerg Med. 2006 Nov; 24(7):795-800*

# Localization of air leak

- Identifying the airway leading to the leakage
- Proximal / Distal BPF’S
- Perform selective airway occlusion with a fogarthy / swan - ganz balloon catheter while observing the air coming through the chest tube for 20 to 30 seconds

# Localization of air leak

- Cessation of the leak may be immediate and complete with test occlusion/ significant decrease in the air leak


- *Douglas E. Wood et al . Clin Chest Med 2010; 31: 127–133*
- *Manuel lois et al.CHEST 2005; 128:3955–3965*

# Localization of air leak

- Sometimes - to treat more than one segment or subsegment to maximize the outcome
- Preferable to test and treat at a sublobar level, avoiding occlusion of an entire lobe that is associated with lobar atelectasis
- Sublobar level - less impact on patients' work of breathing

# Agents used to stop air leaks

Glues or adhesives: fibrin, albumin, glutaraldehyde, or acrylic

Gel foam or cellulose

Ethanol

Antibiotics

Metal coils

Decalcified spongy calf bone

Watanabe spigots

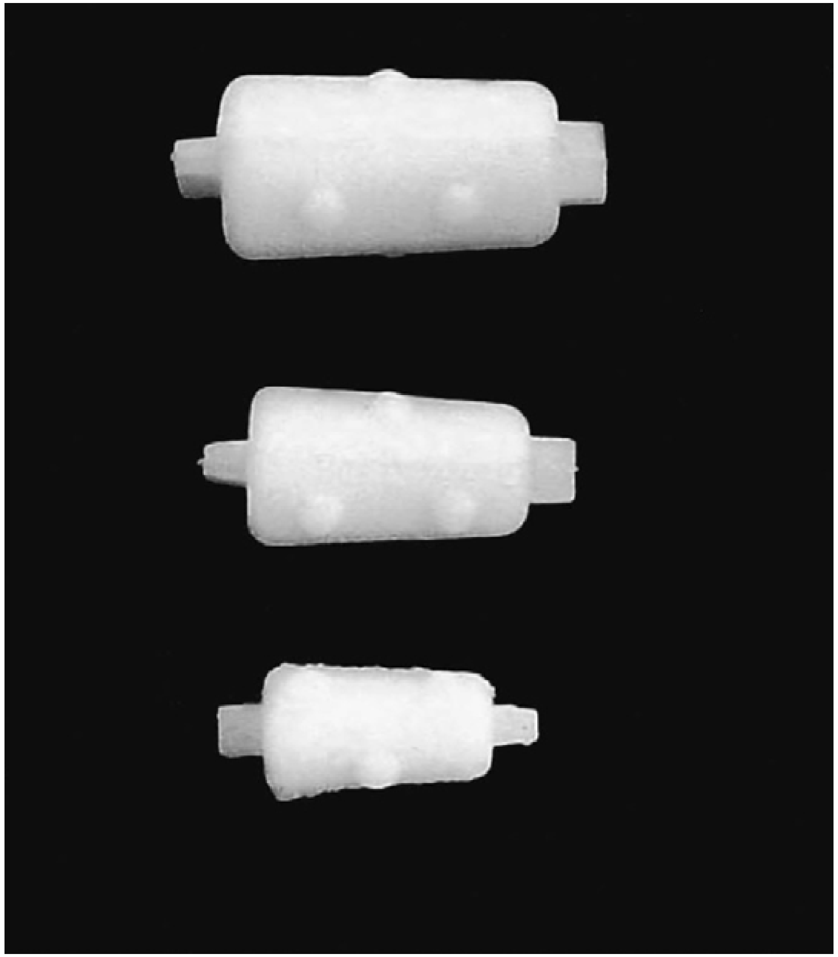
Cautery

Laser

*2010; 31: 127–133*

# Watanabe Spigot

- Watanabe Spigot is the only bronchial blocker - (Novatech, Cedex, France)
- Silicone plug that comes in multiple sizes



*Douglas E. Wood et al . Clin Chest Med 2010; 31: 127–133*

# Watanabe Spigot

- Weinreb et al - watanabe spigot for treatment of alveolopleural fistulas

-Treated 60 patients

-Air leak reduction in 38%

-Stoppage in 40%

-Average of 4.0 spigots per case


- *Weinreb N et al. J Bronchol Intervent Pulmonol 2009;16:130–2*

# Endobronchial valves

- Endobronchial valve - reduce airflow through the leaking tissue, facilitating local tissue healing and spontaneous resolution
- Trials with LVRS – interest for research in less invasive means
- Emphasys Medical and Spiration

# Emphasys bronchial valve (EBV)

# Spiration IBV Valve System

- EBV and IBV approved in EU
- IBV valve approved  in USA
- Novatech spigots – small, medium and large – 6,500 rupees/spigot

# Treatment of Persistent Pulmonary Air Leaks Using Endobronchial Valves

*Background:* Prolonged pulmonary air leaks are a significant source of frustration for patients and physicians. When conventional therapy fails, an alternative to prolonged chest tube drainage or surgery is needed. Bronchoscopic blockage of a bronchus can be performed with the hope of accelerating closure of the air leak by reducing the flow of air through the leak. To our knowledge, this article presents the largest series of patients with prolonged air leaks treated with an endobronchial valve.

*Methods:* With Internal Review Board approval, endobronchial valves were compassionately placed using flexible bronchoscopy in patients with prolonged air leaks at 17 international sites.

*Results:* Between December 2002 and January 2007, 40 patients (15 women; mean age ± SD, 60 ± 14 years) were treated with one to nine endobronchial valves per patient. The air leaks had recurrent spontaneous pneumothorax (n = 21), postoperative (n = 7), iatrogenic (n = 6), first-time spontaneous pneumothorax (n = 4), bronchoscopic lung volume reduction (n = 1), and trauma (n = 1) etiologies. Nineteen patients (47.5%) had a complete resolution of the air leak, 18 (45%) had a reduction, 2 had no change, and 1 had no reported outcome. The mean time from valve insertion to chest tube removal was 21 days (median, 7.5 days; interquartile range [IQR], 3 to 29 days) and from valve procedure to hospital discharge was 19 ± 28 days (median, 11 days; IQR, 4 to 27 days).

*Conclusions:* Use of endobronchial valves is an effective, nonsurgical, minimally invasive intervention for patients with prolonged pulmonary air leaks. *(CHEST 2009; 136:355–360)*

Chest 2009;136:355–60

**Abbreviation:** IQR = interquartile range

*John M. Travaline et al.Chest 2009;136:355–60*

# Endobronchial Closure of Bronchopleural Fistulae Using Amplatzer Devices

## Our Experience and Literature Review

*Oren Fruchter, MD; Mordechai R. Kramer, MD; Tamir Dagan, MD; Yael Raviv, MD; Nader Abdel-Rahman, MD; Milton Saute, MD; and Elchanan Bruckheimer, MBBS*

**Bronchopulmonary fistulae (BPFs) are a severe complication of lobectomy and pneumonectomy and are associated with high rates of morbidity and mortality. We have developed a novel, minimally invasive method of central BPF closure using Amplatzer devices (ADs) that were originally designed for the transcatheter closure of cardiac defects. Ten patients with 11 BPFs (eight men and two women, aged 66.3 ± 10.1 years [mean ± SD]) were treated under conscious sedation with bronchoscopic closure of the BPFs using ADs. A nitinol double-disk occluder device was delivered under direct bronchoscopic guidance over a guidewire into the fistula. By extruding a disk on either side of the BPF, the fistula was occluded. Bronchography was performed by injecting contrast medium through the delivery sheath following the procedure to ensure correct device positioning. In nine patients, the procedure was successful and symptoms related to the BPF disappeared following closure by the AD. The results were maintained over a median follow-up period of 9 months. Therefore, we state that endobronchial closure using an AD is a safe and effective method for treatment of a postoperative BPF.**

*CHEST 2011; 139(3):682–687*

# The Amplatzer Atrial Septal Occluder device

# Advantages of amplatzer device

- Occluders can be fully deployed, retrieved, and repositioned prior to detachment – helps in accurate positioning
- Two disks - greater coverage and increases the likelihood of closure, as opposed to the use of glue - applied to the internal aspect alone

# Advantages of amplatzer device

- Large BPFs - not amenable to closure with small devices such as coils or glue
- glue - spill over into the pleural space or into the contralateral bronchi
- Coils - more suitable for small fistulae, do not anchor well in a large central lesion
- conscious sedation - implantation of these devices

# Approach to prolonged to airleaks

Drainage of pneumothorax by chest tube

↓

Large or prolonged air leaks

↓

-Not Surgical candidate
-failure of surgery

↓

Bronchoscopic approach

↓

Localization of air leak – proximal/distal

↓

Proximal – ASD device, silver nitrate
Distal – spigots, EB valves, coils, glue

# Conclusions

- Massive hemoptysis – 300-600 ml
- Bronchial circulation – commonest cause
- Chest CT – initial choice in patients with abnormal CXR and low suspicion of malignancy
- FOB – high suspicion of malignancy and normal CXR

# Conclusions

- Angiographic embolisation in unstable patients
- Rigid bronchoscopy – unsuccesful embolisation, no localisation on angiography, facilities not available for angiography, patients with asphyxiation for immediate maintenance of airway

# Conclusions

- BPF’s - represent a challenging management problem & are associated with an important morbidity
- Numerous non-surgical modalities
- Endobronchial valves, spigots and ASD occlusion devices – used with success