Critical Care Pearls:
Management of Massive Hemoptysis

Definition of massive hemoptysis

- from 200 mL to 1000 mL/24 hrs
- >=600 mL in 24 hrs
- mortality ~7 to 30%
- death results from asphyxiation, rather than exsanguination
- clinical consequences such as degree of aspiration, airway obstruction or hypotension

Degree of bleeding

- measurement of the volume of hemoptysis can be unreliable
  - exaggerated by the patient
  - underrated because the volume of blood engulfing the involved lobes or lungs is not quantitated and may be significant
- the quantity of hemoptysis does not correlate with the seriousness of the etiology

Source of the bleeding

- nasopharynx
- upper GI tract

Excluded

- bronchial arteries (90%) whereas the pulmonary arteries may be the cause in only 5%
- massive hemoptysis accounts for only 1-2% of all hemoptysis

Table 1 Causes of life-threatening haemoptysis

Pulmonary	*Infections*
Bronchietasis, including cystic fibrosis	Mycobacteria, especially tuberculosis
Emphysematous bullae	Fungal, including mycetoma
Tumour	Lung abscess
Bronchogenic carcinoma	Necrotising pneumonia
Bronchial carcinoid	Parasitic
Metastases	*Trauma*
Sarcoma	Blunt or penetrating chest injury
Vascular	Suction induced tracheal ulcers
Airway-vascular fistula	Pulmonary artery rupture
Arteriovenous malformations	Transtracheal procedures
Pulmonary embolism	Bronchoscopy including biopsy
Pulmonary hypertension	*Vasculitis*
Bronchial vascular abnormalities	Goodpasture's syndrome†
Mitral stenosis†	Wegener's granulomatosis†
Left ventricular failure†	Systemic lupus erythematosus†
Haematological†	Bechet's disease
Coagulopathy (congenital & acquired)	*Drugs or Toxins*†
Platelet disorders	Anticoagulants
Miscellaneous	Thrombolytic agents
Broncholithiasis	Penicillamine
Endometriosis	Trimellitic anhyride
Foreign body	Solvents
Lymphangioleiomatosis	Crack cocaine
Idiopathic	

†More commonly manifest as alveolar rather than airway haemorrhage.

Major Hemoptysis in HK

- Retrospective review during 2000 – 2006
- 3006 admissions, involving 2260 patients
- 251 patients have LTH
- mainly due to tuberculosis (active or inactive) and bronchiectasis
- HK ~10% of hospital admission due to hemoptysis is life-threatening

Chan VL, Chu CM et.al
United Christian Hospital, Hong Kong,
Int J Tuberc Lung Dis. 2009 Sep;13(9):1167-73.

Investigation

- Sputum x G/S & C/ST
  AFB smear & C/S
  Cytology
- CBP, clotting profile
- Type & screen
- RFT, urinalysis
- Fungal serology
- Autoimmune markers
- Echo / TEE

CXR

- normal or non-localizing in 20%–45% of patients with hemoptysis
- cavitary lesions, infiltrates, atelectasis, or tumors
- A fine reticulonodular pattern can represent intra-alveolar bleeds or pneumonia

Life-threatening hemoptysis

Airway protection/Lung isolation
+ Identify bleeding source
(CXR / CT / Bronchoscopy)
-correct coagulopathy
-antibiotics

Rigid bronchoscopy

Angiographic Embolisation

Surgery

Management

- resuscitation and protecting the airway
  - Volume resuscitation, blood transfusion & correct coagulopathy
- positioned with the bleeding side down

Lung Isolation

1. Bronchial intubation by ETT

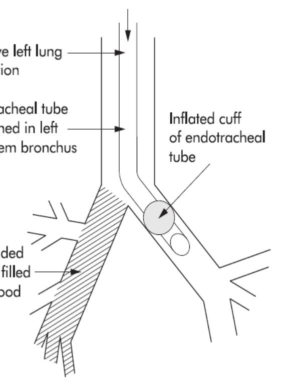


Figure 22.4 Selective intubation of left main bronchus in a case of right sided massive haemoptysis.

Less practical in L-sided bleeding

2. Balloon tamponade

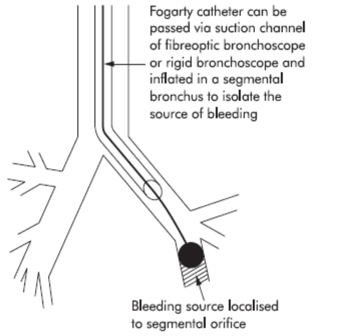


Figure 22.7 Placement of a Fogarty catheter guided by fibreoptic bronchoscopy to control massive bleeding from a segmental bronchus.

4-7 Fr (80 cm long), balloon 0.5-2.0 cc
FOB with a large inner channel (>=2 mm)

2. Balloon tamponade

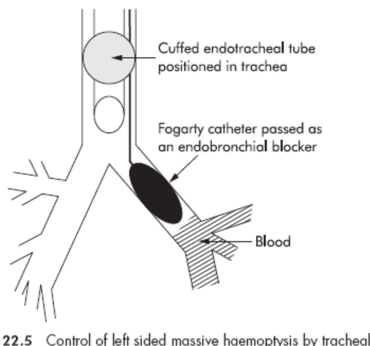


Figure 22.5 Control of left sided massive haemoptysis by tracheal intubation, placement, and inflation of a Fogarty catheter in the left main bronchus.

Adult: 8 to 14 French tube
Children : 3 to 5 French tube
larger catheters used to obstruct the larger, more proximal airways

For left-sided bleeding

- the trachea is intubated over the bronchoscope first with the patient in the left lateral position
- A size Fogarty catheter is passed through the vocal cords beside the endotracheal tube
- balloon is inflated in the left main bronchus

Endobronchial blockers

- balloon catheters
  - Fogarty, Foley or pulmonary artery catheters
  - Fogarty blockers with smaller balloon catheters (0.5 to 3 ml) allow segmental lung isolation
  - the Arndt wire-guided or Cohen flexitip blockers

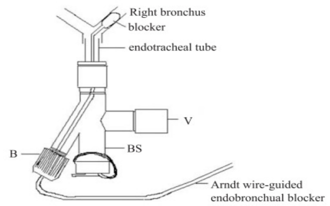


Fig. 1 Illustration of an Arndt wire-guided endobronchial blocker via an endotracheal tube and the special bronchoscopic port with a ventilation port (V), bronchoscopic port (BS), and blocker port (B).

Parallel Technique of Endobronchial Balloon Catheter Tamponade

Fig. 1. A wing with sterile surgical tape is attached to a 5 Fr Swan-Ganz catheter.

Fig. 2. The catheter was grabbed at the oropharyngeal level with biopsy forceps.

Fig. 3. The catheter with biopsy forceps at the bleeding site.

Fig. 4. The balloon situated at the proximal site of bleeding after procedure.

J Korean Med Sci 2002; 17: 823-5

Parallel Technique of Endobronchial Balloon Catheter Tamponade

Avoid using several previous methods

- to cut the cap
- to make a detachable cap
- to use a guide wire

Advantage:

- The suction channel is available during the procedure

Univent blockers

- single-lumen endotracheal tubes with an anterior channel that houses a balloon catheter
- the central lumen of the balloon catheter
  - allows suctioning
  - to give insufflate oxygen into the non-ventilated lung
- bronchial mucosal ischemia, bronchial rupture and pneumothorax are possible side effects because of generating high cuff pressures

Univent blocker advantages over the F.C

- displacement is less likely
- suctioning, pulmonary lavage, oxygen insufflation, and even high-frequency jet ventilation can be provided through the univent tube to the occluded lung.
- if conventional ventilation is desired, the blocker can be deflated and withdrawn without having to reintubate the patient

Problems of endobronchial blockers

- tedious final placement after intubation
  - especially when bronchoscopic visualisation is limited by massive hemoptysis
- cannot be used when the side of the bleeding is unknown
- Dislodgement is more common than in double-lumen tubes
- By blocking up the pathological side, it is impossible to monitor continued bleeding or secretions

Balloon tamponade

- potential risk of ischemic mucosal injury and postobstructive pneumonia

3. Double lumen endotracheal tube

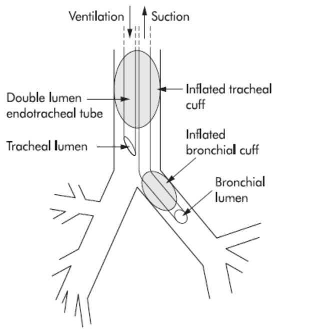


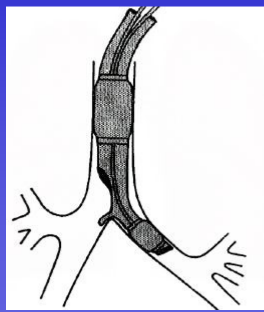
Figure 22.6 Application of a double lumen endotracheal tube for the control of massive haemorrhage. The bronchial lumen is positioned in the left main bronchus to ventilate the left lung and the tracheal lumen is positioned above the carina, allowing ventilation of the right lung while preventing occlusion of the right upper lobe orifice.

Double Lumen ET tubes (DLT) (Carlens & Robertshaw)

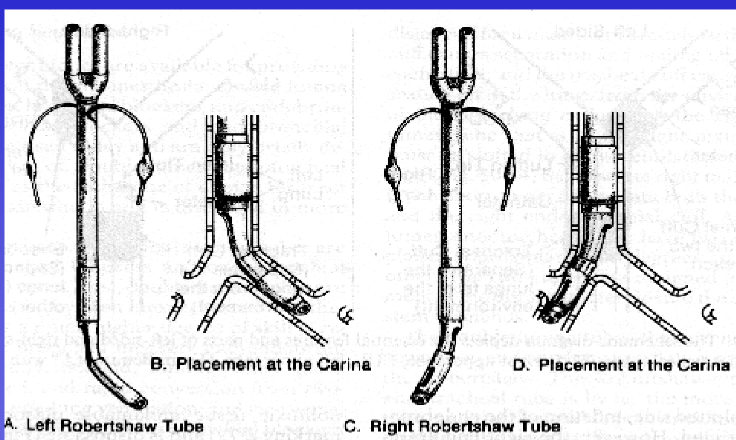
- Most widely used means of achieving lung separation and one-lung ventilation.
- Several different types of DLT,
  - **Carlens** (with carinal hook), 1949
  - **Robertshaw** (without carinal hook)
    - Red Rubber
  - **Bronchocath** PVC (similar to Robertshaw)

Double Lumen ET tubes (Carlens) with Carinal Hook

- Left mainstem endobronchial intubation using a Carlens tube.
- A carinal "hook" used for correct positioning



Double Lumen ET tubes (Robertshaw)



Double Lumen ET tubes (Robertshaw)

- **Lt and Rt-sided forms without a carinal hook, (easier insertion)**
- **D-shaped, large-diameter lumina**
    - **Allow easy suctioning + low resistance to gas flow**
    - **Fixed curvature to facilitate proper positioning + reduce the possibility of kinking.**
- **Original Red rubber tubes three sizes: (S,M,L)**
    - **For our local population size S & M are used**
    - **S for Female, M for Males**

Double Lumen ET tubes (Robertshaw PVC = Broncho-Cath

- **Disposable**
- **Sizes**
    - **French sizes 35, 37, 39, and 41.**
    - **Size 28 for pediatric cases.**
- **Design**
    - **The right-sided endobronchial tube is designed to minimize occlusion of the right upper lobe.**
        - **The right endobronchial cuff is doughnut shaped and allows the right upper lobe ventilation slot to ride over the right upper lobe orifice.**

DLT main features

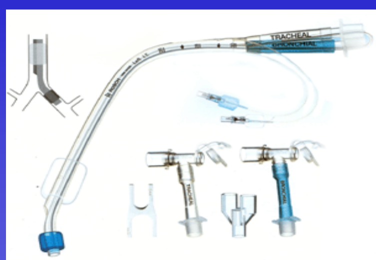
2 Sides: Right & Left

For right-sided DLT :

- additional ventilation slot at bronchial cuff
- for ventilating the RUL (because the right mainstem bronchus is too short to accommodate both the right lumen tip and a right bronchial cuff)

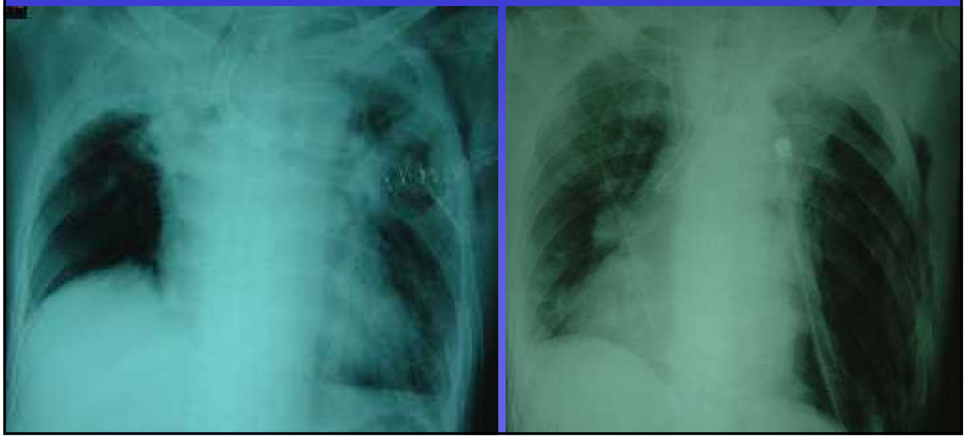
DLT main features (1)

- two catheters are bonded together
  - 2 Curves: Oropharyngeal, bronchial;
  - 2 Lumens
    - Bronchial lumen is long enough to reach a mainstem bronchus.
    - Tracheal lumen ends with an opening in the trachea.



DLT main features

- 2 Cuffs :bronchial (1-3mls) & tracheal (20ml)
  - Lung separation is achieved by inflation of two cuffs, the proximal tracheal cuff and the distal bronchial cuff located in the mainstem bronchus.



Original Red rubber vs Clear, PVC (Bronchocath)

Original Red rubber

1. Reusable tubes
2. Less cost
3. Although the red rubber tubes may be more difficult to insert, they are less likely to dislocate during patient positioning and surgical manipulation.
4. Durable tracheal cuff rubs against the patient's upper teeth if these teeth are prominent and sharp, as compared with the thicker-walled cuffs of the red rubber tubes.
5. Can withstand repeated sterilization.

Clear, PVC (Bronchocath)

1. Disposable
2. More Expensive
3. Easy to insert, positioning and to dislocate.
4. the thin-walled tracheal cuffs of the disposable tubes are much more likely to tear
5. If Wrong size of tube is used (insertion is attempted) - tube cannot be reused because sterility is compromised

Original Red rubber vs Clear, PVC (Bronchocath)

5. No color differentiation of endobronchial cuffs
6. Radiolucent, no radioopaque line.
7. Red/yellow color tube – gas exchange not visible.
8. Foreign body reaction not suitable for long term used.

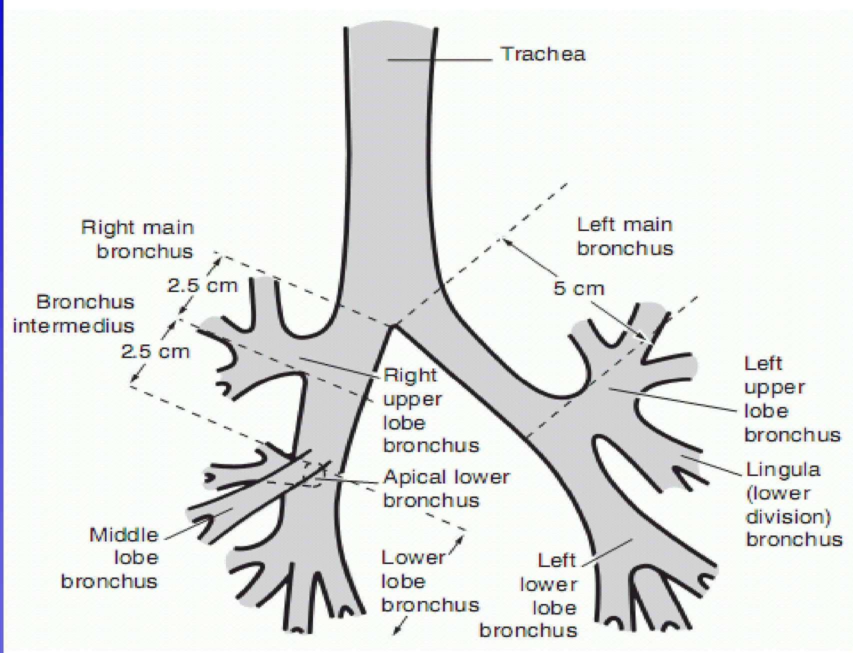
5. easy recognition of the blue colored endobronchial cuff when FOB is used.
6. confirmation of position on CXR (radioopaque lines)
7. Clear PVC easy for cont observation of tidal gas exchange and of respiratory moisture.
8. Suitable for use in long-term ventilation in the intensive care unit (a high-volume low-pressure cuff.)

Original Red rubber vs Clear, PVC (Bronchocath)

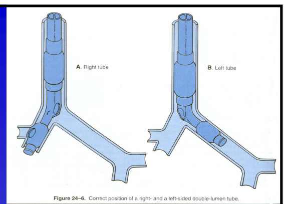
9. R &L ; L, M, S ,XS
10. Slot in bronchial cuff (21 mm large tube), more likely to be opposite to RUL orifice
11. Only allow to use paediatric FOB

9. R & L; 35-41F, 28F
10. Right upper lobe ventilation slot only 11 mm in 41-French
11. Malleable plastic tubes, easier to use anaesthetic FOB

Bronchocath is the choice nowadays for lung separation and ILV in ICU setting



Choices of DLT



- Left Sided – mostly used
  - Because of problems with proper positioning of Right-sided DLT in ensuring that Rt upper lobe is well ventilated (more difficult)
- Left Sided DLT contraindicated only if;
  - Left main bronchus stenosed, distorted or infiltrated by tumour.

Sizing

- Adequate functional lungs separation
- establish optimum access for suctioning and bronchoscopy
- prevent migration of the tube and consequent herniation of the bronchial cuff into the carina.
- oversized tubes can cause excessive tracheobronchial trauma and are difficult to insert

DLT sizes (Broncho-Cath™)

- Size ranges from 28-41 Fr.
  - based on the patients height
- 37 Fr for women
- 39 Fr for men
- Patient height/ Tube size/ Depth of insertion
  - 136-164 cm / 37 Fr / 27cm
  - 165-179 cm / 39 Fr / 29cm
  - 180-194 cm / 41 Fr / 31cm

Table 10.5 Recommendations for size and length of left double-lumen tube. (Adapted from Brodsky et al. 1991, 1996.)

Length of tube

Male/females 170 cm tall: insert tube to a depth of 29 cm

For every 10 cm increase in height, increase depth of insertion by 1 cm

Size of tube from measured tracheal width

Width of trachea (mm)	Tube size (French gauge)
18	41
16	39
15	37
14	35

The above lengths and sizes are not necessarily applicable to right-sided tubes.

Size of DLT

Sizing polyvinyl chloride double-lumen tubes [63]

Tube size (F)	Circumference (mm)	Lumen diameter (mm)	Indication
35	38.0	5.0	Pediatrics
37	40.0	5.5	Small adults
39	44.0	6.0	Medium adults, usual female size
41	45.0	6.5	Large adults, usual male size

- Too Small
  - fail to provide adequate lung isolation
  - will require large endobronchial volume or pressure that could damage the bronchus
- Too LARGE
  - can rupture the trachea or bronchus
- Minimal leaking technique
  - the bronchial cuff should be inflated to the minimal volume that provide lung isolation

Positioning of DLT

Steps for insertion

A. Preliminary steps;

- prepare and check tube
- lubricate tube
- Established patient monitors.
- Pre Oxygenate patient for 3 – 5 minutes
- Induce with I/v miadazolam /fentanyl/scoline

Positioning of DLT

Steps for insertion

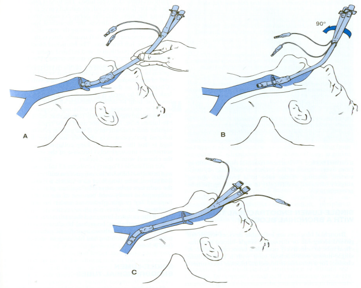


Figure 24–7. Placement of a left-sided double-lumen tube. Note that the tube is turned 90 degrees as soon as it enters the larynx. *A:* Initial position. *B:* Rotated 90 degrees. *C:* Final position.

B. Intubation;

1. Laryngoscopy is performed once pt is adequately anesthesized.
2. insert tube with distal concave curvature tip facing anteriorly.
3. remove stylet once through the vocal cords
4. rotate tube 90 degrees (in direction of desired lung)
5. advancement of tube ceases when resistance is encountered. Average lip line is 29 $\pm$ 2 cm.

Positioning of DLT

Steps for insertion

B. Intubation;

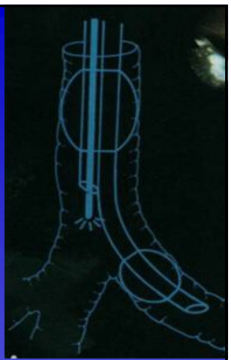
6. If a carinal hook is present (Carlens DLT), must watch hook go through cords to avoid trauma to them.

   Insert tube with distal concave curvature facing anteriorly, and remove stylet once through the vocal cords. (As step 2 – 3)
7. Then in step 4, rotate 180 degrees (so distal concavity faces posteriorly and hook is anterior). Once hook is past cords, rotate so that distal concavity is pointed right or left as desired.
8. Connect to the breathing circuits.

Position confirmation

- Height may be poorly correlated with tracheobronchial dimensions (r< 0.25)
- Chest X-rays
- Auscultation
  - following sequential clamping
  - result in incorrect positioning in ~40% of cases
- Bronchoscopic confirmation

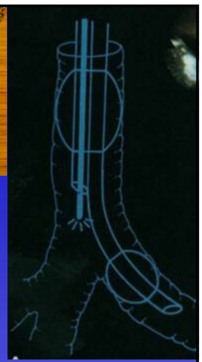
Placement checking by auscultation



1. Inflate tracheal cuff (high volume, low-pressure, capacity 20 mL max)- expect equal lung ventilation (same as regular ETT).
   - Both lungs should expands and BS should equal bilaterally. This indicates the DLT is in the trachea not in esophagus
   - If BBS not equal, probably too far down (tracheal lumen opening is at carina or even endobronchial). Withdrawal by 2-3 cm fixes this.

2. Inflate bronchial cuff and ventilate.
   - Both lungs should expand & BS should equal bilaterally
   - This indicate the bronchial cuff is not over inflated to such an extent to occlude the bronchial lumen.

Placement checking by Auscultation



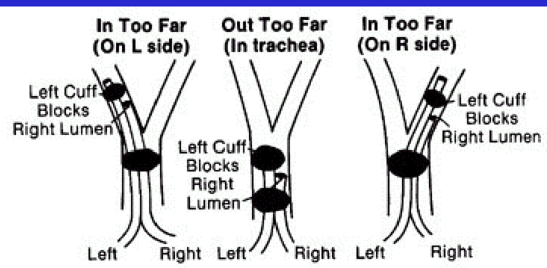
3. Disconnect (remove the cap) the tracheal tube (Rt tube of Lt DLT) and clamp the right side
   - Only the left lung should expand
   - Listen to the disconnected tube to detect air leak

4. Disconnect (remove the cap) the bronchial tube (left tube in the Lt. Sided DLT) & Clamp the Left Side.
   - Only the right lung should expand.

Note if lung isolation needs to be achieved urgently to prevent soiling of the unaffected lung (eg. Empyema or Bleeding into the lung) the Bronchial cuff should be inflated FIRST before the above steps are taken.

Placement checking of DLT

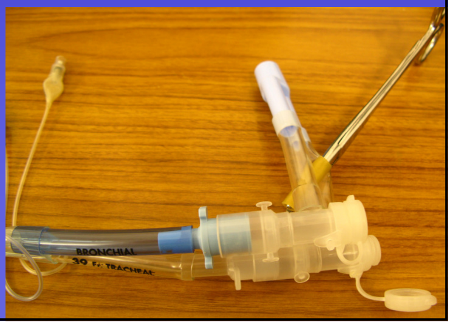
Cuff inflation and sequential clamp; by auscultation



Normal	Procedure	Breath Sounds Heard		
left	Clamp Right Lumen Both Cuffs Inflated	Left	Left and Right	Right
right	Clamp Left Lumen Both Cuffs Inflated	None or Very ↓↓	None or Very ↓↓	None or Very ↓↓
Left & right	Clamp Left Lumen Deflate Left Cuff	Left	Left and Right	Right

Minimal Leaking Technique

1. Inflate tracheal cuff (high volume, low-pressure, capacity 20 mL max)- expect equal lung ventilation (same as regular ETT). If BBS not equal, probably too far down (tracheal lumen opening is at carina or even endobronchial). Withdrawal by 2-3 cm fixes this.
2. Clamp the right side (marked "tracheal" for left-sided tube) and remove cap from the right connector. Expect some left sided ventilation through bronchial lumen, and some air leak past bronchial cuff, which is not yet inflated.



Minimal Leaking Technique

3. Slowly inflate bronchial cuff until minimal or no leak is heard at uncapped right connector. Go slow - it only requires 1-3 cc of gas and bronchial rupture is a risk
4. Remove the clamp and replace the cap on the right. Check that both lungs are ventilated. This ensures that the bronchial cuff is not partially or completely obstructing the contralateral hemithorax.
5. Selectively clamp each side, and expect visible chest movement and and audible breath sounds only on the right when left is clamped, and vice versa.

DLT malposition

1. The bronchial lumen enters the wrong side
   Consequences:
   - wrong lung collapse,
   - inadequate separation,
   - increased PIP,
   - instability of the DLT,
   - tracheal or bronchial laceration,
   - obstruction of RUL bronchus by left-sided tube bronchial cuff.
2. Too far down
   - BS will not be heard on contralateral side since tracheal lumen may be endobronchial.

DLT malposition (cont)

3. Too shallow.
   - BS good bilateral through bronchial lumen, inaudible through tracheal lumen (inflated bronchial cuff obstructs gas flow through tracheal lumen).
   - Deflate cuff(s) and rotate/advance bronchial tube into desired side.

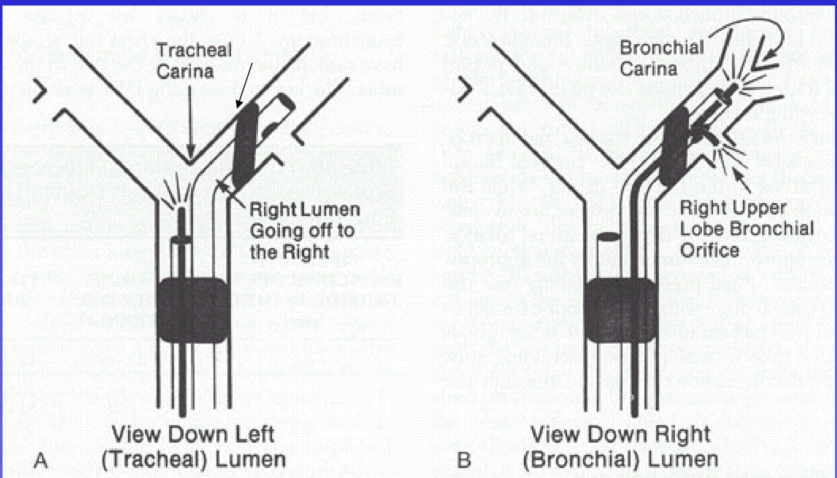
4. R sided tube may obstruct RUL bronchus.

DLT malposition (con't 2)

5. LUL bronchus may occasionally be obstructed by L DLT bronchial cuff
6. Bronchial cuff herniation may obstruct ventilation on its own side, or herniate over the carina and obstruct contralateral ventilation
7. Rare complication is
   - Tracheal rupture
     - use minimal-leak technique to inflate tracheal cuff
   - Bronchial rupture

Placement checking of Rt-DLT

Checking tube placement with fiberoptic bronchoscope



Placement checking of DLT

Checking tube placement with the fiberoptic bronchoscope

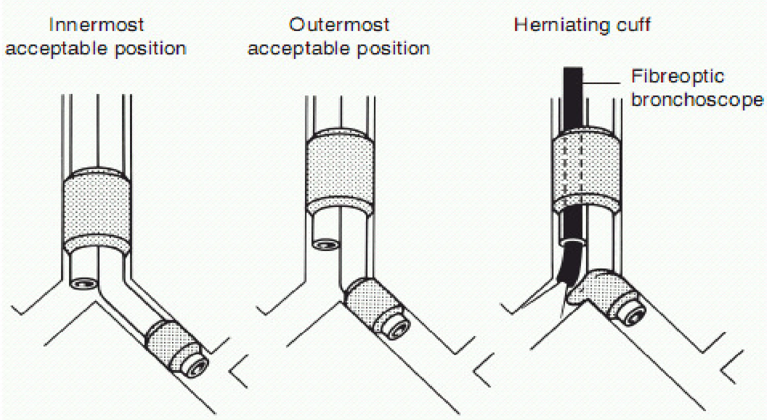
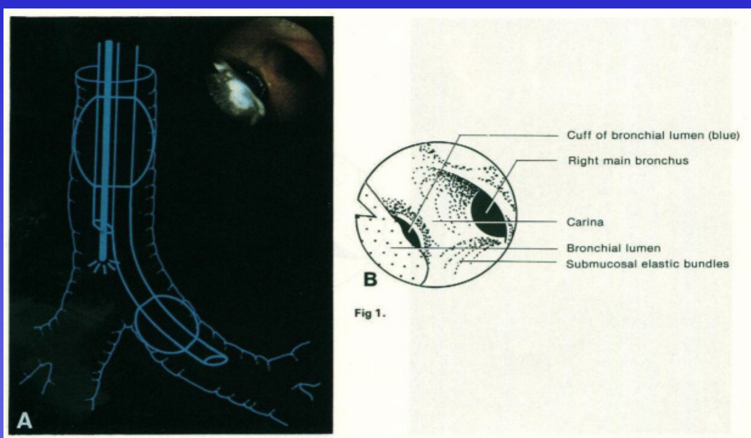


Figure 10.4 Left-sided double-lumen tube position. (After Aitkenhead AR, Jones RM. Clinical Anaesthesia. Edinburgh: Churchill Livingstone; 1996, with permission.)

Tracheal lumen view: Good placement



Tracheal lumen view: too proximal

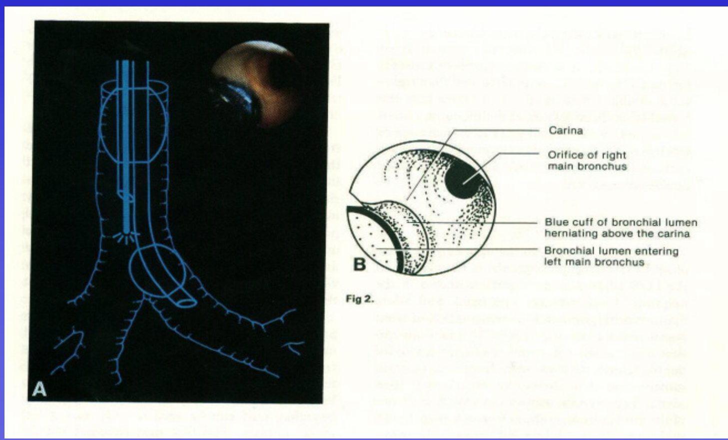


Fig 2.

Bronchial lumen view: good placement

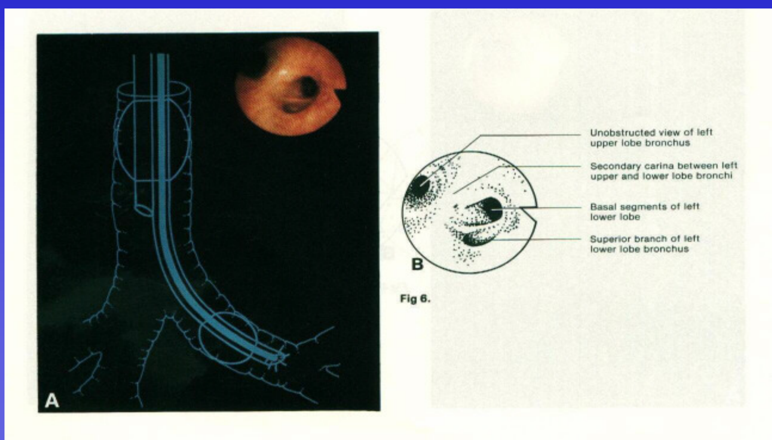
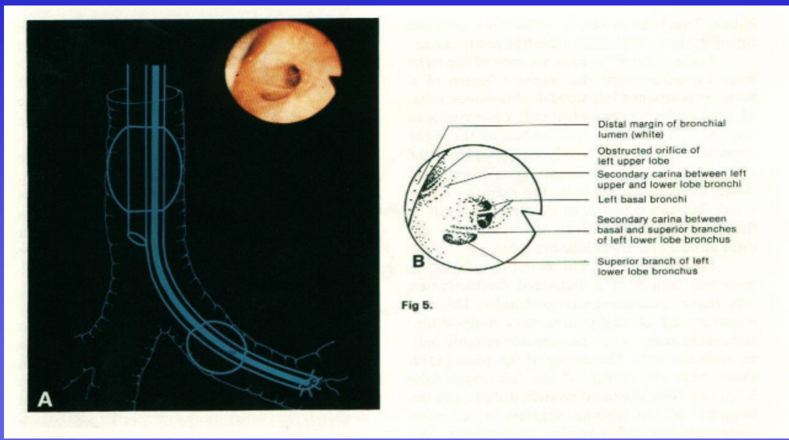


Fig 6.

Bronchial lumen view: too distal



After Position Checking & Confirmation by FOB

- Movement as small as 16 to 19 mm with left-sided tubes and 1 to 8 mm with right-sided tubes can cause malposition and inadequate ventilation
- Sedation
- The DLT is anchored and securely tapes.
- Recheck by means of auscultation and /or FOB after positioning patient laterally.

Fiberoptic bronchoscopy in DLC

- A standard 4.9-mm outside diameter bronchoscope will pass through the lumens of 39 and 41 French tubes with adequate lubrication and can be utilized to assess tube placement in most adult patients
- a pediatric bronchoscope (3.6- to 4.2-mm outside diameter) is needed to pass through the lumens of 37 French

Complications of double-lumen tubes

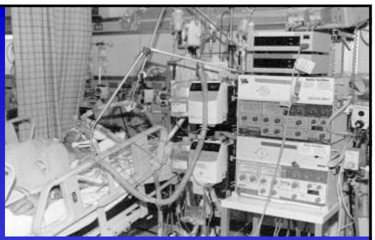
- Malposition
- Traumatic laryngitis
- Tracheobronchial tree disruption especially overinflated bronchial cuff

ILV

- can be life saving in massive hemoptysis until definitive therapy like surgery, embolotherapy or interventional bronchoscopy can be instituted
- When the site of bleeding is unknown, double-lumen tubes should be used instead of endobronchial blockers

ILV

1. CPAP to each limb of the DLT with spontaneous ventilation
2. Differential ventilation and PEEP applied with a single ventilator and a flow divider
3. Independent ventilation with two synchronized ventilators
4. Ventilation with two independent asynchronous ventilators
5. A combination of different modalities



Synchronous ILV

- either one or two ventilator circuits
- identical respiratory rate of both lungs
- but, the respiratory cycle can either be in phase or 180 degrees out of phase.
- Selective PEEP can also be added to either lung
- tidal volumes and inspiratory flow rates are set independently
- Using two Servo 900 ventilators, a ‘master’ and a ‘slave’ ventilator are synchronised using an external cable.
- A one-ventilator system employs a Y-piece with separate PEEP valves, the airflow and tidal volume to each lung is then determined by the individual lung compliance and airway resistance.

Asynchronous ILV

- Using two ventilators
- greater flexibility, less complicated
- well tolerated
- no proven disadvantage compared to synchronized ILV
  - The potential for decreased venous return, increased PVR, & decreased CO exists when the lungs are being randomly ventilated, particularly when the two systems are out of phase.
  - Although PAP & PAWP were noted to be difficult to interpret, CO determinations and systemic pressures were stable when compared with values obtained before AILV.
  - Experimental study confirmed no significant difference in gas exchange or hemodynamic measurements when synchronous and AILV were compared in an animal model of acute ULD

Localisation of bleeding site

Flexible fiberoptic bronchoscopy

- ETT >8mm ID
- Allow supporting oxygenation and ventilation while allowing passage of the bronchoscope through the ET tube
- to visualize the origin of bleeding
- to control bleeding

PROS:
- safe
- bedside procedure
- without GA
- can evaluate bleeding down to the fifth or sixth bronchial orifice
- to obtain specimens by biopsy, washing, and brushing to aid in bacteriologic, histologic, and cytologic evaluations

CONS:
- suctioning abilities inferior to the larger diameter rigid scope.

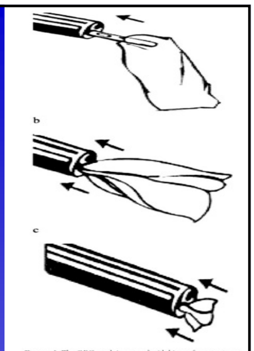
FOB : control bleeding

- endobronchial wedging technique
- endobronchial balloon tamponade
  - Heibert CA. Balloon catheter control of life threatening hemoptysis. Chest 1974;66:308–9
- topical instillation of vasoactive agents
  - epinephrine (1 : 20000 dilution)
  - iced saline lavage
  - Thrombin, thrombin-fibrinogen-thrombin, fibrin glue
- oxidized regenerated cellulose (surgicel) mesh
  - Chest 2005;127;2113-2118
- precision laser photocoagulation

Bronchoscopy-Guided Topical Hemostatic Tamponade Therapy - Oxidized regenerated cellulose mesh

- in 57 patients (13 TB patients) with persistent endobronchial bleeding
- Immediate arrest of haemoptysis was obtained in 56 of 57 patients (98%)
- all remaining free of haemoptysis for the first 48h
- recurred in six patients (10.5%) between 3 and 6 days after the procedure
- postobstructive pneumonia developed in five patients
- the material used was absorbed in all of these patients without significant signs of visible foreign body reaction on follow-up bronchoscopy 4 weeks later

Chest 2005;127;2113-2118



Rigid Bronchoscopy

- larger diameter tube
- greater suctioning capability
- reliably maintains a patent airway
- commonly requires general anesthesia, although conscious sedation can be used.
- limited use in accessing the upper lobes or peripheral airways; therefore, sites of bleeding expected in these areas of the lungs are better evaluated with a flexible bronchoscope or angiographic technique.

Timing of bronchoscopy

- Controversial
- Early:
  - high rate to localise bleeding
- Delay (> 48hr after admission):
  - preferred in stable patients

Massive hemoptysis (N=80)

	Site of bleeding	*Cause*
CXR	46%	35%
CT	70%	77%
FOB	73%	8%

Revel MP, Fournier LS, Hennebicque AS, et al: Can CT replace bronchoscopy in the detection of the site and cause of bleeding in patients with large or massive hemoptysis? *Am J Roentgenol* 2002; 179:1217-1224

Computed Tomography

- Except for life-threatening condition, CT should be performed before bronchoscopy
- ~5 - 30% remained non-diagnostic among patients with hemopysis

FOB or CT

- Complimentary
- Stable : CT
- Unstable : bronchoscopy

FOB before BAE ?

N= 28 patients,

- bleeding site determined through bronchoscopy was consistent with that determined through radiographs in 23 patients (82%)
- bronchoscopic findings were indeterminate in 7%
- May not be necessary if the aetiology of haemoptysis is known, the site of bleeding can be determined from radiographs, and no bronchoscopic airway management is needed

Hsiao EI, Kirsch CM, Kagawa FT, et al: Utility of fiberoptic bronchoscopy before bronchial artery embolization for massive hemoptysis.
Am J Roentgenol 2001; 177:861-867

Angiography + embolisation

In stable patients, multiple imaging modalities (CXR, CT, bronchoscopy)

- to confirm the diagnosis
- to locate the bleeding site
- with a variable success rate of 17 to 93%.

In unstable patients, diagnostic angiography for localizing the bleeding site because it allows for immediate institution of treatment

Indications for BAE

- Unresectable tumor
- postradiation-treated lung
- bilateral lung parenchymal diseases
- recurrent hemoptysis after surgery
- any other refractory massive hemoptysis

Steps of transcatheter embolization

1. Thoracic aortogram:

- to visualize and localize all the main systemic arteries to the lung(s).
- these arteries may be bronchial or nonbronchial/systemic. (including the bronchial arteries, internal thoracic artery, external thoracic artery, periscapular artery, cervical artery, intercostal artery, and inferior phrenic artery)

2 Once the feeding arteries are localized, selective bronchial arteriography is performed to characterize the bleeding vessels.

Common characteristic:

(1) dilatation and tortuosity of the course of the peribleeding vessels,

(2) marked hypervascularity

(3) active contrast extravasation

3.An embolic is used

polyvinyl alcohol (PVA) particles, Gelfoam and/or dextran microspheres

4.Postembolization bronchial arteriogram and thoracic aortogram are performed

to ensure a complete blockage of all the feeding arteries with no further bleeding from the vessels.

Studies on BAE

Authors	N	Underlying Disease	Success Rate (%)	Recurrence Rate (%)	Embolic Agent
Fernando et al	26	Various (malignancy 35.5%)	85	27	PVA, Gelfoam, or Hilal coils
Barben et al	38	Cystic fibrosis	95	29	PVA
Bustamante et al	37	TB/Bronchiectasis	92	37	Microspheres
Cohen et al	20	Cystic fibrosis	95	40	PVA + Gelfoam
Corr	70	TB, PNA	90	13	Microspheres
Cremaschi et al	209	Various Bronchiectasis 46%	98	13	PVA + Gelfoam
Kato et al	101	Benign pulmonary diseases	94	32	PVA + Gelfoam
Mal et al	56	TB/Bronchiectasis	77	43	Gelfoam, microsphere, PVA, bucrylate
Park et al	19	Malignancy	79	33	PVA
Uflacker et al	33	TB	81.8	18	Gelfoam, Absolute ethanol

control rates 77-95%

recurrence rate 13-43%

Semin Respir Crit Care Med 2008;29:395–404

Recurrence

- immediate recurrence
  - often occurs due to imcomplete embolisation
- later recurrence
  - collateralization or recanalization of either the feeding artery or new bleeding vessels

Recurrence after BAE in HK

N=251, UCH in HK

- immediate success rate of 95.7%
- 5-year recurrence rate of 45.0%
- Recurrent life-threatening haemoptysis was independently associated with
  1. past history of haemoptysis (P = 0.024)
  2. presence of broncho-pulmonary shunt (P = 0.013)
  3. incomplete embolisation (P = 0.002).

Int J Tuberc Lung Dis. 2009 Sep;13(9):1167-73.
Major haemoptysis in Hong Kong: aetiologies, angiographic findings and outcomes of bronchial artery embolisation.

Recurrence after BAE

Italy study, N=88, FU 8d-102m

- chronic lung disease , especially to pulmonary tuberculosis or mycetoma
- systemic-pulmonary shunts
- history of massive haemoptysis

Radiol Med. 2003 Jan-Feb;105(1-2):48-55.
Indicators predictive of success of embolisation: analysis of 88 patients with haemoptysis

Recurrence of hemoptysis in mycetoma

- BAE is usually unsuccessful
- Contributions from the non-bronchial systemic arterial system involved in abnormal vascular connections and cannot be targeted
- Collateral vascular channels from the pulmonary and systemic circulation may supply enough blood flow to the involved area in which haemoptysis often recurs;
- Re-embolization will not be successful.

- Patients with mycetoma were at risk of
  - technical failure of BAE (4/15; 27%)
  - early recurrence after BAE (7/25; 28%)

Fartoukh M et al. An integrated approach to diagnosis and management of severe haemoptysis in patients admitted to the intensive care unit. Resp. 2007

Complication of BAE

- immediate complication rate of less than 1%
- most frequently observed complications are postembolization syndrome (leukocytosis, fever, atelectasis, pleural effusion,or pleuritic pain)
- bronchial wall or esophageal wall necrosis
- embolization of nonfeeder/bleeding vessels
  - the coronary arteries, resulting in chest pain and ACS
  - spinal arteries causing spinal cord ischemia

Surgery

Surgery

- Until 3 decades ago, Rx of choice once bleeding site was localised.
- During acute life-threatening hemoptysis, there is a 20%–40% operative mortality (within 7days of OT)
- Morbidity 25-50%

Surgery

Indication

- when BAE is unavailable
- bleeding is unlikely to be controlled by embolisation
- leaking aortic aneurysm,
- selected cases of arteriovenous malformations, hydatid cyst, iatrogenic pulmonary rupture, chest injuries, bronchial adenoma, or haemoptysis related to mycetoma resistant to other treatments

A patient with PA catheter

- Pulmonary artery rupture
  - May be temporarily controlled by withdrawing the catheter slightly
  - and reinflating the balloon to compress the bleeding vessel more proximally
  - surgical resection of the bleeding vessel is the definitive management

A patient with tracheostomy

- development of a tracheal-arterial fistula, usually the innominate artery
- prompt application of anterior and downward pressure on the tracheal cannula and overinflation of the tracheostomy balloon may help to tamponade the bleeding vessel
- immediate surgical review should be requested
- Deflation of the tracheostomy balloon and removal of the tracheal cannula should be performed in a controlled environment

Surgical Rx: not an option

(i) it is not therapeutic;

(ii) it is not feasible because of poor lung function or bilateral pulmonary diseases

or inoperable carcinoma

(iii) patients decline surgery

(iv) patients of other comorbidities

Table 4. Comparison of Characteristics and Preoperative Factors, and Therapeutic Outcomes in Patients Treated for Life-Threatening Haemoptysis Between Former (1995–1999) and Recent (2000–2005) Therapeutic Strategies

Characteristics/Variable	1995–1999 (n = 49)	2000–2005 (n = 71)	p Value
Age (years)	57.9 ± 14.1	62.2 ± 23.5	0.8
Etiology			
Active tuberculosis	17	34	
Bronchiectasis	31	14	
Lung cancer	2	4	
Others	4	10	
Cardiovascular diseases (Yes/No)	15/34	36/35	0.1
Diabetes mellitus (Yes/No)	12/37	29/42	0.4
Hemoglobin < 10 g/dl (Yes/No)	22/27	39/32	0.1
Preop. Blood transfusion (Yes/No)	20/29	25/46	0.6

Type of Management	1995–1999 (n = 49)	2000–2005 (n = 71)
Surgery	27	16
Pneumonectomy	2	1
Bilobectomy	4	0
Lobectomy	21	14
Wedge resection	0	1
Rigid bronchoscopy prior to surgery	3 (11%)	12 (75%)
In-hospital mortality after surgery	4 (15%)	0
Surgical morbidity	8 (30%)	3 (18%)
BA embolization (BAE)/angiography	21/26	55/62
Immediate success of BAE (cease of haemoptysis)	15/21 (71%)	48/55 (88%)

BA = bronchial artery; BAE = bronchial artery embolization.

Table 1. Characteristics of Patients Undergoing Bronchial Artery Embolization (BAE) for Life-Threatening Haemoptysis From 2000 to 2005

Age	59 ± 13
Sex ratio (M:F)	52:10
Underlying diseases	
Old tuberculosis	34
Bronchiectasis	14
Mycetoma	5
Lung cancer	4
Necrotizing pneumonia	4
Arterio-venous malformation	1

Table 2. Outcomes of Bronchial Artery Embolization (BAE) for Life-Threatening Haemoptysis Under Recent Therapeutic Strategy (2000–2005)

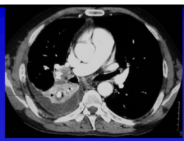
Control of Haemoptysis	
Technical success	48/55 (88%)
Control within 48 hours	45/55 (81%)
30-day Control	38/50 (76%)
180-day Control	31/42 (72%)
1-year Control	28/40 (70%)
Proceeded to surgery after BAE	7/55 (13%)
Died after 30 days	14/55 (25%)
Lost to follow up after 1 year	15/55 (27%)

Shigemura et al. Multidisplinary care for massive hemoptysis
Ann Thorac Surg 2009;87:849 –53

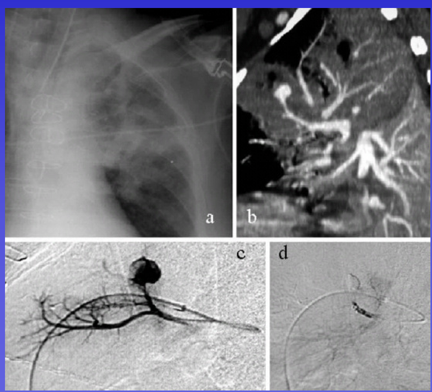
Pearls

1. ABC
2. Skills on lung isolation
3. Angiographic embolisation: excellent immediate control, semi-definitive Rx
4. Surgery: definitive, but high m/m; important to arrest bleeding with a non-surgical modality and stabilise the patient first, if possible, before a definitive surgical procedure
5. Understand merits and limitations of each modality, to make a rational clinical decision during Dx and Rx

Rasmussen aneurysm



- hemoptysis occurs in a patient with cavitary tuberculosis
- relapse of hemoptysis is observed after a technically good embolization by BAE
- in a few cases Rasmussen aneurysm, which results from the destruction of the media of segmental pulmonary arteries by granulation tissue



Arteriovenous malformation

- Hereditary hemorrgaic telangiectasia
- Rendu-Weber-Osler syndrome
- Simple (85%) or complex
- Congenital 75-95%;
- Acquired 10% such as hepatopulmonary syndrome
- Hemoptysis (ruptured of aneurysmal sac),
  Stroke (paradoxical embolism), or severe respiratory compromise (shunting)
- Currently, if the feeder vessel has an angiographic diameter greater than 3 mm, selective *pulmonary* artery embolization is considered