Flexible Bronchoscopy:
More Than Just a Diagnostic Tool

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Objectives

• Brief historical background on bronchoscopy
• Review variety of Indications for bronchoscopy
• Discuss role of bronchoscopy in central airway obstruction
  • Benign & malignant
• Discuss role of bronchoscopy in some chronic lung diseases
Brief Historical Background

• Indications have expanded over the years and likely will continue to expand

• Rigid bronchoscopy 1897 (*Gustav Killian*)
  • Visual inspection of trachea and proximal mainstem bronchi
  • Initially for removal of foreign bodies

*Fig 1* Rigid Bronchoscope
Brief Historical Background

• Flexible bronchoscope 1966 (*Shigeto Ikeda*)
  • Better visualization of upper lobes and inspection of distal segments of lower lobes
  • No need for general anesthetic
  • Better tolerated
  • Procedure could be performed as an outpatient

• Ongoing development of tools for use through the flexible scope
Indications for Bronchoscopy

• Inspection
• Diagnostic
• Therapeutic
• Research
Indications for Bronchoscopy:

**Inspection**

- Cough
  - After other extensive workup non-diagnostic
- Hemoptysis
  - To secure airway; insert endobronchial blocker; localize site of bleeding
  - Examine upper airway at same time
- Localized/fixed wheeze
  - Endobronchial tumor/foreign body
- Recurrent/Persistent PNA (in same location)
Indications for Bronchoscopy: Inspection

• Unexplained hoarseness/vocal cord paralysis
• Suspected TE fistula
  • Setting of esophageal cancer; XRT to chest
  • Pre-op evaluation in esophageal cancer (looking for invasion)
• Chest trauma
  • Disruption of tracheobronchial tree
Case for Diagnostic Indication
EBUS
Case for Diagnostic Indication
EBUS
Indications for Bronchoscopy: Diagnostic

- Adenopathy
  - Diagnosis – malignant/nonmalignant
  - Staging info

- Mass
  - TBBX
  - TBNA
  - TB Brush
  - ?BAL
Indications for Bronchoscopy: Diagnostic

- Interstitial Lung Disease
  - BAL
  - TBBX
- Non-Resolving Pneumonia
- Evaluating for pulmonary infections in critically ill patients
- Infiltrate in an immunocompromised host?
- Lung transplant:
  - Evaluate for rejection/infection
    - Surveillance/change in pulmonary function
    - Symptoms concerning for infection
  - Evaluate anastomosis
Indications for Bronchoscopy
Diagnostic

- Foreign body:
  - Known/suspected
- Persistent atelectasis/lobar collapse
- Localization of BP fistula
Indications for Bronchoscopy: Therapeutic
Indications for Bronchoscopy: Therapeutic

- Remove secretions/mucous plugs (IF conventional noninvasive techniques have been unsuccessful)
  - ‘Snot’ bronch
- Removal of foreign bodies
  - Rigid/flexible scope
- Difficult intubations
Indications for Bronchoscopy: Therapeutic

• Relief of Obstruction
  • Benign/Malignant
  • Debulking of tumor
  • Dilation of stenosis
• Therapy for Asthma
  • Bronchial Thermoplasty
• Closure of BP Fistula
• Bronchoscopic Lung Volume Reduction
Case #1: History/Physical

• 41 year old woman presenting with 1 year of dyspnea and cough that has gradually gotten worse
• Sometimes told she has ‘noisy’ breathing
• Sputum sometimes hard to expectorate
• No other significant medical history or family history
  • Remote intubation as a child
• No improvement with inhalers
• Exam unremarkable except insp/exp ‘wheeze’ over neck
Case #1: PFTs and Imaging

<table>
<thead>
<tr>
<th>Previous Study</th>
<th>Current Study: 02/05/18</th>
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<tbody>
<tr>
<td>FVC Liters</td>
<td>FVC 3.04 Liters</td>
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<tr>
<td>FEV1 Liters</td>
<td>FEV1 2.52 Liters</td>
</tr>
<tr>
<td>FEF25-75% L/sec</td>
<td>FEF25-75% 3.15 L/sec</td>
</tr>
<tr>
<td>PEF L/sec</td>
<td>PEF 3.84 L/sec</td>
</tr>
<tr>
<td>TLC Liters</td>
<td>TLC ( ) % impr by</td>
</tr>
<tr>
<td>RV Liters</td>
<td>RV ( ) % impr by</td>
</tr>
<tr>
<td>DLCO mL/mmHg/min</td>
<td>DLCO ( ) % impr by</td>
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Diagnosis: SUBGLOTTIC STENOSIS

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<th>DATE</th>
<th>FVC</th>
<th>FEV1</th>
<th>POST FEV1</th>
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<th>PEF</th>
<th>PI F</th>
<th>TLC</th>
<th>FRC-PL</th>
<th>RV</th>
<th>DLCO</th>
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<tr>
<td>CURRENT STUDY</td>
<td>3.04</td>
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<td>3.15</td>
<td>3.84</td>
<td>2.08</td>
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Spirometry

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<tr>
<th></th>
<th>Pre</th>
<th>Ref</th>
<th>95% CI</th>
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<th>% Ref</th>
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<tr>
<td>FVC Liters</td>
<td>3.04</td>
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<td>(2.9 - 4.2)</td>
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<td>FEV1 Liters</td>
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<td>2.87</td>
<td>(2.3 - 3.4)</td>
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<td>FEV1/FVC %</td>
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<td>(72.3 - 91.9)</td>
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Case #2 – Presentation/History

• 55 year old healthy man. Has had 1 year of dry cough and DOE, worse over last month.
  • Saw pulmonary and treated for asthma – no benefit
  • Saw ENT who scoped down to level of cords 3-4 months ago
  • EGD for GERD a few months ago – tolerated no problems
  • CT done few weeks prior to presentation because things ‘just not getting better’

• Otherwise healthy

• Exam mainly remarkable for insp/exp stridor auscultating over trachea (forced maneuvers but not with normal tidal breathing)
Case #2 - Spirometry

Flattening of expiratory limb suggesting variable intrathoracic defect
Case #2 - Images

Now what do we do?
What Next for Case 1 and 2?

• Send home to follow up in a few months?
• Send to ENT for emergent tracheostomy to secure airway/biopsy/debulk?
• Perform rigid bronchoscopy to secure airway/biopsy/debulk/dilate?
• Perform flexible bronchoscopy to secure airway/debulk/biopsy?
What Is Interventional Pulmonology (IP)?

• It is a subspecialty within pulmonary medicine that deals specifically with minimally invasive endoscopic and percutaneous procedures for diagnosis and treatment of neoplastic and non-neoplastic diseases of the airways, lungs, and pleura

• Performance of ‘Advanced’ diagnostic and therapeutic procedures
<table>
<thead>
<tr>
<th>Flexible Bronchoscopy</th>
<th>Rigid Bronchoscopy</th>
<th>Artificial Airways</th>
<th>Pleural Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic</td>
<td>Balloon/rigid dilation</td>
<td>Percutaneous tracheostomy</td>
<td>Thoracic US</td>
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<tr>
<td>EBBX</td>
<td>Mechanical debulking</td>
<td>Transtracheal oxygen catheter placement</td>
<td>Chest tube</td>
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<tr>
<td>TBBX</td>
<td>Heat</td>
<td>Tunneled pleural catheters</td>
<td>Medical pleuroscopy</td>
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<tr>
<td>TBNA</td>
<td>Laser</td>
<td>APC</td>
<td>Pleurodesis</td>
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<tr>
<td>EBUS</td>
<td>APC</td>
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<td>Pleural biopsies</td>
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<td>Therapeutic</td>
<td>Electrocautery</td>
<td>PDT</td>
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<td>Balloon Dilation</td>
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<td>Cryotherapy</td>
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<tr>
<td>Heat</td>
<td></td>
<td>Brachytherapy</td>
<td></td>
</tr>
<tr>
<td>Laser</td>
<td></td>
<td>Metallic &amp; silicone stents</td>
<td></td>
</tr>
<tr>
<td>APC</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Electrocautery</td>
<td></td>
<td>Y stent placement</td>
<td></td>
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<tr>
<td>PDT</td>
<td></td>
<td>Montgomery T tube placement</td>
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<tr>
<td>Cryotherapy</td>
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<tr>
<td>Brachytherapy</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Metallic Stent</td>
<td></td>
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</table>
Central Airway Obstruction

• Occlusion of >50% of trachea/mainstem bronchi, BI, or a lobar bronchus

• Qualitative Evaluation:
  • Benign/malignant
  • Mechanism of obstruction
  • What are the dynamic features?

• Quantitative Evaluation:
  • Vertical length
  • Location
  • Multifocal?

• Type of obstruction will often dictate therapeutic options

• Symptoms may not manifest until critical stenosis of 5-8 mm or new event exacerbates underlying stenosis
## Nonmalignant Central Airway Obstruction/Stenosis

<table>
<thead>
<tr>
<th>Benign Airway Tumors</th>
<th>Granulation tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squamous papilloma</td>
<td>ETT</td>
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<tr>
<td>Hamartoma</td>
<td></td>
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<tr>
<td>Lymphadenopathy</td>
<td></td>
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<tr>
<td>Sarcoidosis</td>
<td>Airway stents</td>
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<tr>
<td>Infectious (TB)</td>
<td>Foreign bodies</td>
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<tr>
<td>Vascular</td>
<td></td>
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<tr>
<td>Vascular Ring</td>
<td>Surgical anastomosis</td>
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<tr>
<td>Aneurysm</td>
<td></td>
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<tr>
<td>Cartilage</td>
<td></td>
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<tr>
<td>Relapsing Polychondritis</td>
<td></td>
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<tr>
<td>Pseudotumor</td>
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<tr>
<td>Endobronchial pseudotumor</td>
<td></td>
</tr>
<tr>
<td>Hyperdynamic</td>
<td></td>
</tr>
<tr>
<td>Tracheomalacia</td>
<td></td>
</tr>
<tr>
<td>Bronchomalacia</td>
<td></td>
</tr>
</tbody>
</table>

### Other

- Goiter
- Mucous plug
- Vocal cord paralysis
- Airway hematoma
- Burn/smoke injury
- Pill aspiration
- Idiopathic subglottic stenosis
- Wegener’s
- Relapsing Polychondritis
- Squamous papilloma
- ETT
- Trach tubes
- Airway stents
- Foreign bodies
- Surgical anastomosis
- Idiopathic subglottic stenosis
- Wegener’s
- Post Radiation
- Post Transplant
- Vocal cord paralysis
- Airway hematoma
- Burn/smoke injury
- Pill aspiration
## Bronchoscopic Ablative Techniques

<table>
<thead>
<tr>
<th>Modality</th>
<th>Effects</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Restoration of Airway Lumen, %</th>
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</thead>
<tbody>
<tr>
<td>Nd:YAG laser</td>
<td>Coag and vaporization</td>
<td>Excellent debulking</td>
<td>SSS, often requires rigid</td>
<td>83-93%</td>
</tr>
<tr>
<td>Electrocautery</td>
<td>Superficial coagulation</td>
<td>Safety, multiple tools available, inexp</td>
<td>Frequent cleaning of probe</td>
<td>89%</td>
</tr>
<tr>
<td>APC</td>
<td>Superficial</td>
<td>Safety</td>
<td>Ineffective for in depth tissue debulking</td>
<td>91%</td>
</tr>
<tr>
<td>Cryotherapy</td>
<td>Delayed tissue destruction (1-2 weeks)</td>
<td>Safety; retrieval of foreign object, mucous plugs, clots</td>
<td>Not for acute debulking; multiple procedures</td>
<td>78%</td>
</tr>
<tr>
<td>Brachytherapy</td>
<td>Delayed but in depth destruction</td>
<td>Long lasting effects</td>
<td>May predispose to hemorrhage</td>
<td>75-85%</td>
</tr>
<tr>
<td>PDT</td>
<td>Delayed</td>
<td>Rel long lasting effects</td>
<td>SSS, multiple bronchoscopies, skin photosensitivity</td>
<td>46-67%</td>
</tr>
</tbody>
</table>

Adapted from Wahidi MM, Herth FJ, Ernst A. Chest 2007;131:261-274
Benign Obstruction Stenosis Balloon Dilation

• In most patients rates of immediate success and short term success (2-6 weeks) are high
  • Improved airway patency – radiologic and direct visualization
  • Improved symptoms
  • Improved lung function

• Longer term success is unpredictable
  • Multiple procedures
  • Combination of electrocautery and balloon dilation often needed together

• Less success
  • Localized malacia
Case #1: Post Intervention
Case #2: Post Intervention
Malignant Airway Obstruction

What can we do?

• External beam XRT
• Systemic therapy
• Local therapy via bronchoscopy – debulking, stent placement
• Discuss palliation of symptoms without invasive interventions
## Malignant Central Airway Obstruction

<table>
<thead>
<tr>
<th>Primary Endoluminal Malignancy</th>
<th>Metastatic Carcinoma to airway</th>
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<tbody>
<tr>
<td>Bronchogenic</td>
<td>Bronchogenic</td>
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<tr>
<td>Adenoid Cystic</td>
<td>Renal cell</td>
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<tr>
<td>Mucoepidermoid</td>
<td>Breast</td>
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<tr>
<td>Carcinoid</td>
<td>Thyroid</td>
</tr>
<tr>
<td>Plasmacytoma</td>
<td>Colon</td>
</tr>
<tr>
<td>Laryngeal and nasopharyngeal carcinoma</td>
<td>Sarcoma</td>
</tr>
<tr>
<td>Esophageal carcinoma</td>
<td>Melanoma</td>
</tr>
<tr>
<td>Lymphadenopathy</td>
<td>Mediastinal Tumors</td>
</tr>
<tr>
<td>Associated with above malignancies</td>
<td>Thymic and thyroid carcinomas</td>
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<tr>
<td>Lymphoma</td>
<td>Germ cell tumors</td>
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</table>
Malignant Airway Obstruction

• Estimated that up to 30% of patients diagnosed with primary lung cancers can present with central airway disease
  • Progressive obstruction contributes to morbidity
  • Tracheal/carinal obstruction
    • Progressive dyspnea and slow asphyxiation
  • Bronchial obstruction
    • Cough/breathlessness
    • Retained secretions
    • Recurrent infections

• Treatment often palliative and rarely curative
Malignant Central Airway Obstruction

• Goals of therapeutic bronchoscopy
  • Palliate symptoms
  • Improve functional status
Mechanisms of Malignant Obstruction

Endoluminal  Extraluminal  Mixed
Malignant Obstruction - Endobronchial
Malignant Obstruction - Combination
Malignant Obstruction – External Compression
Malignant Airway Obstruction

• What ‘can’ we do bronchoscopically?
  • What is technically feasible?
  • Can the patient tolerate a procedure?
  • Debulk alone? Stent alone? Debulk and stent?

• Can doesn’t always mean ‘should’
  • How symptomatic is the patient?
  • Is there ‘salvageable’ lung beyond the obstruction?
  • Are there comorbidities?
  • What is the prognosis?
  • Will the intervention ‘make a difference?’

• Variable approaches
  • Unlikely that one ‘debulking’ mechanism superior to another
  • Combination of debulking +/- stenting
Debulking:
Tools Available to Us

• Thermal Therapy
  • Heat:
    • Nd:YAG Laser; APC; Electrocautery
  • Cold
    • Cryotherapy
• Other: PDT, Brachytherapy
• Baskets/nets/snares/probes
• Variety of forceps
• Balloons
Tracheobronchial Stents

• Re-establish patency of compressed/ strictured airways from benign or malignant process
• Sealing of fistulas
• Rarely for benign conditions like tracheomalacia or granulation tissue
• Often combined with other modalities
  • Debulking
  • Balloon dilation
Airway Stenting

• Reasoning
  • Will it prevent airway reocclusion?
  • Does it provide additional benefit to mechanical debulking?
  • Consider long term complications
  • Palliation of symptoms

• Bridging while therapy is initiated

• Silicone and metal

• Placement via rigid or flexible scope
  • Largely institution dependent
Tracheobronchial Stents
Bronchoscopy in Chronic Obstructive Lung Diseases

• COPD/Emphysema
• Chronic Asthma
Emphysema - Background

Tissue destruction and enlargement of airspaces

- Decreased elastic recoil; decreased support of small airways
  - Impaired exhalation
  - Hyperinflation and air trapping
    - Compress normal lung and lead to low V/Q ratios
    - Additional impaired gas exchange and hypoxemia

- High V/Q ratios → physiologic dead space
  - Reduced efficiency, increased work, impaired gas exchange

Medical therapy does not directly address the hyperinflation
Treatment of Emphysema

- LVRS an option to select group of patients
  - High morbidity and mortality
- Investigations into bronchoscopic lung volume reduction
Bronchoscopic Lung Volume Reduction

• Endobronchial valve
  VENT – Zephyr Valve
• Airway bypass
  EASE
• Aeris Medical
  Clotting Liquid (BLVR)
• Uptake Medical
  Steam
• Spiration
  One way valve
Endobronchial Valves

• Bronchoscopic lung volume reduction for severe emphysema
• Induce lobar atelectasis but dependent on absence of collateral ventilation
• Air escapes during expiration but cannot enter during inspiration
• Complications
  • Anesthesia related
  • Expectoration of valve
  • Bleeding
  • Pneumothorax
Spiration Intrabronchial Valve

- Not approved for treatment of emphysema but can be used in select case for closure of post op persistent air leaks
Zephyr Valve Design

- One way valve allowing air out with exhalation but not allowing inspired air into targeted region
- Allows drainage of secretions
- Silicone valve supported by nitinol self-expanding retainer
- Valve loaded onto deployment device and passed through working channel of bronchoscope
- Designed to be removable if necessary
Bronchoscopic Lung Volume Reduction

• LIBERATE Trial
  • 190 subject; severe heterogeneous emphysema and no collateral ventilation
  • Random assignment
    • ZEPHYR valve or standard of care
  • AT 12 months :
    • 48% with EBV and 17% with SOC had improvement in FEV1 >= 15%
    • Between group dif all significant for FEV1, 6MWD, dyspnea, QOL
    • 26% pneumothoraces in EBV group
    • 4 deaths in first three months in EBV group
The ‘Mechanical’ Side of Asthma

- Airway hyperresponsiveness
- Intermittent obstruction
  - Mucous plugging
  - Airway smooth muscle contraction
    - Variety of triggers
    - Increased mass of airway smooth muscle
Bronchial Thermoplasty

• Delivery of radiofrequency energy to the airway wall

• Objective
  • To reduce the contractile ability of airway smooth muscle
  • Utility based on supposition that blockade of ASM will cause amelioration of symptoms and reduce exacerbations (by means of reducing bronchoconstriction)

• Heat tissue to 65º C
  • Reduce smooth muscle mass
  • Avoid tissue destruction and scarring
Bronchial Thermoplasty in Humans

- Airways reached with bronchoscope
- Expandable basket with four electrode arms opened to make circumferential contact with airway
- Targets airways distal to mainstem bronchi down to 3 mm diameter

Bronchial Thermoplasty

- Local application of methacholine
  - Left: received RFA
  - Right: untreated airway

Cox, et al. AJRCCM. 2004
Bronchial Thermoplasty

• FDA approved for severe persistent asthma despite high dose inhaled steroid and LABA, nonsmoker, no life threatening exac, < 3 hosp in last 12 months, FEV1 ≥ 60
• 3 procedures 3 weeks apart
• Overall when looking at several trials and systematic reviews, BT compared with sham may reduce severe exacerbations
• More trials needed to better delineate its role
Conclusions

• Flexible bronchoscopy is a valuable tool with many indications
• There are a variety of interventions available via flexible bronchoscopy to restore airway patency/relieve symptoms in central airway obstruction
  • Choice of intervention is largely institution/physician dependent
• Bronchoscopy has found a role in select patients with chronic obstructive lung disease
Questions?

Thank You!