Tracheal stenosis management by stenting

Arda Kiani MD.
Associate Professor at Shahid Beheshti University of Medical Sciences,Massih Daneshvari Hospital

fppt.com

- surface area of normal glottic aperture ≥50% of the normal tracheal diameter.
- A significant decrease in pressure is typically observed at 75%, 85%, and 90% stenosis.
- At these thresholds, there is an increased work of breathing

fppt.com

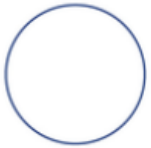
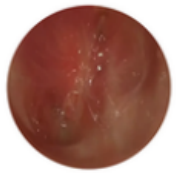
Severity of stenosis:

is divided it into three grades:

- Mild (,70%)
- Moderate (71–90%)
- Severe (.90%)

fppt.com

Myer-Cotton classification

Classification	From	To	Endoscopic appearance
Grade I	 No Obstruction	 50% Obstruction	
Grade II	 51%	 70%	
Grade III	 71%	 99%	
Grade IV	No detectable lumen		

fppt.com

Types of stenosis

- Structural
- Dynamic or Functional

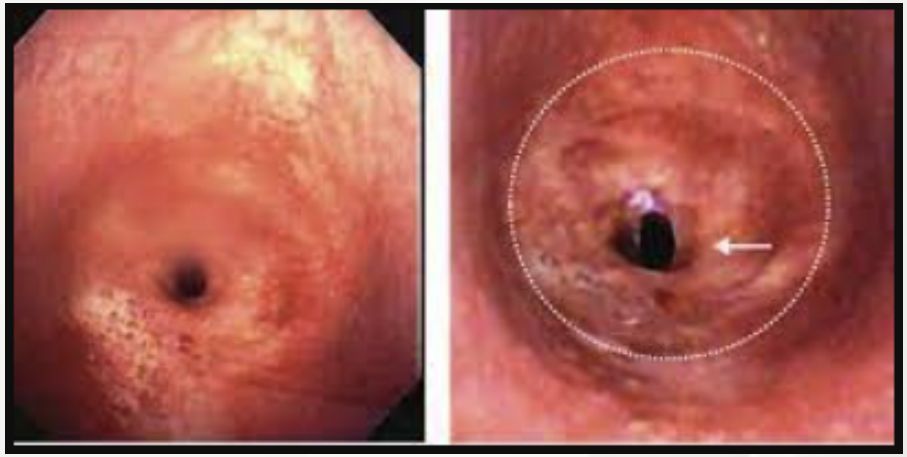
TABLE 1 Stenosis groupings

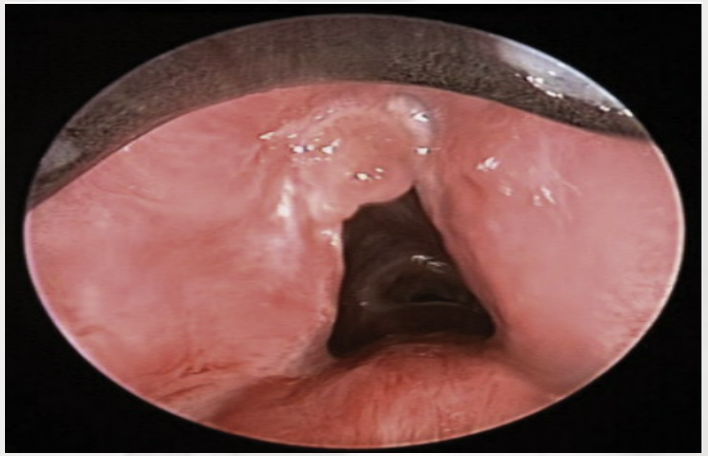
Stenosis	Type	Character
Structural	1	Exophytic/intraluminal
	2	Extrinsic
	3	Distortion
	4	Scar/stricture
Dynamic or functional	1	Damaged cartilage/malacia
	2	Floppy membrane

fppt.com

Morphology of the stricture

for the same degree of airway narrowing, a triangular stricture is less symptomatic than a circumferential stricture





fppt.com

Physiological Rationale for Airway Stenting

In airway stenosis, dyspnea depends on the work of breathing, which is directly related to the amount of pressure drop along the stenosis.

This pressure drop depends on:

the degree of stenosis (i.e., radius)

the flow velocity across the narrowing, which accounts for differences in symptoms among patients with similar degrees of airway narrowing.

This is because flow velocity depends on level of activity. Thus, it is imperative to assess functional status when determining if airway stenting is justified. Functional status and dyspnea scales may actually be more applicable than static lung function measurements, which have a weak correlation with dyspnea scales in laryngotracheal stenosis [21].

fppt.com

Ideal airway stent:

- Easy to place and remove
- Large enough to maintain position
- as congruent as possible to avoid granulation tissue reactions
- Flexible enough to mimic airway physiology but have sufficient radial force to resist airway compression
- Not impair mucociliary clearance

fppt.com

Types of stents:(due to material used)

- Rubber and silicone:
  - Montgomery T-Tube
  - Dumon stent
- Metal and alloys:
  - SEMS
  - Nitinol
- Hybrid:
  - Frietag(Dynamic stent)

fppt.com

Examples of airway stents:

(A) Hood stent, (B) Nova-Stent,(C) Polyflex, (D) Dumon bronchialstent, (E) Dumon hourglass trachealstent, (F) Silmet stent, (G) DynamicFreitag stent and (H, I) patient-specific stents (both post-transplantstenoses of right (H) and left(I) anastomoses)

fppt.com

Silicone stents:

Advantages:

- Easy to place and remove
- Well tolerated
- Offer a marked vault effect
- Cause less granulation tissue reaction
- Possibility of on-site customization based on bronchoscopic and CT measurements

fppt.com

Continued...

Disadvantage:

compared to SEMS is a narrower internal diameter that can result in mucus plugging which can lead to bacterial colonization.This pitfall can however be balanced with the possibility for on-site customization to limit the covered surface to the stenotic area and thus favour mucus clearance

fppt.com

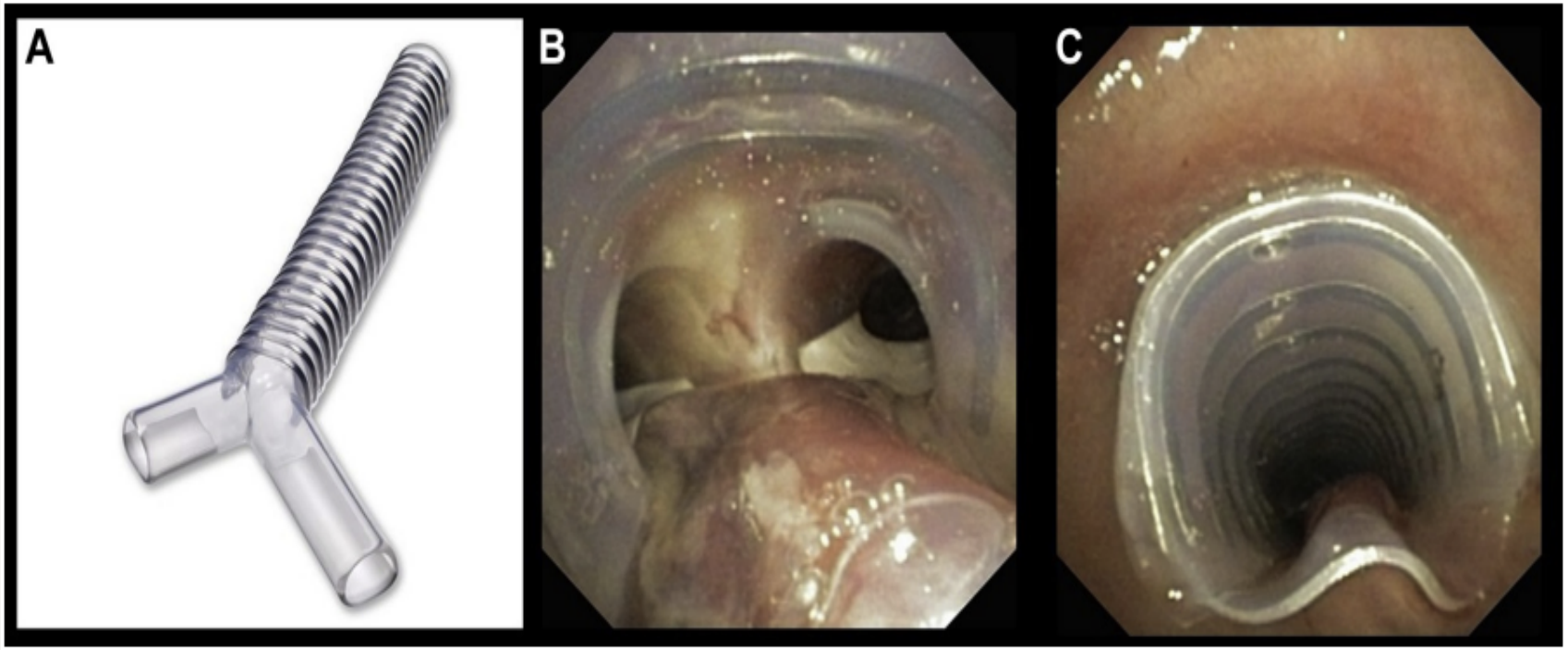
Dynamic stent:

(Freitag; Rüsch, Kernen, Germany)

has a flexible thin posterior wall that mimics the tracheal behaviour during cough, resulting in theory in a lower risk of granulation reaction because of a more homogeneous distribution of pressures

fppt.com

Dynamic stent:



fppt.com

Self-expandable metallic stents

particularly suitable for:

- tight and distorted stenoses,
- tracheoesophageal fistulas (TEF)
- highly necrotic stenoses,as they avoid the need to pass over the stenosis with a rigid tube(which increases the risk of perforation).

fppt.com

Continued...

Advantages:

- Lower risk of migration (for partially covered devices due to the granulation reaction at the non-covered extremities),
- Better preserved clearance
- Larger internal diameter.
- Easy to place, do not require skills in rigid bronchoscopy
- Immediate success, in particular in malignant situations, where they quickly improve dyspnea, quality of life and respiratory function.

fppt.com

Continued...

major limitations,including:

- Higher risk of granulation tissue reaction(particularly partially covered SEMS);
- Neo-epithelialization with incorporation into the mucosa resulting in the stent being highly difficult to remove after3–6 weeks (especially partially covered devices);
- Weaker vault effect; and
- Increased risk of perforation (a rare complication).

fppt.com

Continued...

- Early complications:
  - Pneumothorax
  - Pneumonia and
  - Migration
  - Haemoptysis
  - Infections
- Later stages:

symptomatic granuloma formation

more prevalent when used for longterm management of benign airway stenoses

fppt.com

Table 1 Principles, results and pitfalls of the silicone and SEMS stents available

	Anaesthesia	Principle	Indication	Advantages	Drawbacks
Silicone stent	General mandatory	Inserted through a rigid tube during rigid bronchoscopy	Any CAO	Good tolerance Low granulation tissue reaction Easy to remove	Altered clearance Risk of migration (rare, except in case of purely extrinsic compression)
SEMS	General preferred	Self-expandable placed using a guide wire (if necessary) under fluoroscopic or bronchoscopic control flexible and/or rigid bronchoscopy	Second intention, except in cases of highly necrotic lesions or distortion	Easy placement Possible with flexible bronchoscope (if rigid not available)	Frequent complications (partially covered SEMS): granulation, perforation and rupture Hard to remove after 3 weeks of migration (fully covered)

CAO, central airway obstruction; SEMS, self-expandable metallic stent.

Activate Windows
Go to Settings to activate Wi

fppt.com

FUTURE DIRECTIONS

- Drug-eluting stents
- Biodegradable airway stents
- personalization of airway stents

fppt.com

Drug-eluting stents:

novel way to prevent granuloma and malignant tissue formation.

This approach has mostly been evaluated in gastrointestinal endoscopy, with anticancer or antiproliferative [(mTOR) inhibitors] agents.

A biodegradable cisplatin-eluting stent (locally releasing cisplatin for at least 5 weeks) has been designed, dedicated to the central airways, but has not yet been tested in humans.

A potential pitfall of such stents may be an enhanced risk of a fistula caused by its anti proliferative or cytotoxic action

fppt.com

Biodegradable stents:

have not been thoroughly evaluated in adults.

It has been demonstrated to be feasible in six adults with post-transplant ACBA85and in 2 children with TBM,two situations where AS is usually temporary.

Although the concept is very appealing for the management of transient airway stenoses, four of six adult patients and both children needed further stenting, indicating that the degradation is too fast.

This approach can thus not be considered yet as an alternative to silicone stents.

fppt.com

Pationt-customized stents:

- Progress towards customization of airway stents has been made: most manufacturers offer personalization of sizes, diameters and angles measured by CT scan and bronchoscopy.
- (3D) printing is rapidly entering the medical environment and represents another opportunity for more accurate AS.
- In the vast majority of cases, CT measures and perioperative data are sufficient for accurate stent choice and on-site customization.

.

fppt.com

Continued...

Stents customized using the patient's CT scan should in theory dramatically reduce the risk of migration, granulation tissue reaction and mucus plugging.

The feasibility of the use of 3D-engineered, patient-specific

Stents has been now clearly demonstrated. All reports used a time-consuming, two-step approach (using a mould) because 3DP in medical-grade silicone is not ready for prime

This approach seemed particularly appealing for post-transplant ACBA, where anatomy in often highly distorted. However, we still encountered complications such as mucus plugging or migrations, underscoring that congruence is only one parameter for stent tolerance/safety

fppt.com

Continued...

Direct 3DP of the stent, reinforcements rings, studs or patient-specific structures in predefined areas to favour stability and tolerance, use of four-dimensional(4D) dynamic CT scan for more accurate design/congruence and a combination of patient-specific, biodegradable and/or drug-eluting stents are potentially exciting future directions

fppt.com

fppt.com

fppt.com

fppt.com

fppt.com

fppt.com

Indications of stent insertion:

Table 23.1 Stents as a palliative therapeutic option in major airways obstruction

	Urgent	Endobronchial	Laser, stent
Neoplasia		Submucosal	Stent
		Extrinsic	Stent
	Elective	Endobronchial	
		Exophytic	Laser, cryo, PDT, electrocautery
		Submucosal	XRT, brachy, stent
		Extrinsic	XRT, stent
Tracheal stenosis		Fibrous stenosis	Laser, stent, dilatation
		Non-fibrous stenosis	Stent
		Postinflammatory	Systemic, stent
Tracheobronchomalacia			Stent

Source: Reproduced with permission from Mehta, Dasgupta [33].

fppt.com

Indications:

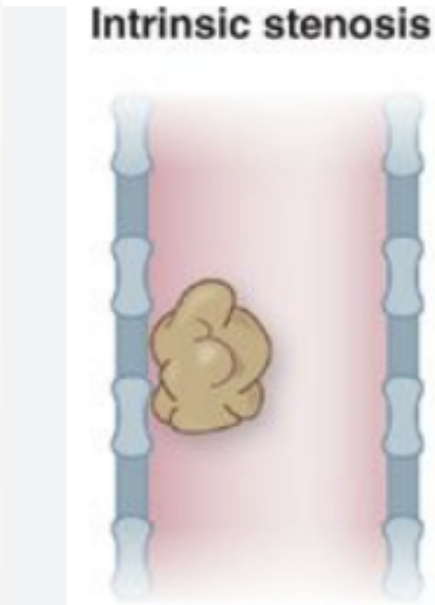
- Benign obstruction
  - Subglottic stenosis
  - Postinfection
  - Postintubation
  - Subglottic and laryngeal cysts or webs
  - Tracheal rings
  - Tracheomalacia
  - Systemic disease (collagen vascular diseases such as Sjögren syndrome)
  - Postlung transplantation
- Malignant neoplasm
  - Extrinsic compression
  - Intrinsic obstruction due to submucosal disease
  - Tracheobronchial-esophageal fistula

fppt.com

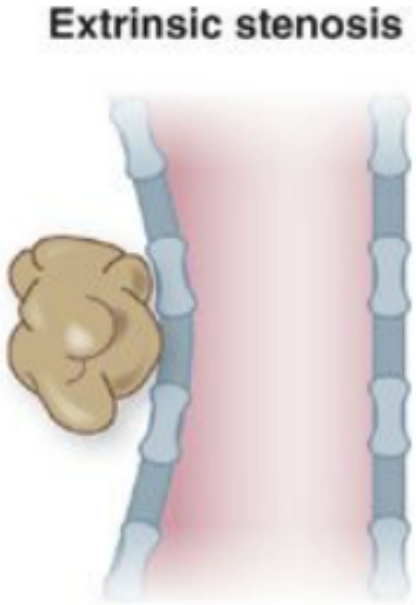
Indications according to the mechanism of obstruction :

- Extrinsic compression
- Intraluminal obstruction
- Mixed obstructive pattern

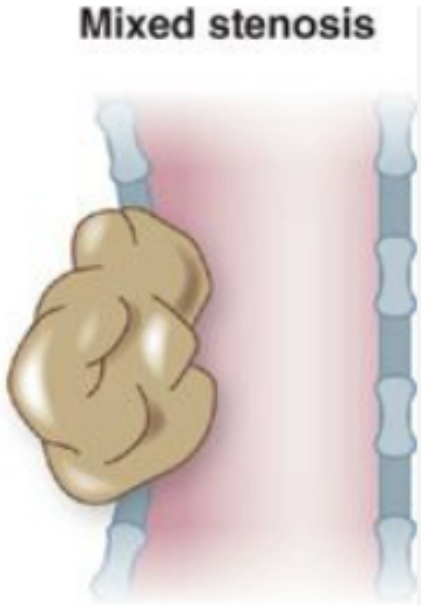
fppt.com



Purely endoluminal tumor without breech of the cartilage



Extra-luminal tumor causing mass effect but no endoluminal involvement



Extra-luminal tumor causing mass effect and endoluminal involvement

fppt.com

Intraluminal and extraluminal obstructions:

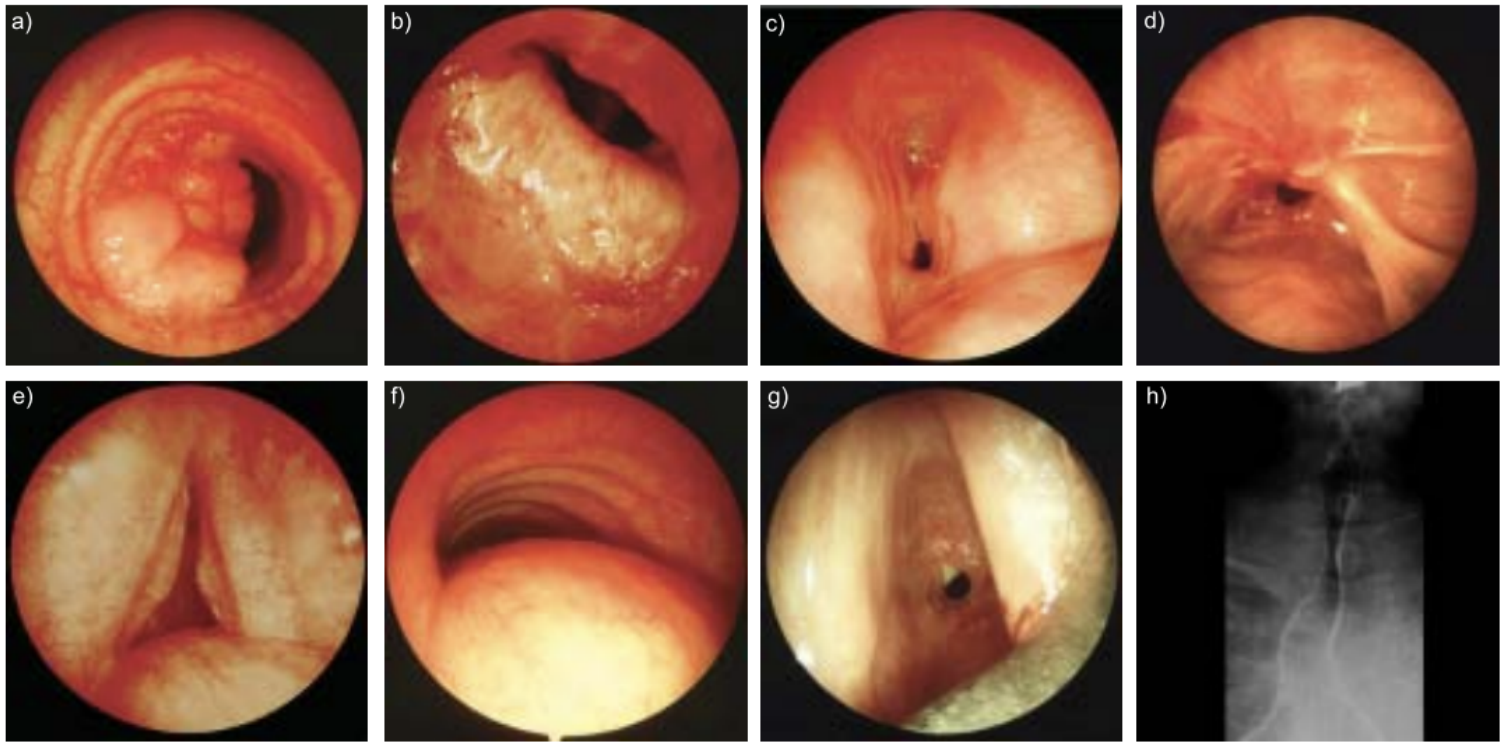


FIGURE 2. Clinical examples of the degrees of stenosis. a) Intraluminar tumour or granulation; b) distortion or buckling; c) extrinsic compression; d) scar stricture; e) scabbard trachea; f) floppy membrane; g) abrupt transition (web stenosis); h) tapered transition (hour glass stenosis).

Activate Win
Go to Settings to

fppt.com

According to location:

TABLE 3 Scoring system according to location

	Location
I	Upper third of the trachea
II	Middle third of the trachea
III	Lower third of the trachea
IV	Right main bronchus
V	Left main bronchus

fppt.com

Continued...

- Regardless of the mechanism of obstruction for which stents are placed, lung function is improved after insertion in patients with CAO.
- Bronchoscopic intervention on malignant CAO is associated with improvement in the 6MWT, spirometry, and dyspnea.

fppt.com

Stenting for Extrinsic Compression

Benign or malignant mediastinal or parenchymal lung disease, thyromegaly, or massive lymphadenopathy can cause symptomatic extrinsic airway compression.

fppt.com

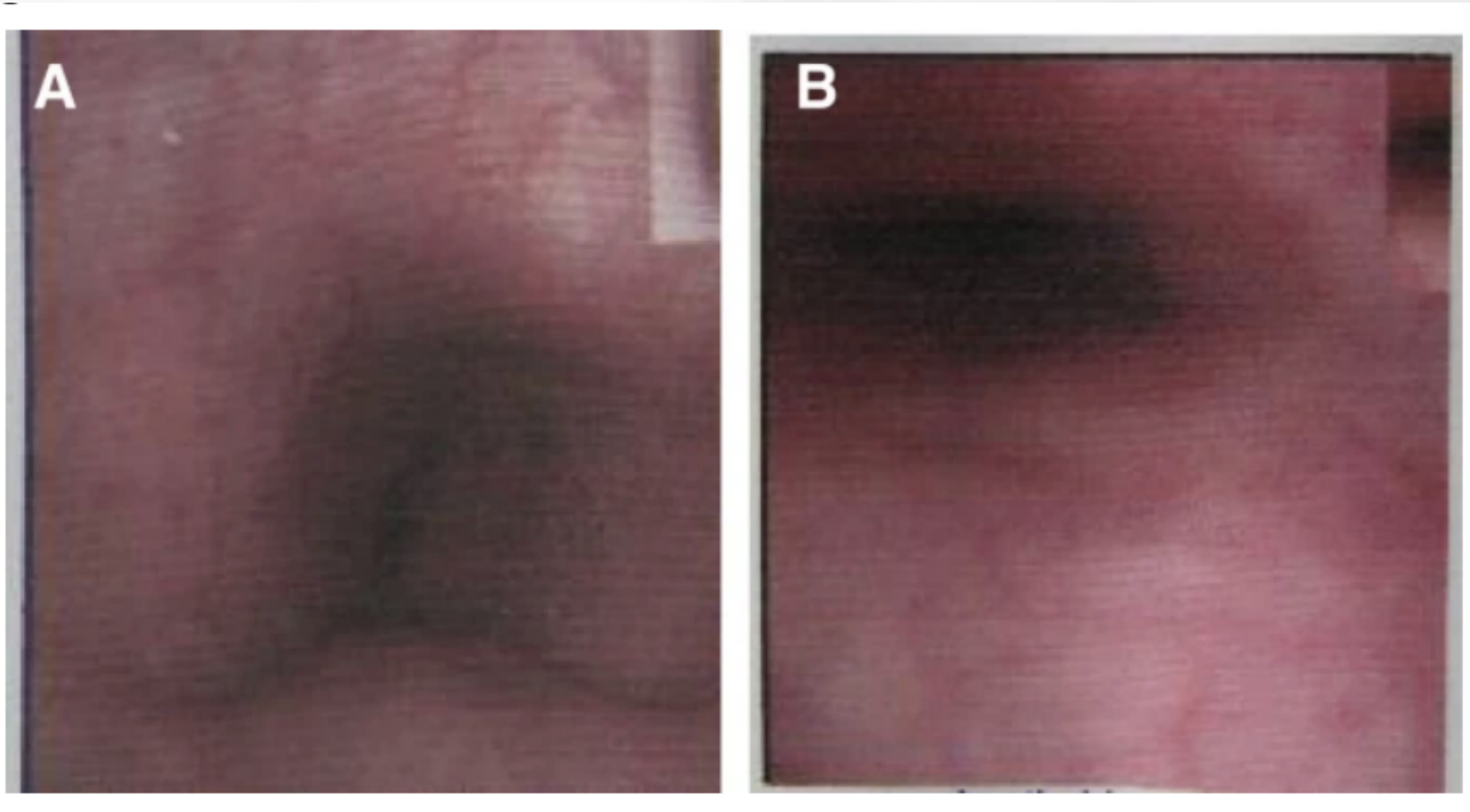
- For patients with extrinsic compression who are not surgical candidates, stenting may be the only option when symptoms are severe and other therapies have delayed effect.
- Rarely, vascular abnormalities, such as aortic aneurysm and double aortic arch, that are not amenable to surgical correction may warrant stent insertion.

fppt.com

A case report of substernal guiter:

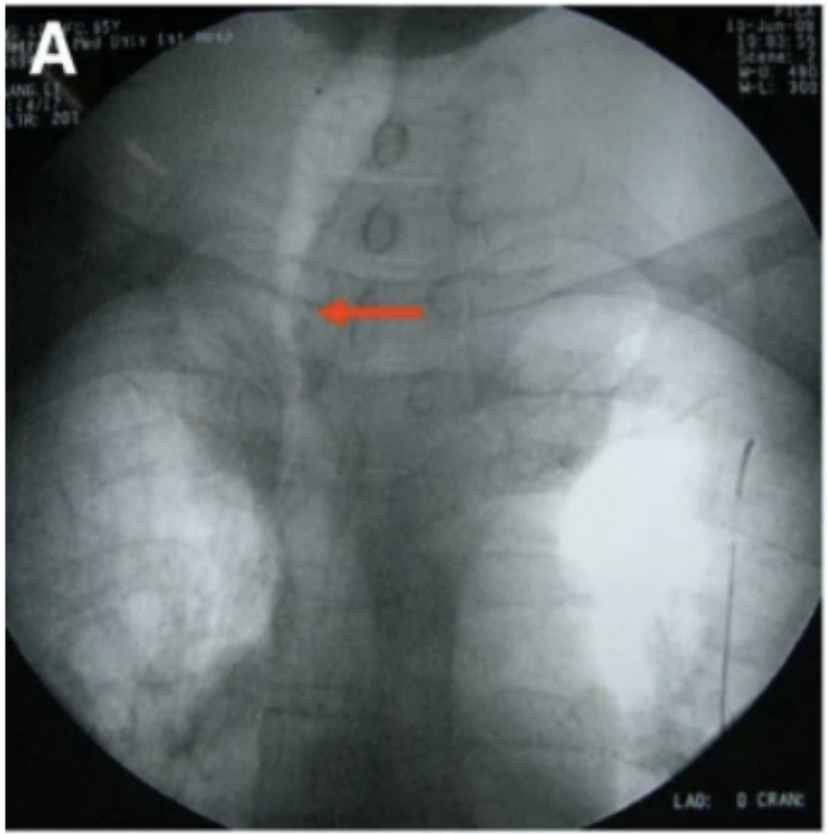
fppt.com

Bronchoscopic examination:

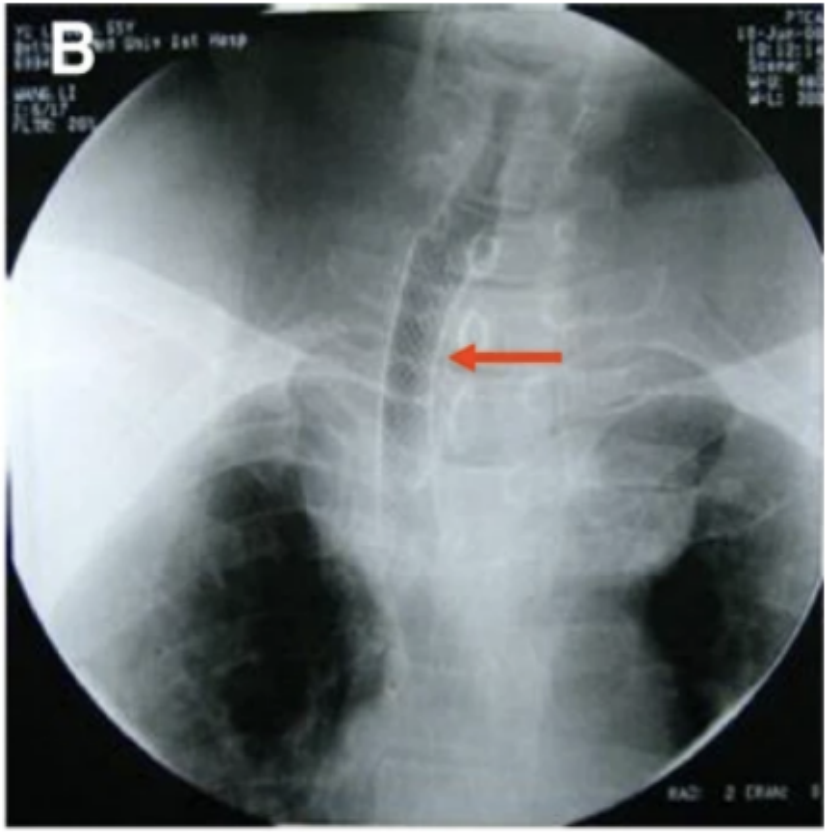


fppt.com

After stent insertion:



Before SEMS placement



After SEMS placement

fppt.com

Intraluminal Obstruction (Strictures or Exophytic)

- if ≥50% residual stenosis after the intraluminal component of an obstruction has been treated using an endoluminal therapy,stent should be considered.
- This principle usually applies to malignant obstruction.
- Stenting of idiopathic tracheal stenosis, postintubation and posttracheostomy strictures in nonsurgical candidates.

fppt.com

Complex strictures

which have an extent of >1cm, often have associated chondritis, so dilation alone will usually be unsuccessful.

Silicone stents are the preferred option

fppt.com

Complex tracheal stricture:

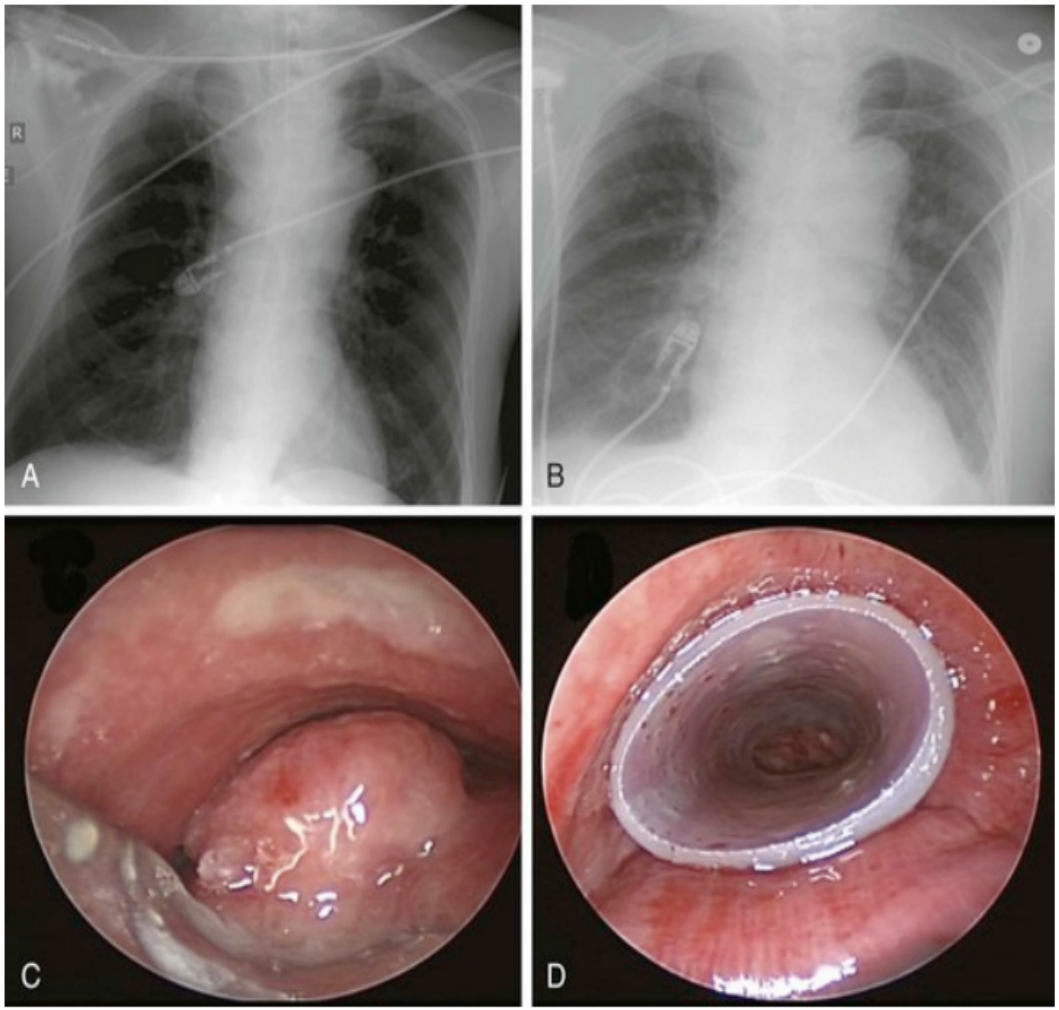


Figure 21-1 **A,** Chest x-ray (CXR) before the bronchoscopy showed a soft tissue mass density projecting to the right of the trachea, enlarged lung volumes bilaterally, and the endotracheal tube (ETT). **B,** The day after the rigid bronchoscopy, the ETT was removed, and air trapping had resolved. **C,** Rigid bronchoscopic view of the mixed airway obstruction, which consisted of exophytic endoluminal mass and extrinsic compression. **D,** Indwelling silicone stent after rigid bronchoscopy restored airway patency but is still partially compressed in the anteroposterior diameter.

Mixed Obstruction

- With a mixed process, the indications for stent placement do not change, but these patients may require a multimodal bronchoscopic approach (i.e., debulking of the endoluminal component, followed by dilation and stent insertion)

fppt.com

Different methodes of tumor debulking:

Table 2 Principles, results, and pitfalls of the techniques available for the bronchoscopic management of malignant central-airway obstructions

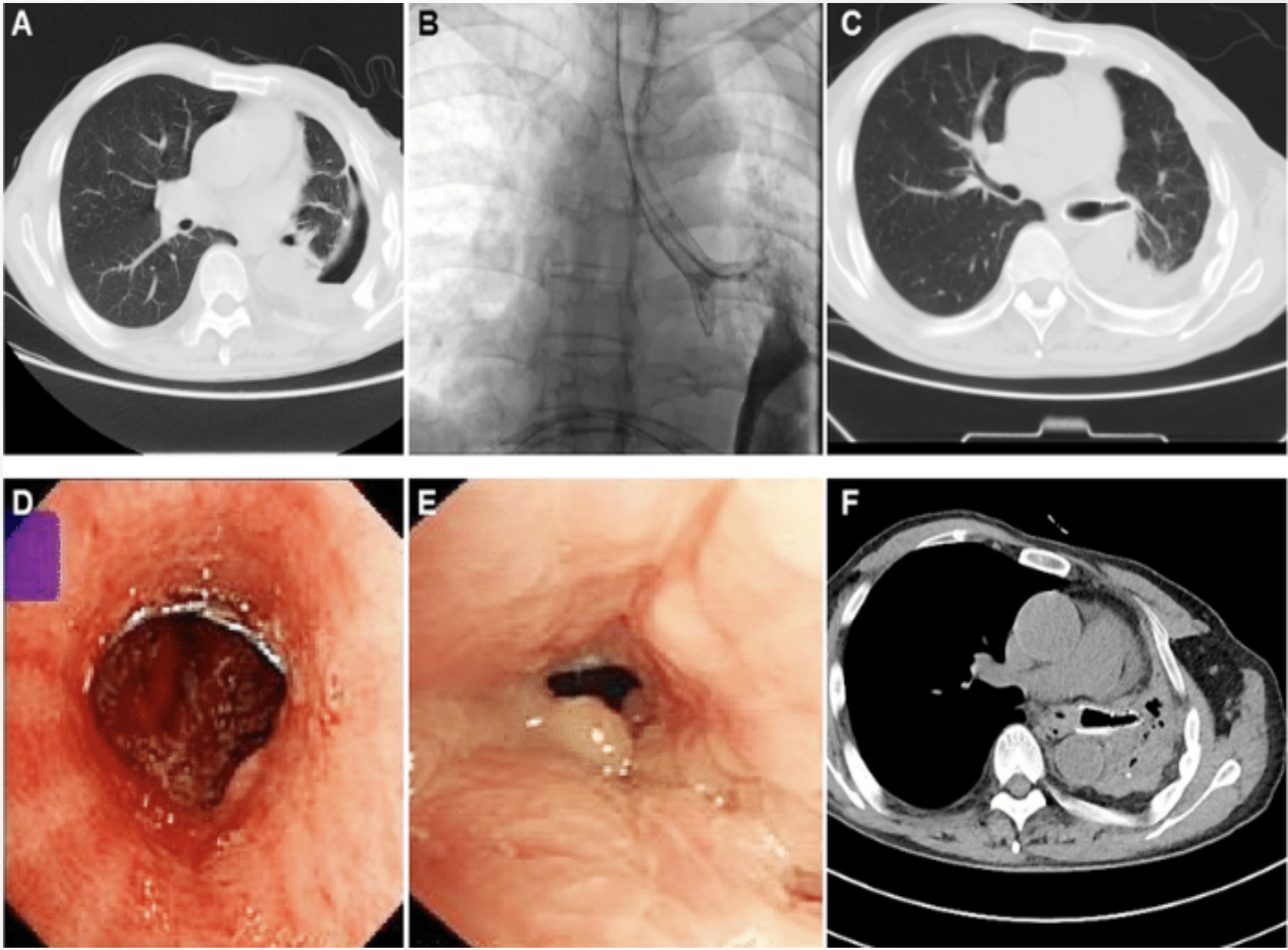
Methods	Principle	Indication	Advantages	Limitations
Mechanical debulking	Resection with the beveled end of rigid tubes and rigid forceps	Proximal, slightly hemorrhagic intraluminal lesions	Rapidity; cost	20% severe complications (bleeding, perforation)
Thermal techniques with immediate effect				
Laser	Short pulsations in the bronchial axis	Critical intraluminal obstructions	Rapid, immediate, and prolonged effect	Cost; perforation and fistula risks
Electrocoagulation + argon plasma coagulation	High-frequency electric current +/– argon as a carrier gas (APC)	Intraluminal proximal obstructions	Cost; low risk of perforation; APC: extended and hemorrhagic lesions	Risk of cicatricial stenosis if circumferential treatment; cost for APC
Thermal techniques with delayed effect				
Cryotherapy	Expansion of a cryogenic gas; cycles of rapid freezing and slow thawing	Non-critical endoluminal obstructions (except cryoextraction and spray cryotherapy)	Low cost; easy procedure; no perforation; prolonged efficacy	Delayed effect (except cryoextraction and spray cryotherapy); retention of tumor material
Photodynamic therapy	Activation of a photosensitizer by light; phototoxic reaction, cell death	Intraluminal or mixed nonthreatening obstructions	Good symptom control (hemoptysis) ; prolonged efficacy	Delayed effect; retention of tumor material; cleaning bronchoscopy; phototoxicity; cost

Stump Fistulas

- Covering large stump fistulas after lobectomy or pneumonectomy is a less common indication for stent insertion.
- Bronchoscopic management is generally reserved for inoperable candidates or when surgery must be delayed.
- Large stent must be used in this situation in order to seal the stump fistula as tightly as possible in order to avoid aspiration pneumonia and allow single-lung ventilation.

fppt.com

Stump fistula:



Esophago-Respiratory Fistulas

The majority of ERF occur after esophagectomy, after intubation, or in the setting of malignancy.

Benign ERF may not improve after stent insertion and may actually enlarge. Therefore, stenting should only be considered if operative correction is not feasible.

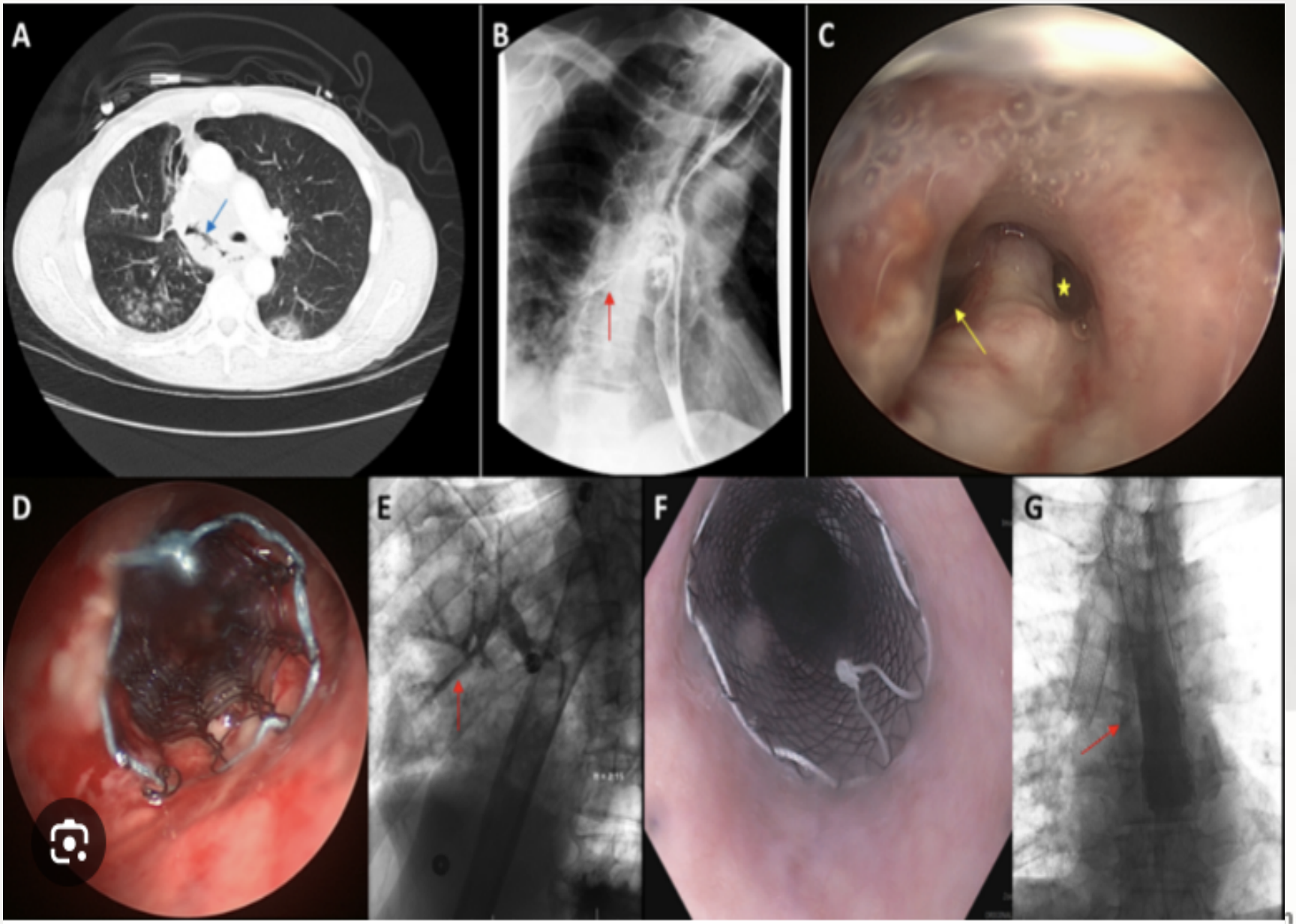
Most stents placed for malignant ERF are for palliation and used to improve quality of life.

Palliation for malignant ERF is usually achieved with esophageal, airway, or dual stent insertion.Silicone Y stents have been shown to improve symptoms, reduce infections, and improve quality of life in this setting. Older studies identified a mean survival rate of only approximately two months.

As a guiding principle, any benign ERF should be considered for surgical repair. SEMS and silicone stents have been occasionally used for inoperable patients.

It appears that covered SEMS are preferred, likely because of more intimate contact between the airway wall and the stent resulting in more durable closure. Stenting for benign ERF should only be considered as a temporary measure until surgery can be tolerated. For malignant ERF, an esophageal stent is preferable, unless there is concurrent airway obstruction. Of note, airway obstruction can get worse after esophageal stent deployment. On occasion, airway stenting is performed first, and an esophageal stent is only placed if there is still residual fistula documented on radiological studies.

fppt.com


A
B
C
D
E
F
G

Expiratory Central Airway Collapse:

- Airway stent insertion has been used to improve:
  - Cough
  - Secretions
  - Quality of life
- The decision to insert a stent in this condition is complicated by at least two factors:

(i) the lack of a standardized definition and threshold value for abnormal narrowing.

(ii) whether this narrowing is actually responsible for air flow limitation.

fppt.com

Continued...

- Excessive airway narrowing in ECAC causes turbulent flow and consequential increased airway resistance.
- Thus, greater transpulmonary pressures are required to maintain expiratory airflow.
- This increases the work of breathing and may result in dyspnea.
- Noninvasive positive airway pressure can serve as a pneumatic stent and decrease pulmonary resistance by maintaining airway patency. This can facilitate secretion drainage and improve expiratory flow.

fppt.com

ECAC stenting:

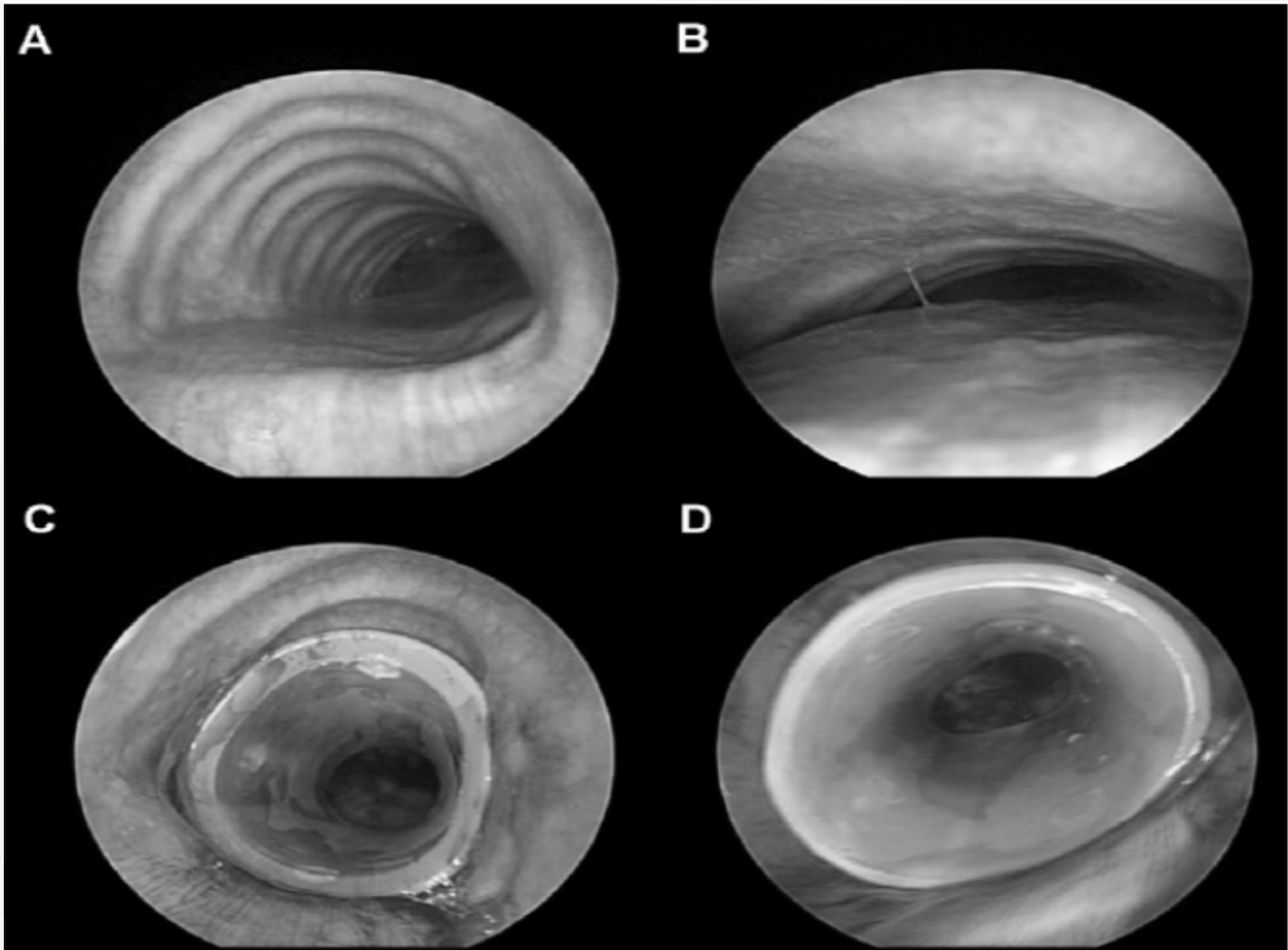
- QOL and functional status improve in patients with ECAC undergoing stent insertion.

But,,,

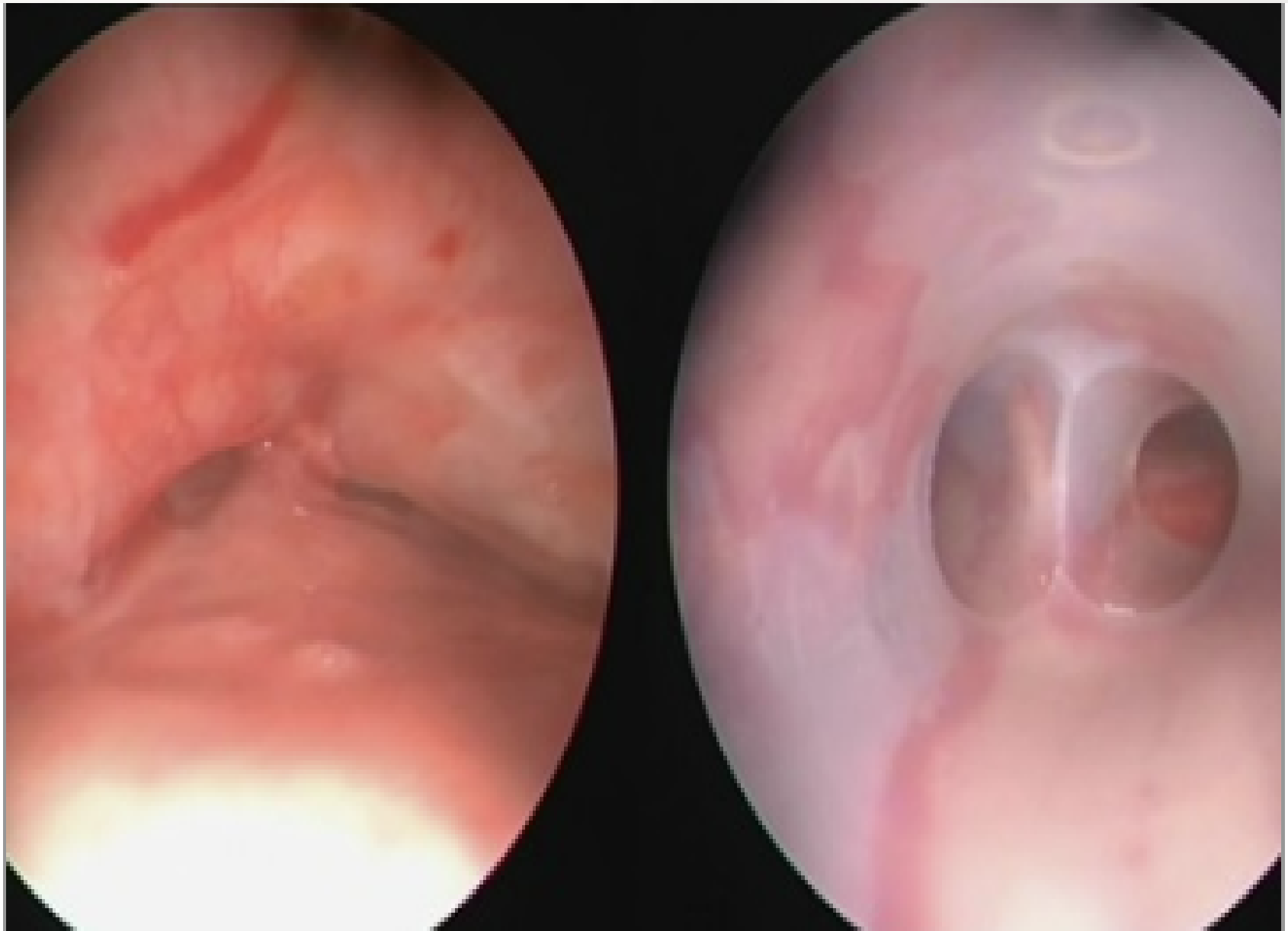
- lung function as measured by FEV1 has not been shown to improve with either stenting or membranous tracheoplasty.

fppt.com

ECAC stenting:



Silicone Ystent for Severe COPD Complicated With Expiratory Central Airway Collapse:



post-transplant airwaycomplications

Airway complications of bronchial anastomosis (ACBA),gathering necrosis/dehiscence/fistula, stenosis and mal-acia, and now more precisely described using the stan-dardized MDS (Macroscopy, Diameter and Suture)classification,59affect approximately 15% of lung trans-plant recipients.60–62AS is rarely the frontline modality forACBA management but is sometimes necessaryBron-chial stenosis occur after the first month, usually preceded by substantial necrosis. When the‘symptom-free’intervalallowed by iterative balloon bronchoplasty is low, AS issometimes necessary. It must however be considered atemporary treatment to appropriately guide bronchialhealing during the delicate phase of neovascularizationand patients must be closely monitored to avoid compli-cations, such as granulation tissue reaction or epitheliali-zation of the stent that hamper stent removal. Therefore,silicone stents or fully covered SEMS must be favoured. Partially covered SEMS also repre-sent an effective and safe alternative (silicone being thepreferred approach) for ACBA,27,64,65but should be closelymonitored to avoid epithelialization and serious granula-tion tissue that could jeopardize their removal. AS has alsobeen reported as an efficient tool to treatdehiscenceandfistulawhen surgery (epiploplasty) has failed or is not pos-sible

fppt.com

Contraindications to Stent Insertion

Absolute and relative contraindications to stenting of the tracheobronchial tree are related to the:

- Condition of the patient
- Degree and duration of the obstruction
- Location of the obstruction
- Available personnel and equipment

fppt.com

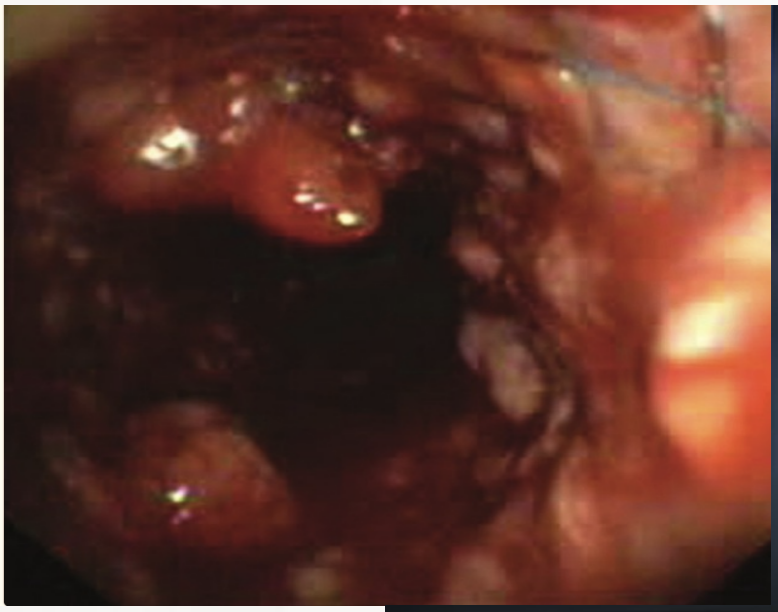
Condition of the Patient:

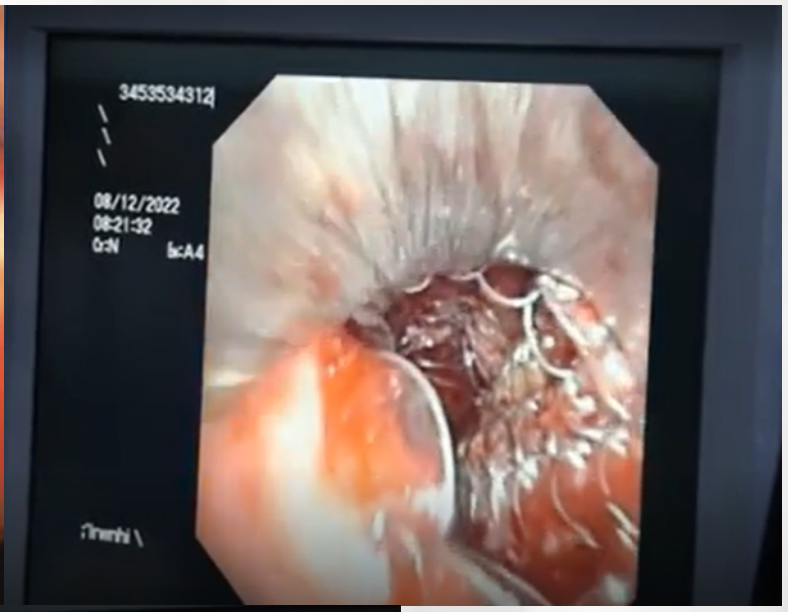
SEMS should never be used in potential candidates for resection.

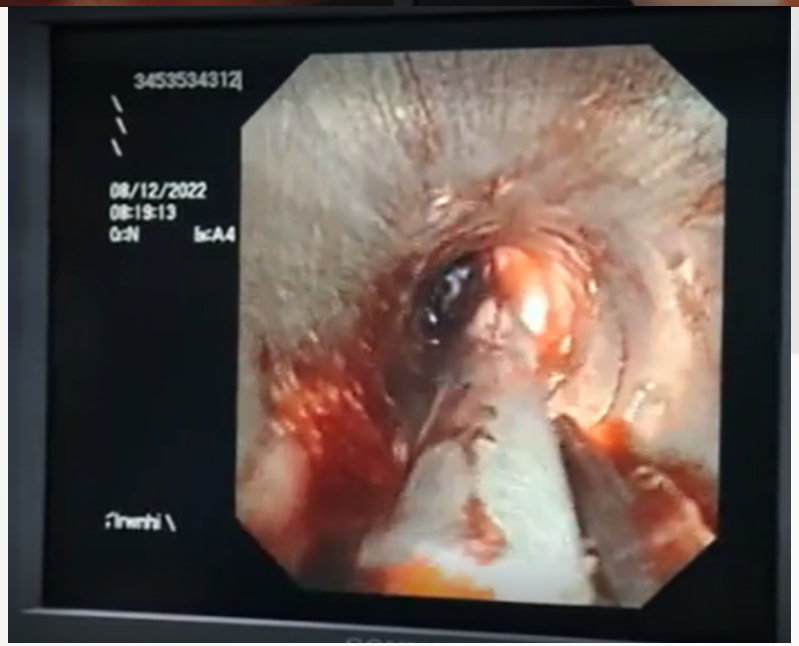
- immobile and patients with limited survival should be spared further intervention

fppt.com

Metalic stent removal in benign stenosis:







fppt.com

Continued...

- Relative contraindications are more dependent upon patient condition and degree of obstruction.
- Patients unable to tolerate moderate sedation or GA have a relative contraindication to techniques of stent insertion.
- GA,safer in these patients undergoing interventional bronchoscopic procedures, especially for malignant CAO.

fppt.com

Degree and Duration of Obstruction

- Prior to attempted stent deployment, the airway lumen should already have been identified and balloon dilated or debulked.
- If a useful airway lumen cannot be identified or the degree of dilation will not permit placement of a stent, then the attempt should be abandoned.
- The condition of the lung to which the newly patent airway leads should be assessed prior to attempted lumen opening and stent placement.

fppt.com

Continued...

- If the parenchyma distal to the occluded lumen has been atelectatic for more than 4 weeks, reexpansion is less likely
- With persistent occlusion of a large airway, the probability of a concomitant thrombotic occlusion of the corresponding pulmonary vessel is relatively high.
- In this situation, bronchial recanalization may offer no functional benefit and may even worsen gas exchange by increasing dead space ventilation.

fppt.com

Location of Obstruction

stent placement in the subglottic space may be more challenging, owing to

- close apposition of the vocal cords
- poor tolerability (cough, aspiration)
- high migration rate.

fppt.com

Available Personnel and Equipment

The equipment necessary is dependent upon the :

- Type of obstruction
- Type of the stent to be placed
- Possibility of complications

Appropriate equipment and personnel should be determined prior to attempted stent placement.

fppt.com

Continued...

- Must be aware that even the routine implantation of a stent complications, requiring immediate use of repositioning instruments such as forceps, balloons,rigid bronchoscopes and rigid forceps.
- Familiar with potential adverse effects and prepared to quickly respond to potential catastrophic complications such as airway obstruction.
- Although the advent of Stent has allowed for placement under moderate sedation, the degree of airway obstruction, particularly in central airways, may require deeper sedation,GA and muscle paralysis.

fppt.com

Continued...

- Essential to this team is the anesthesiologist understands the complex airway and comanagement of the airway with the interventional pulmonologist.
- Target-controlled total intravenous anesthesia (TIVA) may be preferred, especially when using an open system (rigid bronchoscopic stent deployment)

fppt.com

Stent-Related Adverse Events

- choice of stent
- insertion and deployment technique
- migration
- obstruction and infection
- stent failure and perforation.

fppt.com

Complications Related to the Choice of Stent

"different jobs, different stents"

- As mentioned previously metallic stents should never be used in benign conditions.
- If the stent chosen for the patient's abnormality does not fit in terms of length and diameter, then the patient may have only partial relief of the obstruction or may be more at risk from migration of the stent.
- Also, if an uncovered stent is used where tumor ingrowth or a fistula exists, then recurrence of the obstruction or continued aspiration may occur, respectively.
- In contrast to uncovered stents, where ciliary function is maintained, silicone stents and hybrid stents disrupt the normal transport of the mucociliary escalator and result in the accumulation of secretions.

fppt.com

Complications During Insertion and Deployment

- Although silicone stents are easily deployed and manipulated with rigid bronchoscope, there are times when manipulation and balloon or rigid bronchoscopic expansion are necessary.
- Manipulation is more difficult or not possible with self-expanding metallic or hybrid stents.

fppt.com

Continued...

- Deployment of incorrectly sized stent precipitates increased granulation tissue and post stent restenosis.
- Undersized stents resulting in excessive friction of the metallic stent on the airway wall
- Conversely oversized stent causing excessive radial pressure, thus impairing the mucosal microcirculation

Both

leading excessive granulation tissue

fppt.com

Migration

- more common with benign disease such as:
  - post tuberculosis tracheobronchial stenosis
  - ECAC
  - PITS
- In malignancy may be seen while the patient undergoes systemic therapy (immuno-, radiation, targeted, or chemotherapy) as the local disease response may result in the stent becoming loose
- occurs when the extrinsic force generated by the tumor mass is relieved with combined treatment.

fppt.com

The best way to avoid migration is to test its stabilitywith a rigid forceps, and appreciate that a stent mayneed manoeuvres to be fully open. Another option is tofix a stent to the anterior tracheal wall by externalsuturing

fppt.com

Stent Obstruction and Infection

- With interruption of the normal mucociliary escalator and drying of secretions,stent may become obstructed.
- Colonization of the stent or secretions may occur, leading to recurrent cough and mucus production.
- Incidence of LRT infections in patients with stents is 36–39% and is associated with significant morbidity and mortality.

fppt.com

Continued...

- risk factors for stent-related respiratory tract infections:
  - Smoking
  - Ineffective cough
  - Left-sided stents
  - Silicone stents
  - Post-stent chemotherapy
- Nebulized saline may help to prevent the accumulation of secretions but routine use of antibiotics is not recommended unless an infection is suspected.

fppt.com

Continued...

- Tumor overgrowth or granulation tissue is possible with all types of stents.
- Granulation and tumor overgrowth may occur throughout the length of uncovered metal stents and also may occur at the uncovered ends of hybrid stents.
- Granulation tissue is more common in patients with keloids and in those with chronic airway infection.

fppt.com

Stent Failure and Perforation

- The tracheobronchial tree is mobile and subjected to wide swings in pressure.
- With repeated movement,material of a stent may fracture, causing the integrity of the stent to fail,due to metal fatigue.
- repeated movement of the stent, particularly in those with sharp edges, may lead to perforation

fppt.com

stent failure is most often related to:

- Mucus plugging
- Restenosis due to granulation tissue
- Strut fracture
- Migration
- Perforation

fppt.com

Potential complications after stent removal include:

- Stent fracture
- Inability to complete removal(losing the airway)
- Airway perforation
- Airway bleeding
- Laryngeal trauma/edema/spasm
- Retained stent pieces
- Reobstruction
- Anesthesia-related problems
- Death

fppt.com

Follow-Up after Stenting

- Previously Routine surveillance bronchoscopy was noted to be unnecessary after silicone stent insertion, and repeat bronchoscopy should be performed if new symptoms develop .
- recent data suggest that in unselected patients with indwelling airway stents follow-up bronchoscopy can detect complications that may impact further management .

fppt.com

Thanks for your attention

fppt.com