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

Type	Example	Flow characteristic	FEF / FIF 50% 50%
Variable Extra-thoracic	Vocal Cord palsy Glottic Stricture Tumors	Increased Obstn.during inspiration resulting ↓inspiratory flow.	> 2
Variable Intrathoracic	Malignant tumors, Tracheomalacia	Forced Expiration Increases obstruction	~ 0.3
Fixed Extra Or-Intrathoracic	Goitre Post-intubation Stricture	Fixed flow with Inspiration and Expiration	~ 1

- 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% O_2
- Can be used as a bridge in pts. With CAO and resp. distress.
- Heliox ↓ Reynolds number resulting in establishment of laminar flow

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- ↓ Driving pressure to achieve a given flow

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- ↓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

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

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Wire inserted in the stenotic segment

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FOB withdrawn over the wire in a manner similar to Seldinger tech.

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

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

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

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Balloon fully deflated, withdrawn and then 5mm diameter adult size bronhoscope passed to assess for bleeding/airway trauma

Complication:

- Mucosal trauma → Granulation → Restenosis
  (prevented with laser/stent placement)

- Pneumothorax
- Pneumomediastinum
- Mediastinitis
- Bleeding

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:

CO_2 Laser

Neodynium : yttrium- Aluminum-garnet [Nd: YAG] Laser

Mech. Of Action:

Laser absorbed by tissues

Water temperature in tissues raised to 100ºC

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 borderingEsophagus/ 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:

- CO_2 Laser – Extensive equipment [Articulating arns 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 O_2

  Pigmented ETT
- Avoided by: Lower FiO_2, 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)

Venuta F (Ann Thorac Surg, 2002)

- 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 destuction is -15 to- 40^0 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

   Devascularization- Cell Death

Cryosensitive

- Skin
- Mucous Memb.
- Nerve
- Endothelium
- Granulation tissue

Cryoresistant

- Fat
- Cartilage
- Nerve sheath
- Connective tissue
- Fibrosis

- Microscopic epithelial & cartilagenous changes resolve over 4-6 wks.

Indications & Patient Selection

- Used only when palliation is reqd.
- Lesion shouldbe 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_2O cools the probe tip to – 89^0C

  Temp ↑ by 10^0Cper 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 protoudes 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: [Clin Chest Med, 1995]	600 pts. Most had Sq Cell Ca 1/3 pts. Received cryotherapy 78% subjective improvement
• Mathur et al: (Chest 1997)	Tumor removed in 18 of 20 pts. 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 Hz] is used to generate heat which coagulates, vaporizes or cuts tissue.
- Tissue resistance to current generates heat
- Low freq. Current [$<10^5$ Hz] stimulates nerves/muscles so this avoided.
- At 70^0C tissue coagulates, $>200^0$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 crytherapy]

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 FiO_2 used)
- Pacemaker/AICD – May result in devices malfunction

Argon Plasma Coagulation

- Mode of non contact electro-coagulation
- Tungsten electode creates 5000-6000V spark at tip of probe
- Ionize argon gas released at probe tip

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- Argon plasma

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- Coagulative Necrosis
- Coagulation depth- 2-3mm
- Repeat Bronchoscopy reqd. after 1-3 days to remove necrotic material
- Proper grounding & electrical safety must be ensured FiO_2 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

(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

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

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 constrainal form by outer co-axial catheter

- FOB done to define lesion & placement of skin markers Corresponding to distal & promal 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 withdrawl of the outer coltheper allows controlled deployment of stent under continuous fluroscopic monitoring.
- Delivery System is then easily removed through expanded sent.

COMPLICATIOS:

Granuloma formation

Infections Tracheitis

Stent Migration

Restenosis

Airway perforation

- Wood DE et al (Ann. Thorac Surg, 2003)
- 143 Pts.: 309 stent procedures
- Cause of CAO:

Benign-33%

Anastomotic, Tracheo Bronchomalacia Post-Intubation

Malignant- 67%

- 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

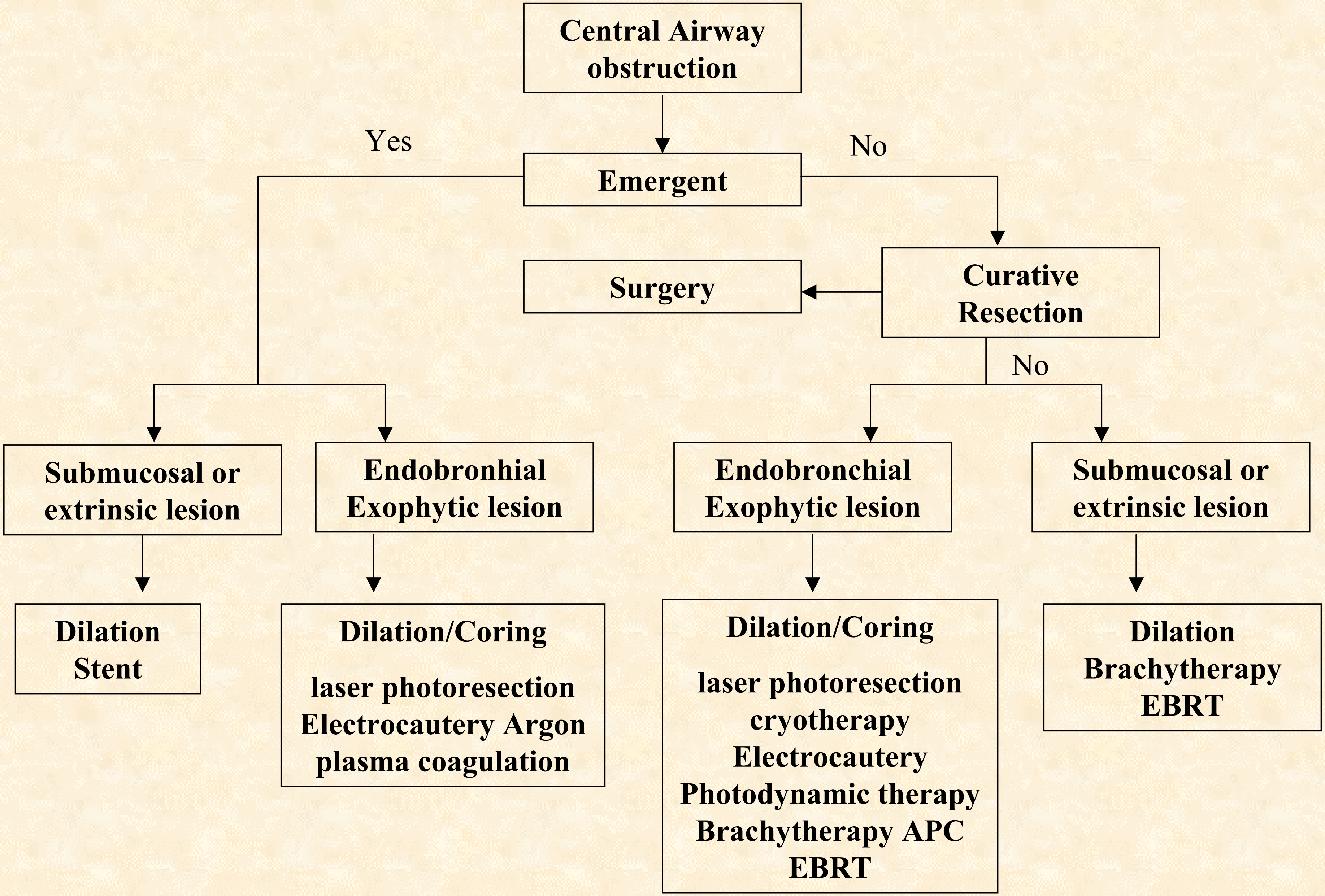
- Complications: 42%
  - Stent - Occlusion by secretions
    - Migration
    - Obstr. By granulation
  - Airway perforation – 1%
  - Improvement in symptoms: 95%
  - 95% maintained good palliation 28 mths after original stent in benign disease.
  - 85% maintained palliation for 4mths. in malignant disease.

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
Emergent
Yes
No
Curative Resection
Surgery
No
Submucosal or extrinsic lesion
Endobronhial Exophytic lesion
Endobronhial Exophytic lesion
Submucosal or extrinsic lesion
Dilation
Stent
Dilation/Coring
laser photoresection
Electrocautery Argon plasma coagulation
Dilation/Coring
laser photoresection
cryotherapy
Electrocautery
Photodynamic therapy
Brachytherapy APC
EBRT
Dilation
Brachytherapy
EBRT

Thanks