Major Airway Obstruction
Introduction

• Obstruction of major airways can result from a variety of disease processes and is a cause of significant morbidity and mortality

• Increasing no. of pts. with lung cancer develop complications of prox. endobronchial disease
  – 20-30% pts with lung cancer develop complications (Atelectasis, Pneumonia, Dyspnea)
  – Upto 40% lung cancer death may be attributed to loco-regional disease
  – With ↑ use of Artificial airways such as ETT, incidence of iatrogenic complications is also increasing
ETIOLOGY

• Infections:
  Ac. Epiglottitis
  Laryngo tracheo bronchitis
  Ludwig’s Angina
  Ac. Tonsillitis with/without Retropharyngeal abscess
  Bacterial bronchitis
  TB

• Angioedema:
  Exposure to Drugs
  [Narcotics, Aspirin, NSAID, ACE(-)]
  C1 esterase deficiency.
• Tumors:
  Pharynx
  Larynx – Haemangioma
  Ca → Supra glottic regions
  Glottic regions
  Sub-glottic regions
  Trachea & Bronchi
  Adenoid Cystic Ca
  Sq. Cell Ca
  Secondary inv.- Bronchogenic Ca
  Laryngeal, Esophageal.
  Thyroid Malignancies.
• **Trauma:**
  - Facial [Crush Injuries, # Mandible]
  - Laryngeal
  - Tracheobronchial injuries
  - Inhalational Injuries

• **Vascular Causes:**
  - Innominate Artery syndr.
  - Thoracic Aorta aneurysms
  - Double aortic arch

• **Foreign Body Aspiration:**
- **Neuromuscular Disorders:**
  - Myasthenia gravis
  - Motor neuron diseases
- **Iatrogenic Causes:**
  - Vocal cord granuloma
  - Glottic stenosis
  - Vocal cord Paralysis
  - Tracheal Stenosis
• Miscellaneous Causes:
  Collagen vascular diseases
  Relapsing Polychondritis
  RA
  Sjogren’s Syndr.
  Tracheal abnormalities
  Tracheobronchiomegaly
  Saber sheath Trachea
  Tracheobronchopathia
  Osteochondroplastica
• C/F:
  Mild Airflow Obstr → Asymptomatic
  Dyspnea, Noisy breathing [wheeze, stridor]
  Post-obstr Pneumonia, Collapse, U/L wheeze
  Hoarseness of voice
  Exertional dyspnea:
  Tracheal diameter-8mm
  Stridor /Dyspnea at rest:
  Tracheal diameter-5 mm

• Physiological assessment
• Diameter of lumen < 8 mm:
  Produce abnormal flow-volume loops.
  Initial effort dependent portion affected in CAO
<table>
<thead>
<tr>
<th>Type</th>
<th>Example</th>
<th>Flow characteristic</th>
<th>FEF / FIF</th>
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<tbody>
<tr>
<td>Variable</td>
<td>Vocal Cord palsy</td>
<td>Increased</td>
<td>&gt; 2</td>
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<tr>
<td>Extra-thoracic</td>
<td>Glottic Stricture</td>
<td>Obstn.during during inspiration resulting ↓ inspiratory flow.</td>
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<td></td>
<td>Tumors</td>
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<tr>
<td>Variable</td>
<td>Malignant tumors,</td>
<td>Forced Expiration</td>
<td>~ 0.3</td>
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<tr>
<td>Intrathoracic</td>
<td>Tracheomalacia</td>
<td>Increases obstruction</td>
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<td>Fixed Extra</td>
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<tr>
<td>Or-Intrathoracic</td>
<td>Goitre</td>
<td>Fixed flow with</td>
<td>~ 1</td>
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<td></td>
<td>Post-intubation Stricture</td>
<td>Inspiration and Expiration</td>
<td></td>
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- Spirometry should not be done in CAO, Resp. distress → Induce Resp. failure
Radiology:

• **CXR:**
  - Rarely diagnostic
  - Tracheal deviation can be identified

• **CT Scan:**
  - Provide much more information
  - Document dynamic airway collapse
  - Multiplanar/3D reconstruction:
    • Better visualization
    • Whether lesions are intraluminal/Extrinsic to airways/features of both
    • Whether airways distal to obstr. are patent
    • Relationship to other structures such as vessels
• Bronchoscopy: (Rigid/Flexible)
  – Helps in assessing obstr.
  – Direct visualization allows nature and extent of obstr. to be determined
  – Allows tissue diagnosis

• Endobronchial ultrasound
  – Extremely sensitive for determining degree of tracheal invasion
  – Aids in planning therapeutic interventions
  – Study by Herth and Colleagues, EBUS utilized in 1174 of 2446 cases over 3 yrs. period. It was found to guide/change management in 43% and change included selecting proper stent size/guiding tumor debridement/selecting pts. for endoscopic therapy Vs surgery
Securing the Airway

• Unstable pts.: Airway immediately stabilized
  TT: Procedure of choice for stabilizing severe upper airway obstr.
• Distal airway obstr.: ETT, Rigid bronchoscopy
• Rigid Bronchoscopy:
  • Allows passage of various instruments
  • Barrel of scope – Tamponade a bleeding central lesion
• Heliox: Mixture of 60-80% helium, 20-40% O₂
• Can be used as a bridge in pts. With CAO and resp. distress.
• Heliox ↓ Reynolds number resulting in establishment of laminar flow ↓
  • ↓ Driving pressure to achieve a given flow ↓
  • ↓ WOB allowing for more stable intubation either ETT/RB
• **Anesthesia for Airway Obstruction**
• Majority of these pts. are ASA III/IV
• Inducing agent: IV anesthesia or inhalational
  (i) Rapid, smooth induction
  (ii) Less airway irritation
• Stable pts.:
  – Combination of short acting IV anaesthetic agent (Propofol) with midazolam/fentanyl/vecuronium
• Provide effective and safe anaesthesia/amnesia/pain control and muscle relaxation
• Airway fires:
  – Use of flammable anaesthetics
  – High conc. O2 in presence of lasers/electrocautery
  – ETT/stents can ignite with lasers.
• **Therapeutic Approaches**

• **Dilation of airway (Bronchoplasty)**
  - Emergencies: airways dilated with barrel of RB
  - Less urgent cases: sequential dilation with balloons preferred

• **Indication**
  - Airway stenosis following lung Tx and surgical resection of airways
  - Post-intubation tracheal stenosis
  - Malignant airway Obstr
  - Preparation of airways for stent placement, Brachytherapy catheters
FOB → visualize the stenosis

Vascular ‘J’ wire introduced through bronchoscope port & visualized in the lumen

Wire inserted in the stenotic segment

FOB withdrawn over the wire in a manner similar to Seldinger tech.

Pediatric bronchoscope re-introduced adjacent to wire through ETT to check its position

Angioplasty balloon catheter introduced over wire and directed across stenosis with pediatric scope

Balloon inflated 5-7 times to 4 atm. pressure under direct visualization for approx. 30 sec.

Balloon fully deflated, withdrawn and then 5mm diameter adult size bronchoscope passed to assess for bleeding/airway trauma
Complication:
- Mucosal trauma $\rightarrow$ Granulation $\rightarrow$ Restenosis
  (prevented with laser/stent placement)
- Pneumothorax
- Pneumomediastinum
- Mediastinitis
- Bleeding

\[\text{Less common}\]
ENDO BRONCHIAL LASER THERAPY

Physics: Light Amplified by the stimulated Emission of Radiation [Laser]

LASER is effective because

1. Monochromatic: Narrow band of wavelength
2. Spatial Coherence: minimal divergence, Maintains Intensity
3. Temporal Coherence: Energy packets travel in uniform time with equal alignment.

Amount of Energy delivered to a lesion depend on

1. Power setting of laser (watts)
2. Distance of laser tip to target
3. Duration of impact
Two most commonly applied material used for Laser:

- CO₂ Laser

Mech. Of Action:
- Laser absorbed by tissues
- Water temperature in tissues raised to 100°C
- Vaporization
- Cell Shrinkage and death.
Indications:
Benign/Malignant Airway Lesions associated with
• Dyspnea
• Cough (Uncontrolled)
• Impending Asphyxiation
• Stridor
• Post-obstructive pneumonia
• Unresolving atelectasis
• Nearly complete (> 50%) obstn. Of one major bronchus
• Recurrent haemoptysis
CONTRA-INDICATIONS:

**Anatomic**
- Extrinsic obstr. Without endobronchial lesion
- Lesion incursion into bordering major vascular structure with potential for fistula formation
- Lesion incursion into bordering Esophagus/mediastinum with potential for fistula formation

**Clinical**
- Candidate for surgical resection
- Unfavorable short term prognosis with hope for palliation of symptoms.
- Inability to undergo conscious sedation/GA
- Coagulation disorder
- Total obstr. > 4-6 wks.
Equipment:
- CO₂ Laser – Extensive equipment [Articulating arms series of mirrors]
  Used for lesion of larynx
- Nd-YAG Laser can be delivered by flexible cable
- Flexible/Rigid Bronchoscope may be used

Complications:
Malfunction of equipment
- Light Scatter – Retinal damage [Keep the Laser in Stand by mode when not inserted through scope]
- Cable Breakage
Anaesthesia:

- Anoxia- Compromised ventilation due to FOB/Haemorrhage or Debris
- Endotracheal fire: Use of combustible anaesthetic gases (Halothane)
  Supplemental O₂
  Pigmented ETT
- Avoided by: Lower FiO₂, Clear ETT, Rigid Scope
• Peri-Operative:
  – Cardiovascular- Arrhythmia: SVT 5%
  – Hypotension 10%
  – Perforation of Underlying/Contiguous structure
    • Haemorrhage
    • Pneumothorax
    • Pneumomediastinum
Personne et al (J Thorac Cardiovasc Surg, 1986)

- 2284 endoscopic laser resections for tracheo bronchial lesion in 1310 pts.
- **Indications:**
  - Malignant tumors (>50%)
  - Benign lesions: 40% (73% – Stenosis, 27% granulomas)
- **Results:**
  - >50% had remission of significant airway obstr. for atleast 6mths.
  - 25% free of airway obstr. for atleast 1yr.
- **Complications:**
  - Pneumothorax 1%
  - Haemorrhage resulting in death 3pts.

  (Involvement of major vessels like pul.artery/innominate artery)

- 351 Nd-YAG Laser resection performed in 273 pts. With lung cancer
  - Trachea - 64pts.
  - Main bronchi – 154 pts.
  - Bronchus intermedius/distal airway – 55 pts.
- Median survival was 12.1 mths.
- Airway caliber improved in 89% pts.
  Improvement in FEV$_1$/PaO$_2$/performance status
- Major complications
  - Bleeding – 7 pts.
  - Hypoxia – 5 pts.
CRYOTHERAPY

- Scientific Basis
- Necessary temperature for tissue destruction is -15 to -40°C
- Other Factors - (i) Rapid freezing and slow thawing – Max. cell death
  (ii) Repeat cycling - ↑ Destruction
  (iii) Mass of tissue frozen – Large contact area with probe ↑ tissue mass exposed to freezing
- Cellular mechanisms:
  1. Formation of Extra-cellular ice crystals
     - Increased Extra-cellular toxicity
     - Increased Intra-cellular toxicity (d/t water shift)
     - Cell shrinkage
     - Membrane damage
2. Intra-cellular ice crystals damage organelles – Mitochondria, Endoplasmic reticulum
3. Change in intracellular pH- Protein/Enzyme damage
4. Freezing – Vasconstriction
   Micro-thrombi Formation \[\text{Devascularization- Cell Death}\]
<table>
<thead>
<tr>
<th>Cryosensitive</th>
<th>Cryoresistant</th>
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<tbody>
<tr>
<td>Skin</td>
<td>Fat</td>
</tr>
<tr>
<td>Mucous Memb.</td>
<td>Cartilage</td>
</tr>
<tr>
<td>Nerve</td>
<td>Nerve sheath</td>
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<tr>
<td>Endothelium</td>
<td>Connective tissue</td>
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<tr>
<td>Granulation tissue</td>
<td>Fibrosis</td>
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- Microscopic epithelial & cartilagenous changes resolve over 4-6 wks.
Indications & Patient Selection

- Used only when palliation is reqd.
- Lesion should be accessible to cryoprobe, polypoidal, short length, large endobronchial component. Allow some visibility beyond lesion, functioning lung distal to the lesion.
- May be used to remove mucus plugs, blood clots, FB

Equipment & Techniques

- Cryogen used in liquid phase – Vaporizes – Removes heat
  - Probe/Tissue cooled
- Nitrous Oxide, Liquid Nitrogen are most commonly used.
- N\textsubscript{2}O cools the probe tip to \(-89^\circ\text{C}\)
  - Temp ↑ by 10\(^\circ\text{C}\) per mm from tip [warning effect]
  - Effective killing zone is 5-8 mm
- Probe diameter:
  - Flexible – 2.2mm
  - Semirigid – 2.6mm
- Pre-op evaluation similar to any routine Bronchoscopy procedure
**Procedure**
- Sedated
  - ETT intubation [Airway control, removal of debris]
  - Anaesthetize airways
  - FOB
  - Inspect airways & localize pathology
  - Cryoprobe passed through working channel until tip proudes from the scope by approx 2cm
  - Under direct visualization tip applied to lesion perpendicularly/tangentially
  - Ice ball forms within 10-15 sec.
  - Freezing time of 30-60 sec.
  - Multiple freeze – thaw cycles applied
  - Forceps- Remove tissue, debris
Results

• Maiwand & Homasson: 600 pts.
  [Clin Chest Med, 1995] Most had Sq Cell Ca
  1/3 pts. Received cryotherapy
  78% subjective improvement

• Mathur et al: Tumor removed in 18 of 20 pts.
  (Chest 1997) with malignant CAO
  12/17 pts. With dyspnea
  5/5 pts. With haemoptysis
  improved clinically
Complications

- Maiwand & Homasson reported – One death from cardio resp. failure in 600 cases [within 5hrs of procedure] – 2 case of TOF
- Mathur et al: One cardio-resp. arrest – Pt. Survived
- Other: Pneumothorax, Bronchospasm
  - Fever
  - Bradycardia

Reported in few numbers
Electrocautery

- Used current to produce heat & destroy tissue.
- **Scientific Basis**
  - Alternating current at a high frequency \([10^5-10^7\ \text{Hz}]\) is used to generate heat which coagulates, vaporizes or cuts tissue.
  - Tissue resistance to current generates heat
  - Low freq. Current \([<10^5\ \text{Hz}]\) stimulates nerves/muscles so this avoided.
  - At 70°C tissue coagulates, >200°C tissue carbonizes
  - Heat
    - Evaporation of Cell water – Tissue destruction
    - Chemical breakdown of cell/tissue constituent
- Electrocautery devices are monopolar: Bronchoscope/Generator/Pt. Should be grounded to complete current
Indication & Pt. Selection

– Similar to cryotherapy
– Impending resp. failure: Accomplish rapid debulking of tumor [Contrary to cryotherapy]
Equipment & Technique

- Insulated FOB with working channel 2.0-2.6mm
- Electrocautery – Blunt tip probe – 1.9mm diameter
  Snare – 1.8mm diameter
- Pt. Grounded with an Electrode pad
- Procedure similar to cryotherapy
- Elongated, flat lesions – Blunt probe used
- Polypoid lesion – snare
- Probe is placed in contact with the tissue so blanching occurs
  - Generator activated
  - Coagulate/cut tissues
  - Debris removed with forceps
Results

Homasson et al: - 56 pts.
- Haemoptysis controlled in 75% cases
- Dyspnea improved in 67%
- Cough/stridor improved in 55%

Sutedja et al: - 15 of 17 pts had immediate restoration of a patent airway defined as >75% of normal airway
- dyspnea relief – 8 pts
- Control of haemoptysis – 4 pts

Complications
- Endobronchial fire (↑ if high FiO₂ used)
- Pacemaker/AICD – May result in devices malfunction
Argon Plasma Coagulation

- Mode of non contact electro-coagulation
- Tungsten electrode creates 5000-6000V spark at tip of probe
- Ionize argon gas released at probe tip
  ↓
- Argon plasma
  ↓
- Coagulative Necrosis
- Coagulation depth- 2-3mm
- Repeat Bronchoscopy reqd. after 1-3 days to remove necrotic material
- Proper grounding & electrical safety must be ensured FiO₂ to be kept below 0.4
- Used for malignant CAO
  - OCC – CAO sec. To granulation tissue at surgical site anastomosis
  - Resp. papillomatosis
Brachytherapy

Brachytherapy allows radiation to be delivered endobronchially most commonly used source: Ir\(^{192}\)

Techniques & Dosage

- After loading technique:
  - FOB is used to place the blind-tipped catheter at desired position
  - Radiation source loaded afterwards

- Can be delivered by Low dose rate [LDR]. Intermediate dose rate [IDR] or High dose rate [HDR] methods

**LDR:** 75-200 cGy/hr use requires placement for 20-60 hrs treatment given in one session—Requires hospitalization

**IDR:** 200-1200 cGy/hr each session lasting 1-4hrs.
HDR:
- > 1200 cGy/hr
- Delivered in 3 fractions at weekly interval lasting 3-30 min
- Treated as OPD basis
- Requires multiple FOB

Pts selection:
- NSCLC/Metastatic carcinoma
- Biopsy proven carcinoma
- Not eligible for curative therapy
- Tumors: Extrinsic/Intrinsic
- Residual tumor post surgery/post-procedures
- CI:
  - Fistulas
  - Malignancy – not proven
  - Moribund

- Advantage:
  - Catheter can be placed in all bronchi, segmental bronchi
  - Peribronchial disease

- Disadvantage:
  - Intolerance of catheter
  - Radiation induced bronchitis, cough
  - Fistula formation between bronchioles and Esophagus/pleura/great vessels
  - Haemorrhage
  - Infection

- Complications
  - Massive Haemoptysis
  - Fistula formation in mediastinum
Muto P et al (Oncologist, 2000)

- 320 pts. With lung cancer received HDRBT with Ir$^{192}$
  - 84 received 10Gy in 1 fraction (Gr. A)
  - 47 received 7Gy in 2 fraction (Gr. B)
  - 189 received 5Gy in 3 fraction (Gr. C)
- Mean survival was 10 mths. from HDRBT
- Symptomatic Improvement:
  - Dyspnea – 90%
  - Cough – 82%
  - Haemoptysis – 94%
  - Obstr. Pneumonia – 90%
- Performance status improved in 70%
- Side-effects: Radiation Bronchitis
  - 80% Gr. A
  - 48% Gr. B
  - 20% Gr. C
  - Fatal Haemoptysis – 5% (similar in each group)
Lo TC et al (Radiother Oncol, 1995)

**LDRBT**
- Gr. 1- 110 pts.
- 30-60 Gy in 1-2 sessions

**HDRBT**
- Gr. 2 – 59 pts.
- 7 Gy 3wkly session

Clinical improvement, survival rates, complications were similar in both groups

Gollins SW (Radiother Oncol, 1994)

406 pts. Treated with HDRBT using Ir$^{192}$

Category I: 324 pts. (80%) previously unirradiated and received single fraction of 15-20 Gy
• Improvement in symptoms at 6 mths:
  Stridor – 92%
  Haemoptysis – 88%
  Dyspnea 60%
  Pain 50%
  23 derived long lasting palliation and reqd. no further treatment

Category II:
• 65 pts (16%) – Received previous EBRT now given HDRBT
• 6 wks post treatment: Symptom palliation similar to category I

Category III:
• 17 pts (4%) – EBRT + HDRBT used concurrently similar levels of palliation compared to category I.
• Conclusion: Efficacy of single HDRBT in palliating symptoms comparable with combination of EBRT + HDRT
• Airway stents
- Play a major role in the management of central airway obstruction
- Indications:
  - Malignant Neoplasm: Extrinsic compression/submucosal disease
    Before EBRT/Endobronchial RT. in acutely symptomatic pts. When all palliative modalities have been exhausted
  - Benign condition: Post-traumatic – fibrotic stricture
• Post Infectious: End bronchial TB
  Fibrosing Mediastinitis
• Post Lung Transplantation: Anastomotic Stenosis
• Tracheobronchomalacea
  Focal – following TT/RT
  Diffuse- Idiopathic
  Relapsing Polychondritis
  Tracheobronchomegaly
• Benign Tumors:
  Papillomatosis
  Amyloidosis
• Miscellaneous:
  Extrinsic Compression from aortic aneurysm
  Tracheal distortion from Kyphoscoliosis
Types

(i) Tube Stents
1. Montgomery T-Tube:
   - Silicone: Simultaneous relief of obstr. at subglottic & distal trachea
2. Westaby Modification:
   - Silicone, tube with distal bifurcation straddles carina
3. Dumon:
   - Silicone, external studs, Y tube most widely used.
4. Fretiag:
   - Silicone with antlat wall metallic reinforcement Y shaped: to prevent migration

Metal stents: Radio-opeque

   Exhibit varying degrees of dynamic expansibility easy to insert

Two types: Fixed diameter stents: Require Balloon dilatation

Self Expandble stents: Spring to pre-defernined diameter once released

(ii) Metallic Stents
1. Palmaz: Stainless steel, balloon expandable
2. Wallstent:
   - Cobalt based alloy self expandable
3. Ultraflex:
   - Nitinol self expandable
4. Gianturco:
   - Stainless steel, self expandable
Techniques:

- Screening FOB to confirm need for stent
- Length of obstructed segment measured
- Stent is delivered using 7-9 F co-axial catheter system
- Stent is mounted on an inner catheter whose central lumen allows guide wire to be passed easily. Stent is maintained in its constraintal form by outer co-axial catheter
• FOB done to define lesion & placement of skin markers corresponding to distal & proximal ends of obs using following:-
• A guide wire then introduced post the obstructed segment under bronchoscope & fluroscopic guidance
• FOB withdrawn with guide wire in place
• Stent with its delivery system inserted over guidewire & distal radio-opaque marker band aligned just beyond the distal skin marker.
• Gradual withdrawal of the outer coltheper allows controlled deployment of stent under continuous fluroscopic monitoring.
• Delivery System is then easily removed through expanded sent.
COMPLICATIONS:
- Granuloma formation
- Infections Tracheitis
- Stent Migration
- Restenosis
- Airway perforation
- 143 Pts.: 309 stent procedures
- Cause of CAO:
  - Benign-33%
  - Malignant- 67%
  - Anastomotic, Tracheo
  - Bronchomalacia Post-Intubation
  - Local extension from Lung/Mediastinum/Thyroid
  - Metastatic: Renal, thyroid sarcoma, breast
  - Majority (77%) > 75% airway narrowing, 82% reqd. Urgent/emergent intervention
  - 87% of stents: silicone rubber
  - 13% Expandable metal stents
• Complications: 42%
  – Stent - Occlusion by secretions
  - Migration
  - Obstr. By granulation
  – Airway perforation – 1%
  – Improvement in symptoms: 95%
  – 95% maintained good palliation 28 mths after original stent in benign disease.
  – 85% maintained palliation for 4mths. in malignant disease.
Vonk-Noondegraf A et al (Chest 2001)

- 14 pts. With imminent suffocation due to major airway obstruction caused by end-stage esophageal cancer (n=5) NSCLC (n=9)
- Stents placed within 24hrs. of hospitalization
- All pts. experienced immediate benefit after stenting (symptom score improved)
- Av Length of survival after stent insertion was 11wks.
- Death mainly due to Tumor progression (10 of 14 pts.)
- No complication was reported
Saad CP et al (Chest 2003)
• Retrospective study at a tertiary care hospital
• 82 pts. who received self expandable metallic airway stents (SEMS)
• Indication:
  – CAO caused by lung cancer (n=50)
  – Post lung transplant (n=11)
  – Other Benign condition (n=21)
• Complications:
  – Infection 15.9%
  – Obstructive granulomas 14.6%
  – Migration 4.7%
• 14 of 16 pts. received mech. ventilation (88%) could be weaned off after procedure
Central Airway obstruction

Yes

Emergent

No

Surgery

Curative Resection

Submucosal or extrinsic lesion

Dilation Stent

Endobronchial Exophytic lesion

Dilation/Coring laser photoresection Electrocautery Argon plasma coagulation

Endobronchial Exophytic lesion

Dilation/Coring laser photoresection cryotherapy Electrocautery Photodynamic therapy Brachytherapy APC EBRT

Submucosal or extrinsic lesion

Dilation Brachytherapy EBRT

No
Thanks