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Interventional Pulmonology: Therapeutic Management of Airway Diseases

Rebecca Priebe MSN, ACNP-BC, FCCP

Objectives

- Describe the sub-specialty of Interventional Pulmonology
- Understand the complications of airway stents
- List the Benefits of Bronchoscopic Lung Volume Reduction

Agenda

- Overview IP
- Tracheal and Bronchial stenosis
- BLVR and treatment for collateral ventilation
- Case Study: Complex malignant airway obstruction

What is Interventional Pulmonology??

- **Pulmonary Medicine sub-specialty**
- **Procedure-based service**
- **Evaluation and Management of complex thoracic diseases of the airways, lung parenchyma, and pleural space**
- **Provides advanced diagnostic and therapeutic minimally invasive procedures, which aid in the treatment of benign and malignant diseases**

History of Interventional Pulmonology??

1876 — 1st reported bronchoscopy by Dr. Gustav Killian

1966 — Modern-day, flexible bronchoscope developed

1990 — First rigid bronchoscopy with silicone stent insertion by Dr. JF Dumon

2001 — Creation of interventional pulmonology

2004 — First EBUS bronchoscope

2006 — Electromagnetic navigational bronchoscopy

2013 — Interventional pulmonology certification exam established

2017 — IP fellowship certification programs

2018 — Robotic bronchoscopy and BLVR

2020 — Advanced bronchoscopy certification

2022 — Cone-beam CT with bronchoscopy

2024 — ACGME Accreditation

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Panchabhai et al. *Ann Am Thorac Soc*. 2015;12:631; Lee et al. *J Bronchology Interv Pulmonol*. 2015;22:189; Shafiq et al. *Ann Am Thorac Soc*. 2019;16:786; Musani et al. *J Bronchol Intervent Pulmonol*. 2020;27:223;
Pic Credit: Henry Ford Health, Olympus and Wikipedia.

Airway Procedures

Flexible Bronchoscopy

- **Diagnostic**
  - **Infection**
  - **Transplant surveillance**
  - **Endo-, cryo- or trans-bronchial biopsy**
  - **Custom tracheostomy**

- **Therapeutic**
  - **Bronchoscopic lung volume reduction (BLVR)**
  - **Bronchial thermoplasty**
  - **Foreign body removal**
  - **Control of bleeding**
  - **Photodynamic therapy**
  - **Air leak management with valves**

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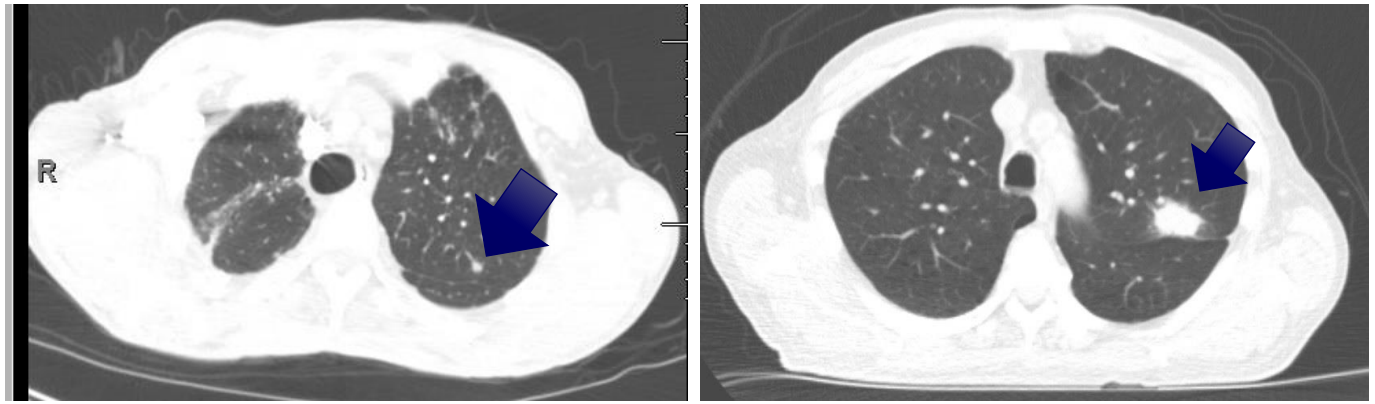
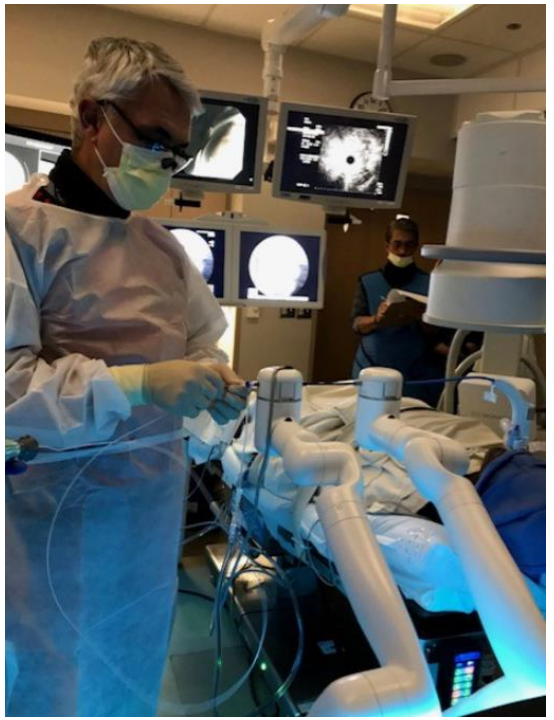
Picture credit: Henry Ford Health.

Airway Procedures

Robotic Assisted Navigational Biopsies

- **Diagnostic**
  - **Lung Nodule/Mass biopsy**





Picture credit: Henry Ford Health.

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Airway Procedures

Endobronchial Ultrasound Biopsy of Lymph nodes or Masses (EBUS)

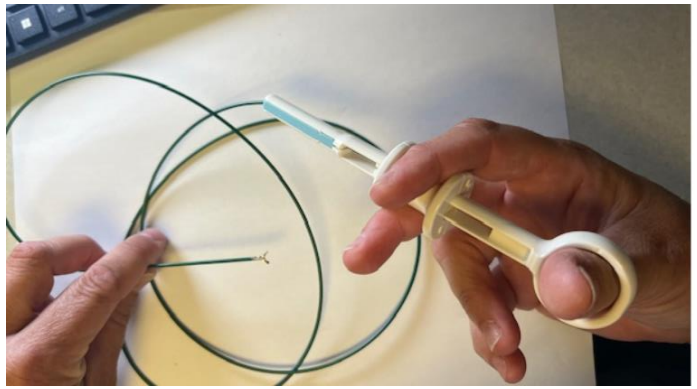
- **Diagnostic**
  - **Assessment of lymphadenopathy**
  - **Biopsy of lesions abutting the central airways**

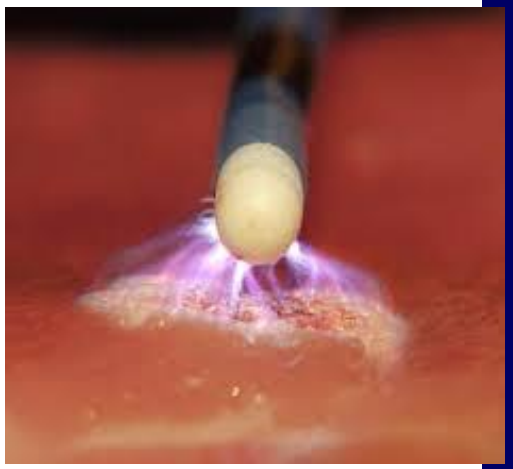
Pic credit: https://onewelbeck.com/tests-diagnostics/endobronchial-ultrasound-ebus/and www.drardakiani.com.

Airway Procedures

Rigid Bronchoscopy

- **Malignant or Benign Disease:**
  - **Thermal ablation**
  - **Balloon dilation**
  - **Mechanical debulking with forceps**
  - **Stent placement**





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Picture credit: Henry Ford Health.

Pleural Procedures

- Thoracic Ultrasound
- Thoracentesis
- Chest tube placement and management
- Medical Pleuroscopy
- Pleural biopsy
- Chest tube Pleurodesis
- Fibrinolytic therapy via chest tube
- Indwelling pleural catheter placement and management

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Picture credit: Henry Ford Health.

Tracheal and Bronchial Airway Stenosis

Airway Stenosis

Bronchial

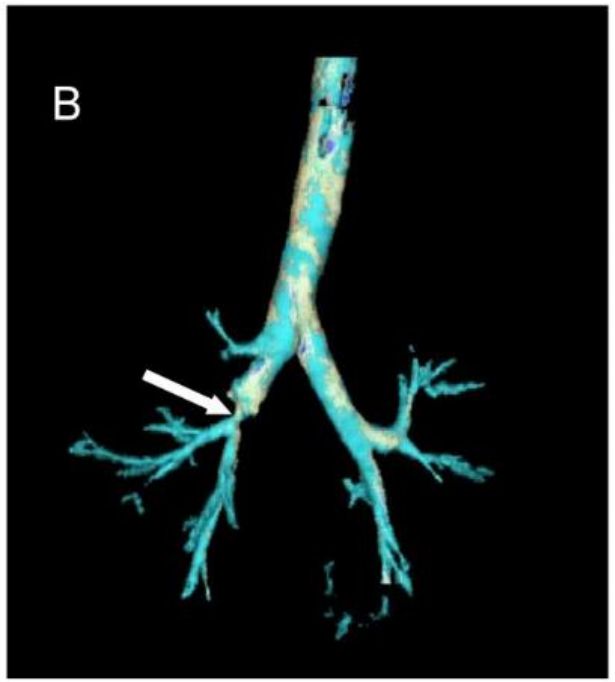


Image credit: BioMed Central. Crit Care. 2007;11:R94

Tracheal

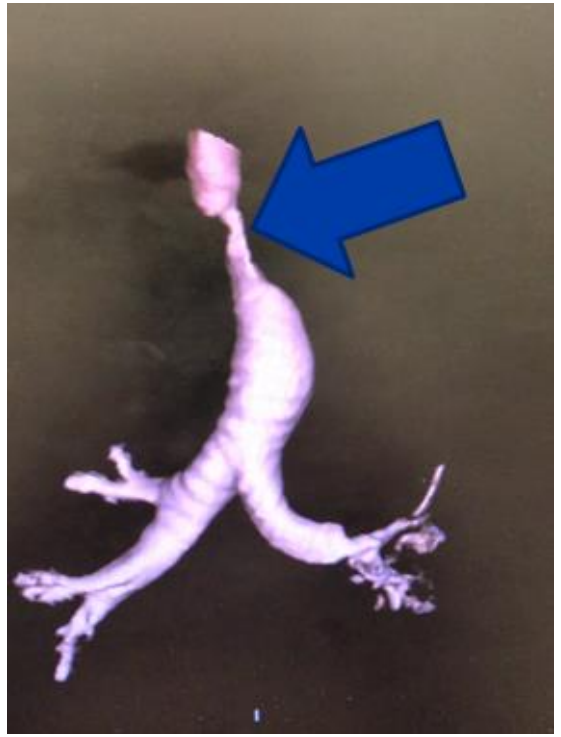


Image credit Henry Ford Health

Factors to Determine Surgery vs Bronchoscopic Intervention

- Type/etiology
  - Benign or Malignant
- Location
- Extent
- Severity
- Functional impairment
- Recurrence

Etiology of Benign Airway Stenosis

Tracheal Stenosis

- Post-intubation
- Post-tracheostomy
- Connective tissue disorders
- Post-radiation
- Local insult (infection, inhalation, intubation injury)

Bronchial Stenosis

- Injury
- Anastomosis failure (transplant)
- Post-lobar resection
- Infection
- Radiation
- Connective tissue disorders

Agrawal. Respir Med. 2021;187:106582.

Etiology of Malignant Stenosis/Obstruction

- Tumor growth into the airway
- Can develop into malignant airway obstruction
- Can cause lung collapse, hypoxia, and respiratory failure

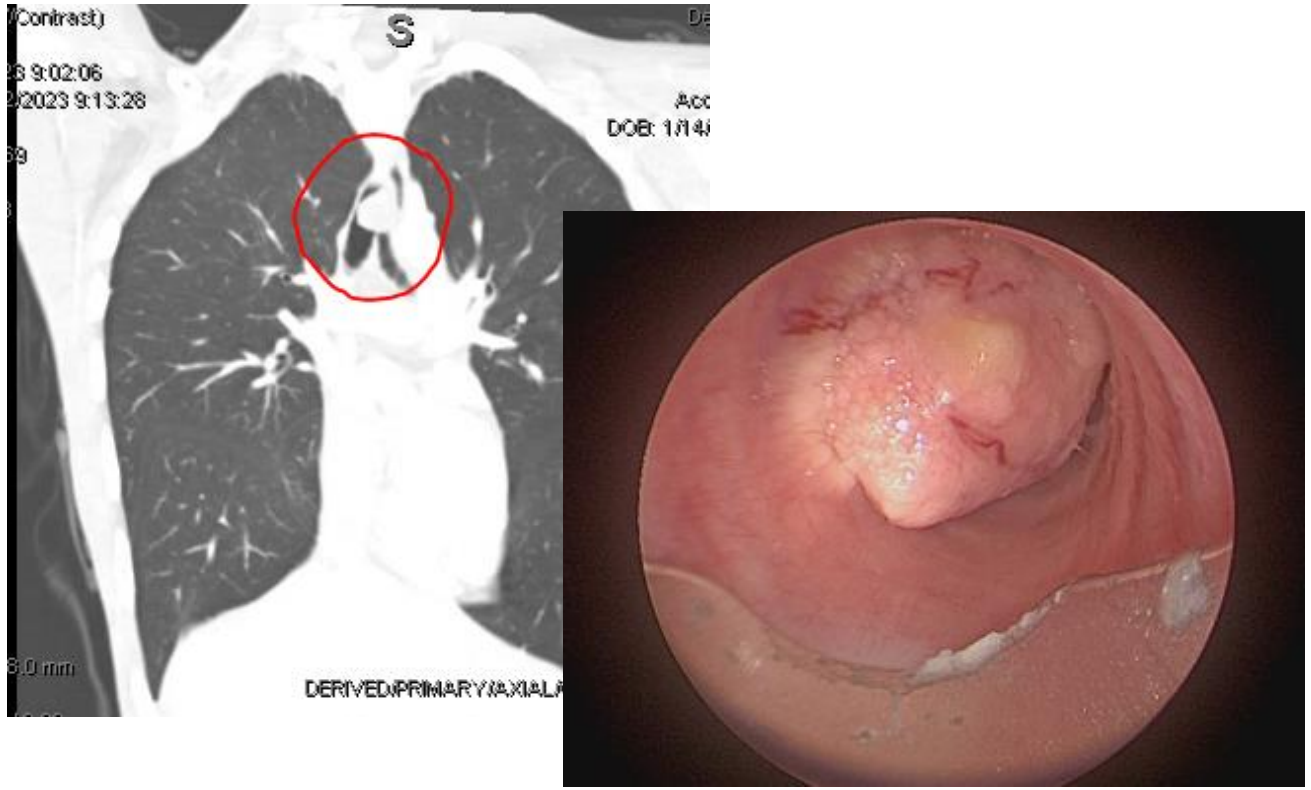
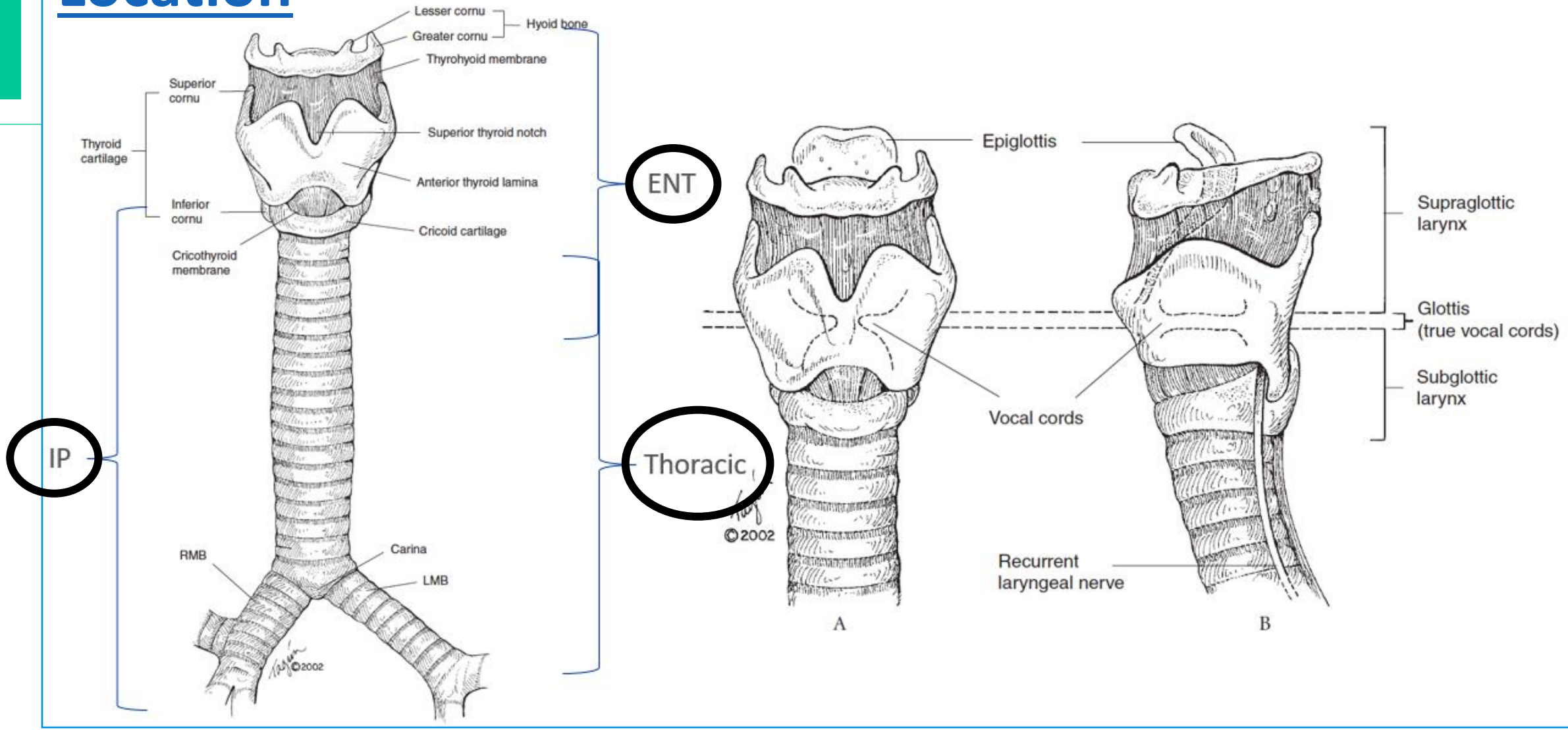


Image credit Henry Ford Health.

Brady. StatPearls. 2023. Mudambi. J Thorac Dis. 2017;9:S1087. Oberg. AME Med J. 2018;3:115.

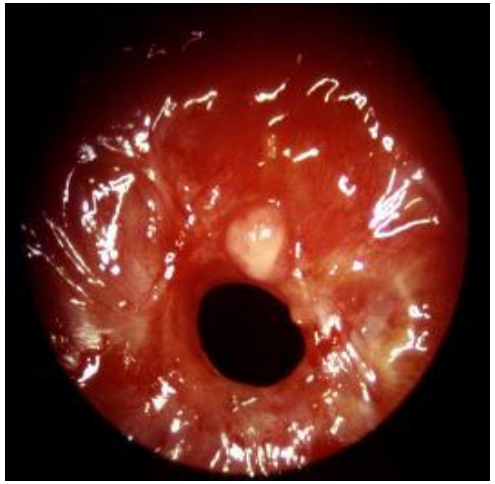
Location



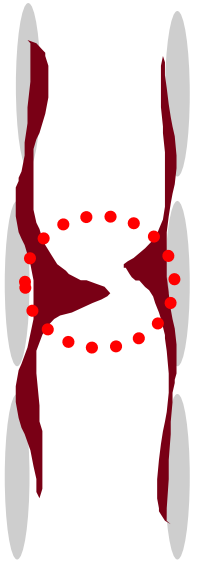
Slide courtesy of Drs Robert Baird and Tim Murgu.

Extent of Stenosis

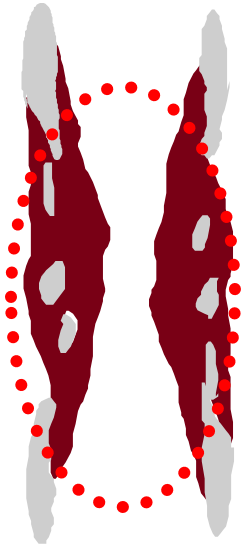
Normal Airway



Simple



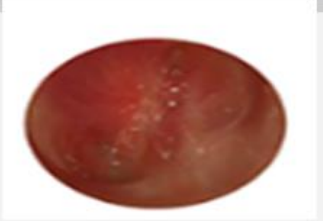
«Mucosal» disease



«Intra-mural» disease

Complex

Severity: Cotton-Myer Grading System

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

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This figure is modified by Filauro. Front Pediatr. 2019;7:532. Creative Commons Attribution License 4.0. No changes made.

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Symptomatology

- **Mild**
  - **Dyspnea with exertion only**
  - **Typically, tracheal diameter of 8 mm**
- **Moderate**
  - **Dyspnea at rest**
- **Severe**
  - **Dyspnea at rest**
  - **Stridor**
  - **Difficulty clearing secretions**
  - **Recurrent lung infections**
  - **Typically, reduction to 5 mm diameter**

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. Eur Arch Otorhinolaryngol. 2003:260:118. Sabath.

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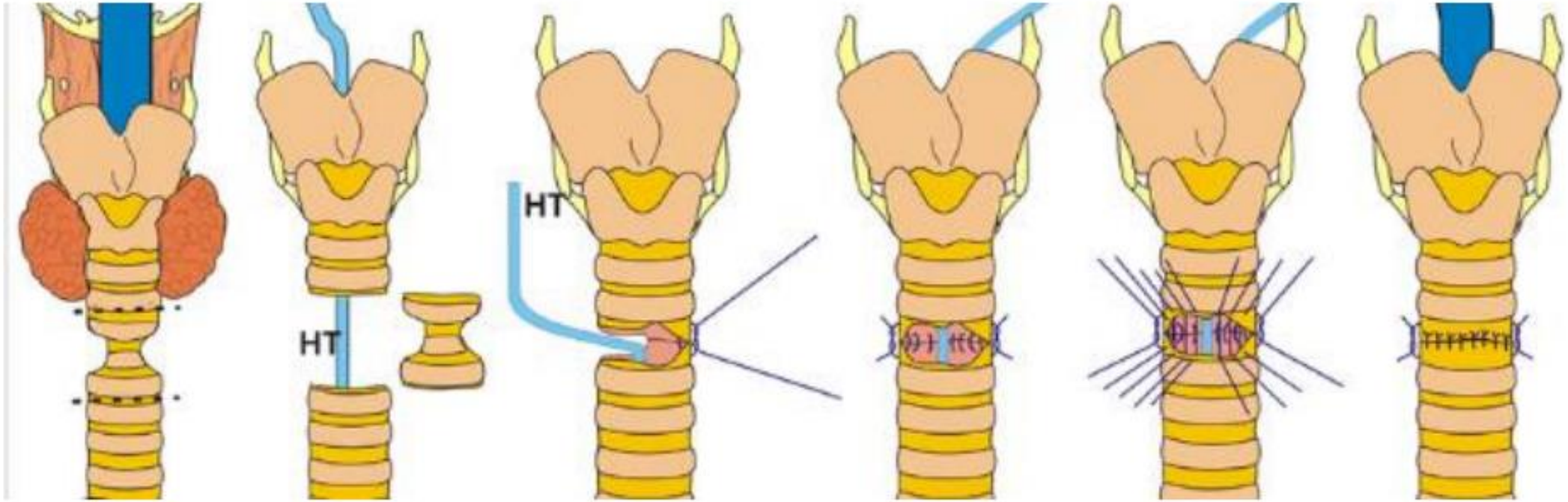
Surgical Treatment

- **Tracheal resection**

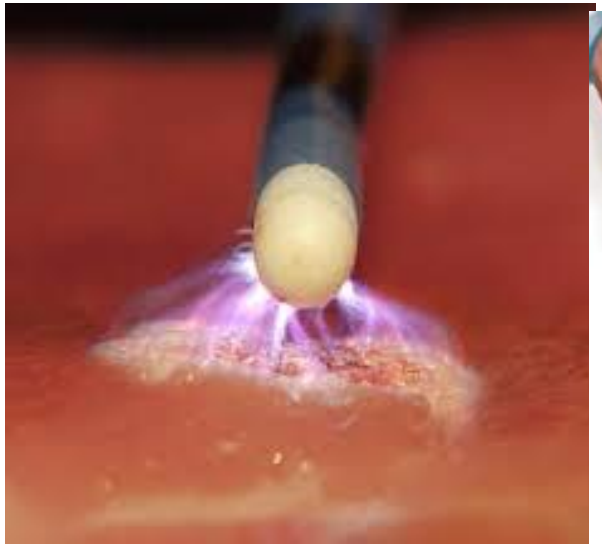


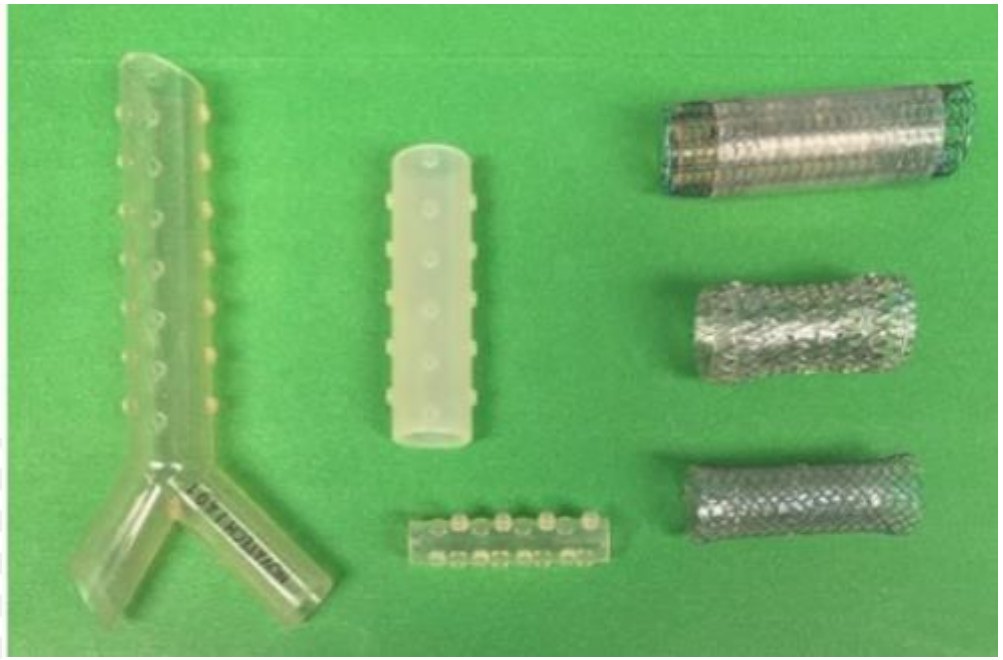
Friedel. GMS e-journal. 2003:1:10.

Slide credit: CAPSAPP

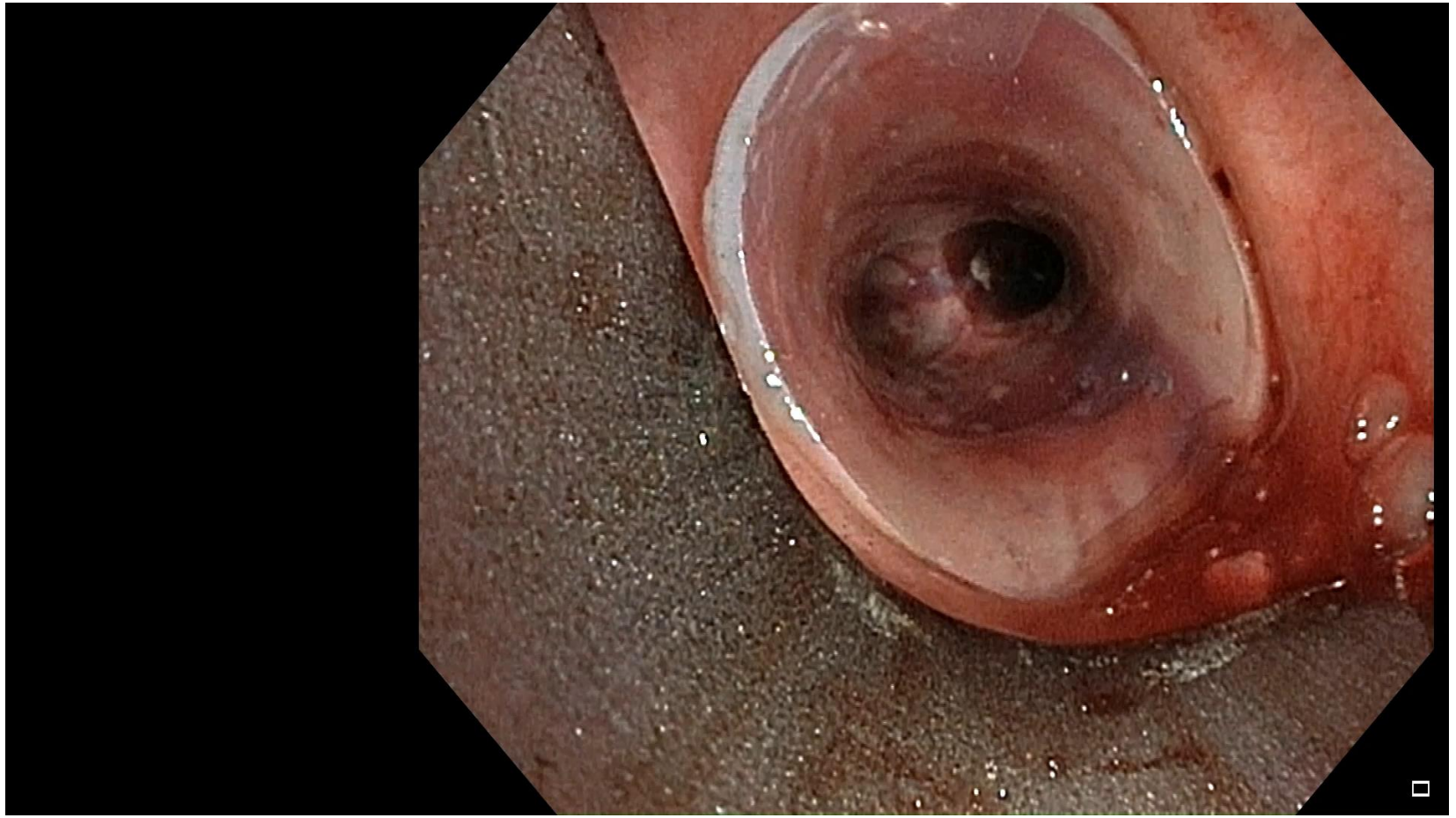
Treatment Options: Rigid Bronchoscopy

- Thermal ablation
- Balloon dilation
- Stent placement





Tracheal-Bronchial Stents



Complications of airway stents

- Cough and increase in mucous
- Infection
- Granulation tissue formation around the edges of the stent
- Obstruction
- Metal stent Fracture
- Migration
- Poor patient tolerance

Respiratory Therapy considerations with Tracheal stent

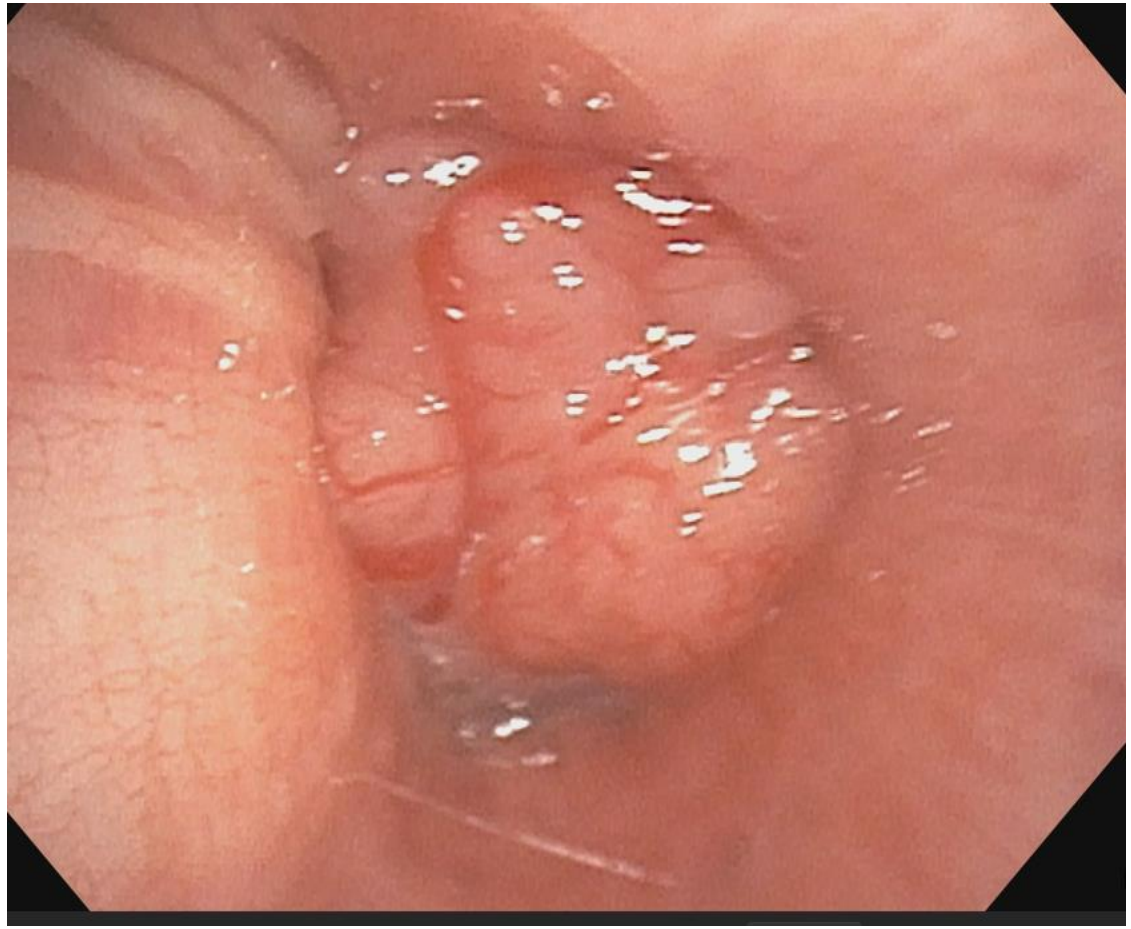
- **Difficulty Airway Flag**
- **Stent Clearance Medications:**
  - Albuterol 2.5mg nebulized Twice Daily
  - Mucomyst 20% 4ml nebulized once daily –or- Hypertonic saline 3ml nebulized Twice daily
- **Endotracheal tube placement**
  - Fiber-optically done to assure ETT above or in the stent
  - ETT size in relation to stent diameter

ETT to Stent Diameter

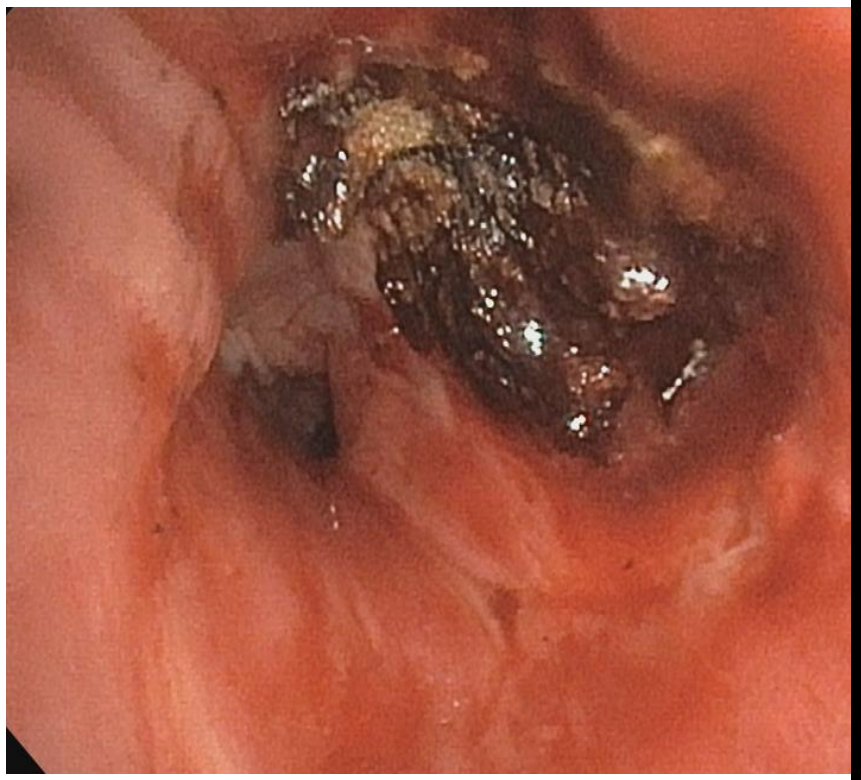
Endotracheal Tube	Tracheal Stent (mm)
5	<12
6	12-14
7	16
8	18

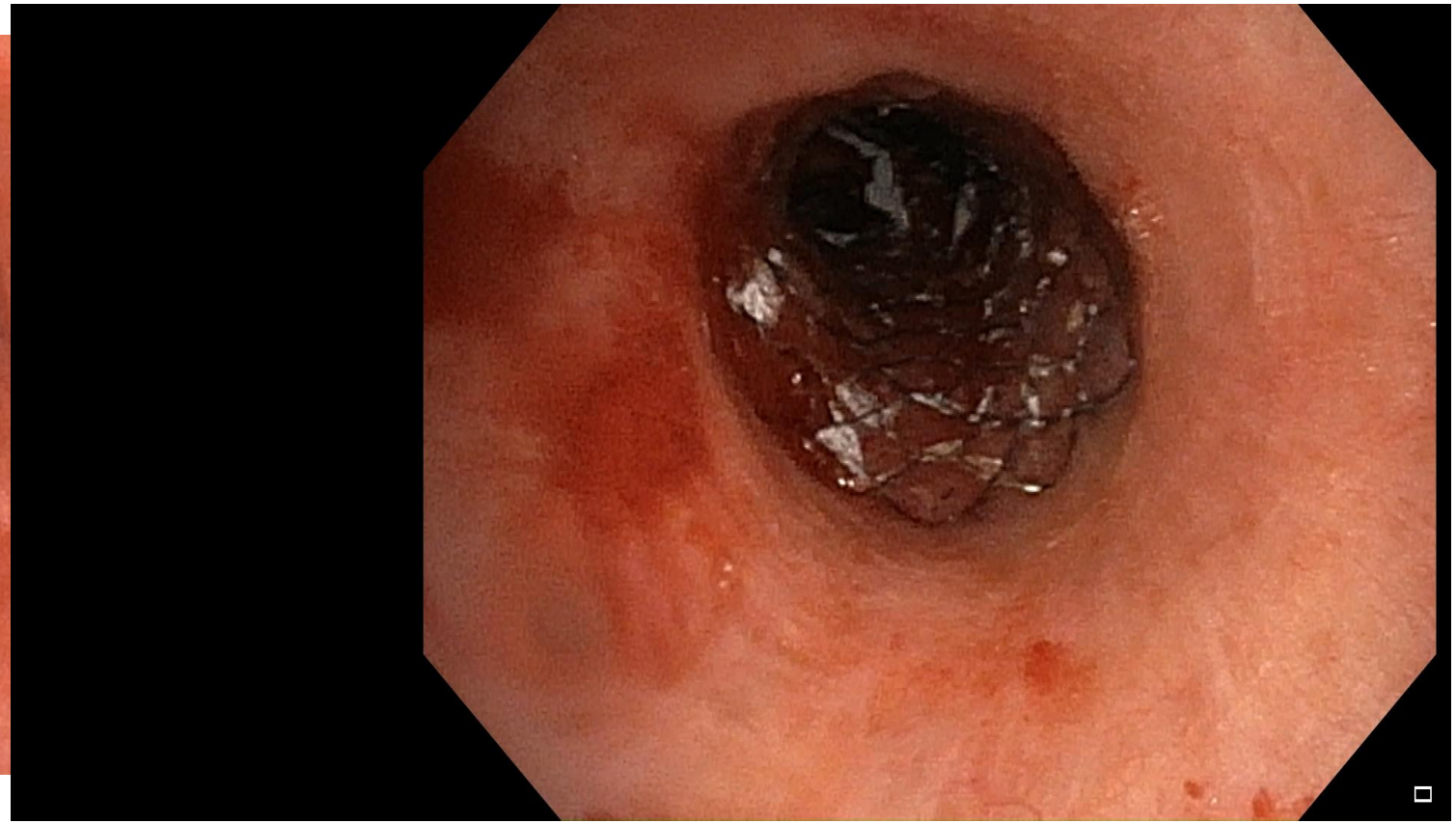
Malignant Airway obstruction Example

62 y/o female, former smoker who presented with dyspnea, cough and hemoptysis. Found to have a left upper lobe tumor – biopsied to be non-small cell carcinoma - causing malignant airway obstruction



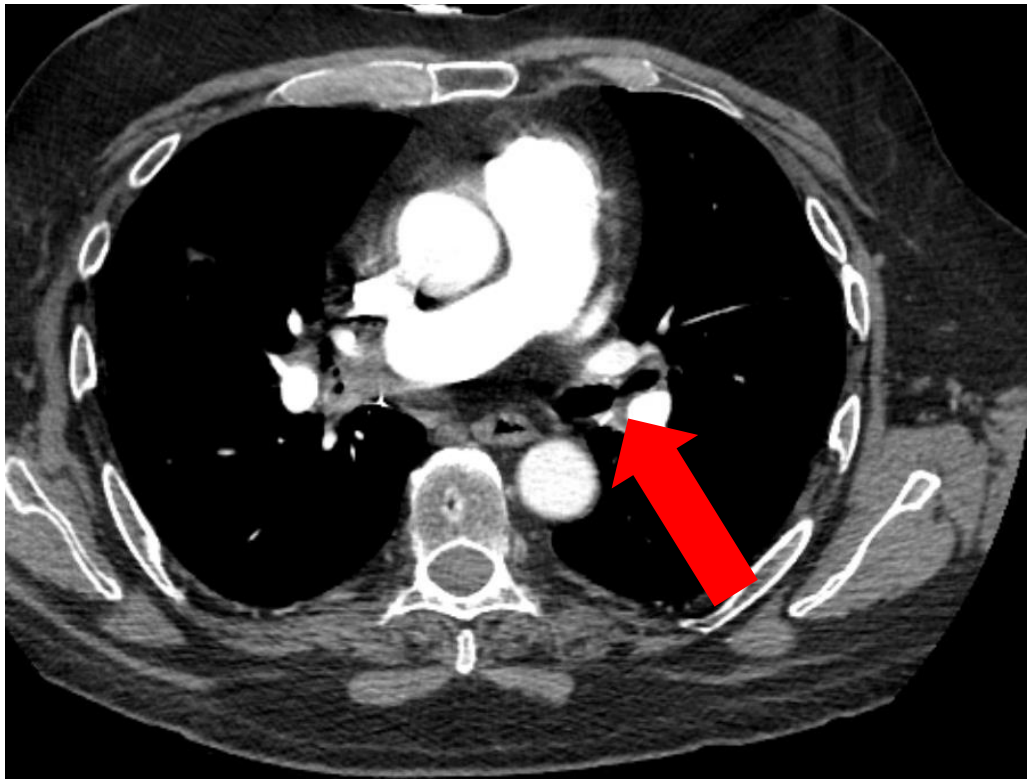
s/p Rigid bronchoscopy and self-expanding metal stent placement

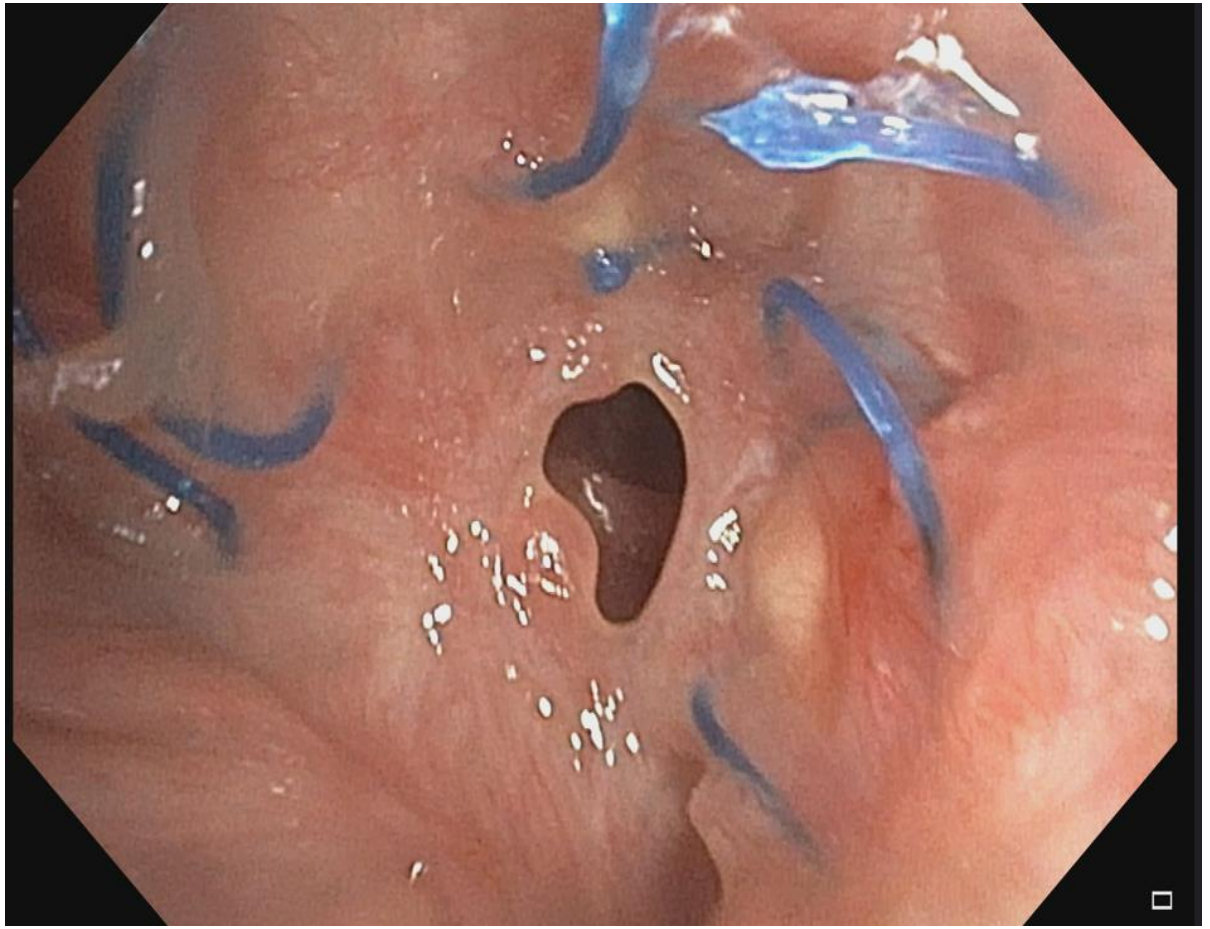




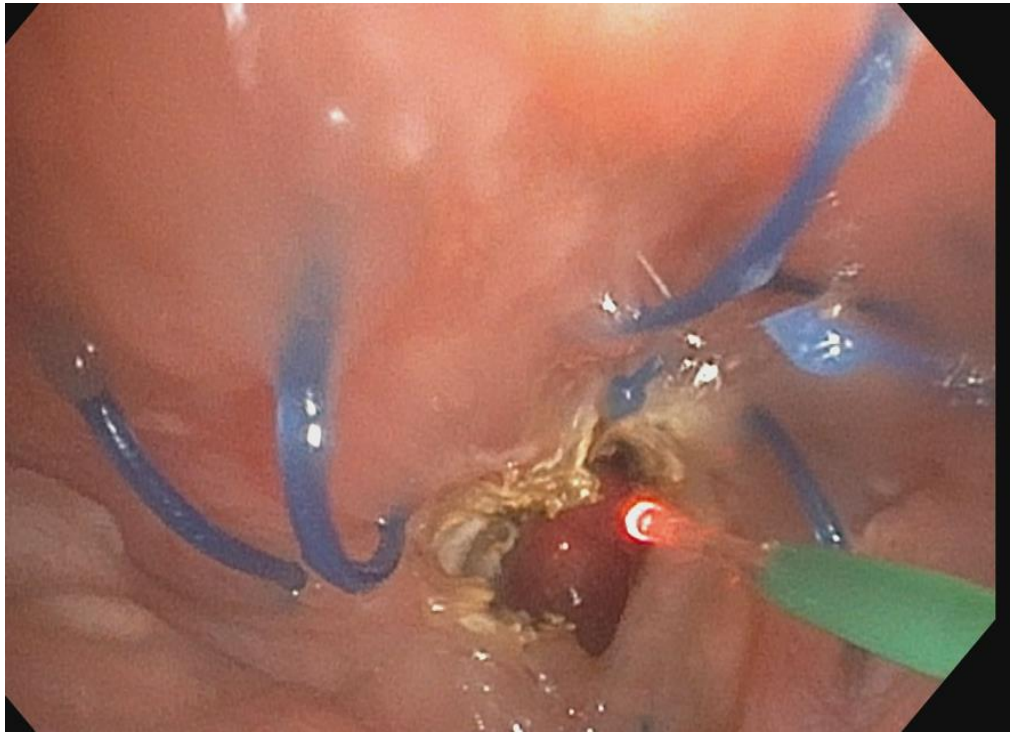
Benign, Anastomosis stenosis example

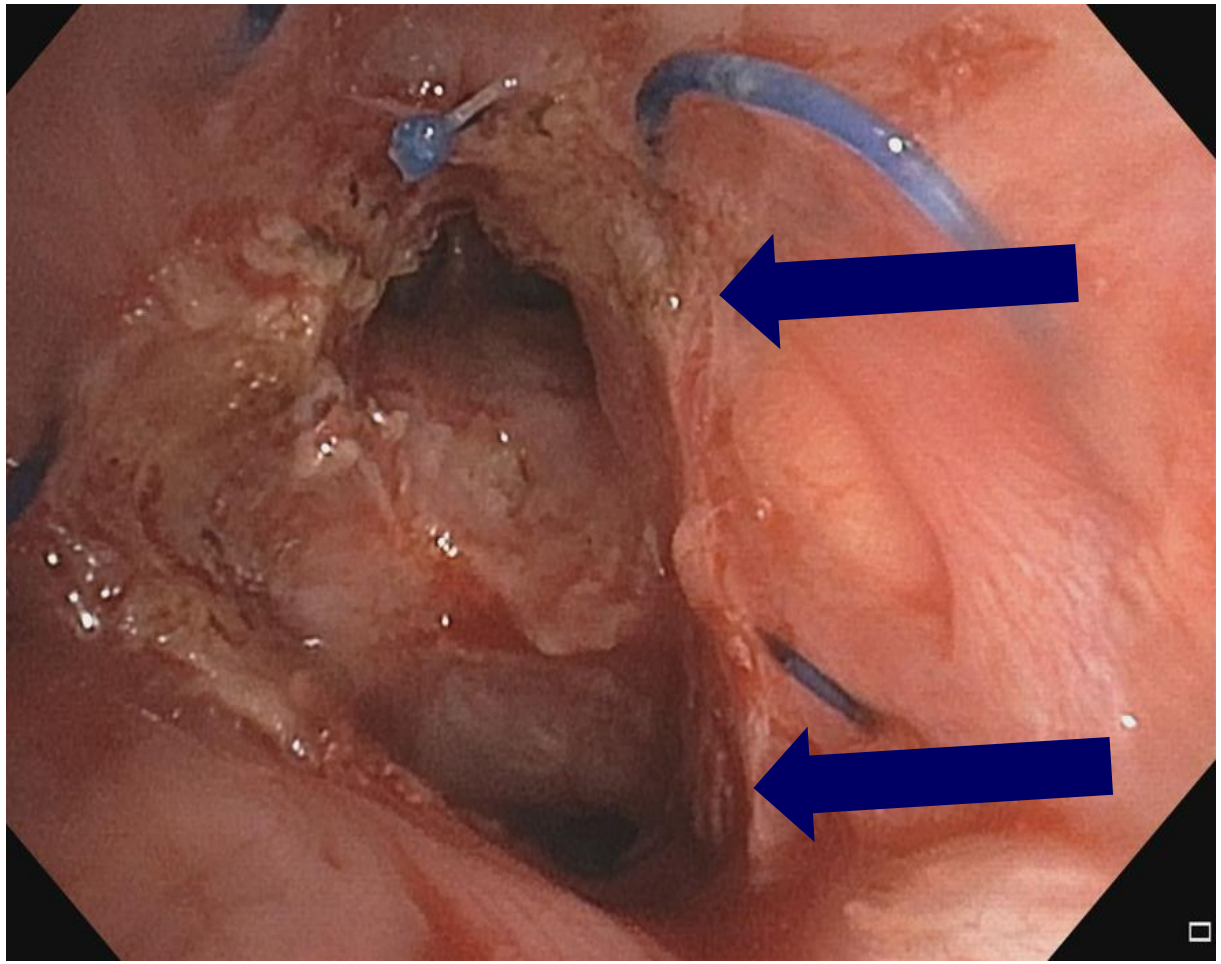
56 y/o Male with bilateral lung transplant complicated by left lung anastomosis bronchial stenosis





s/p rigid bronchoscopy with laser incisions and balloon dilation



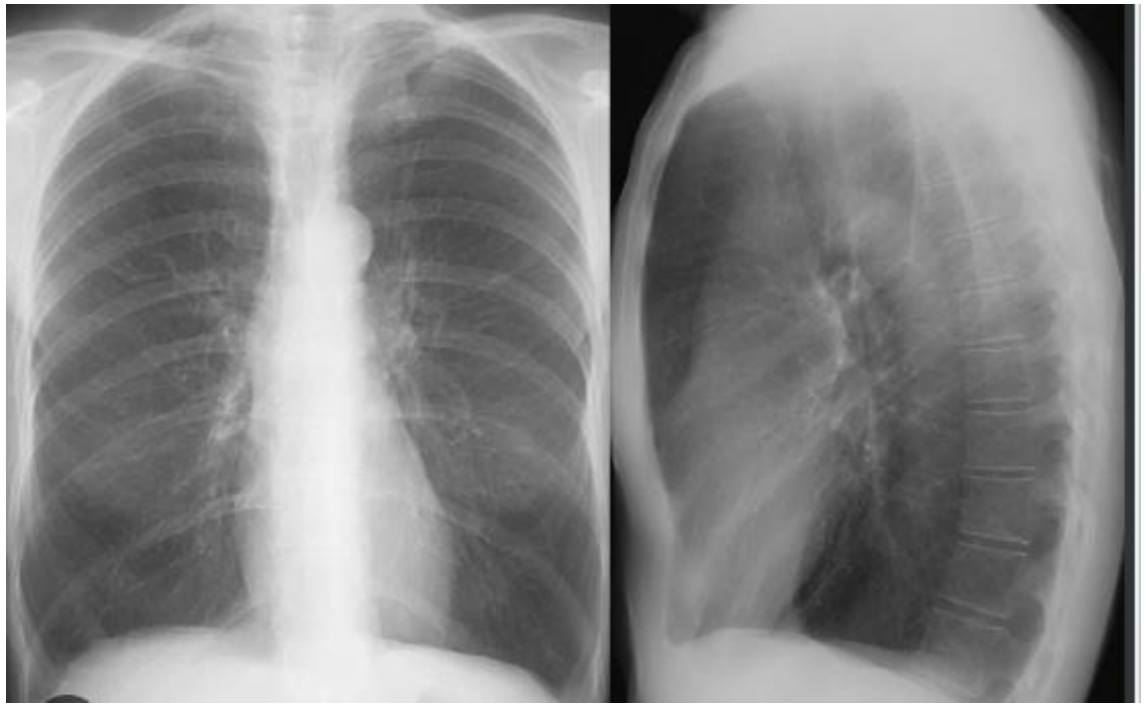


Bronchoscopic Lung Volume Reduction for Severe Emphysema

Emphysema Physiology

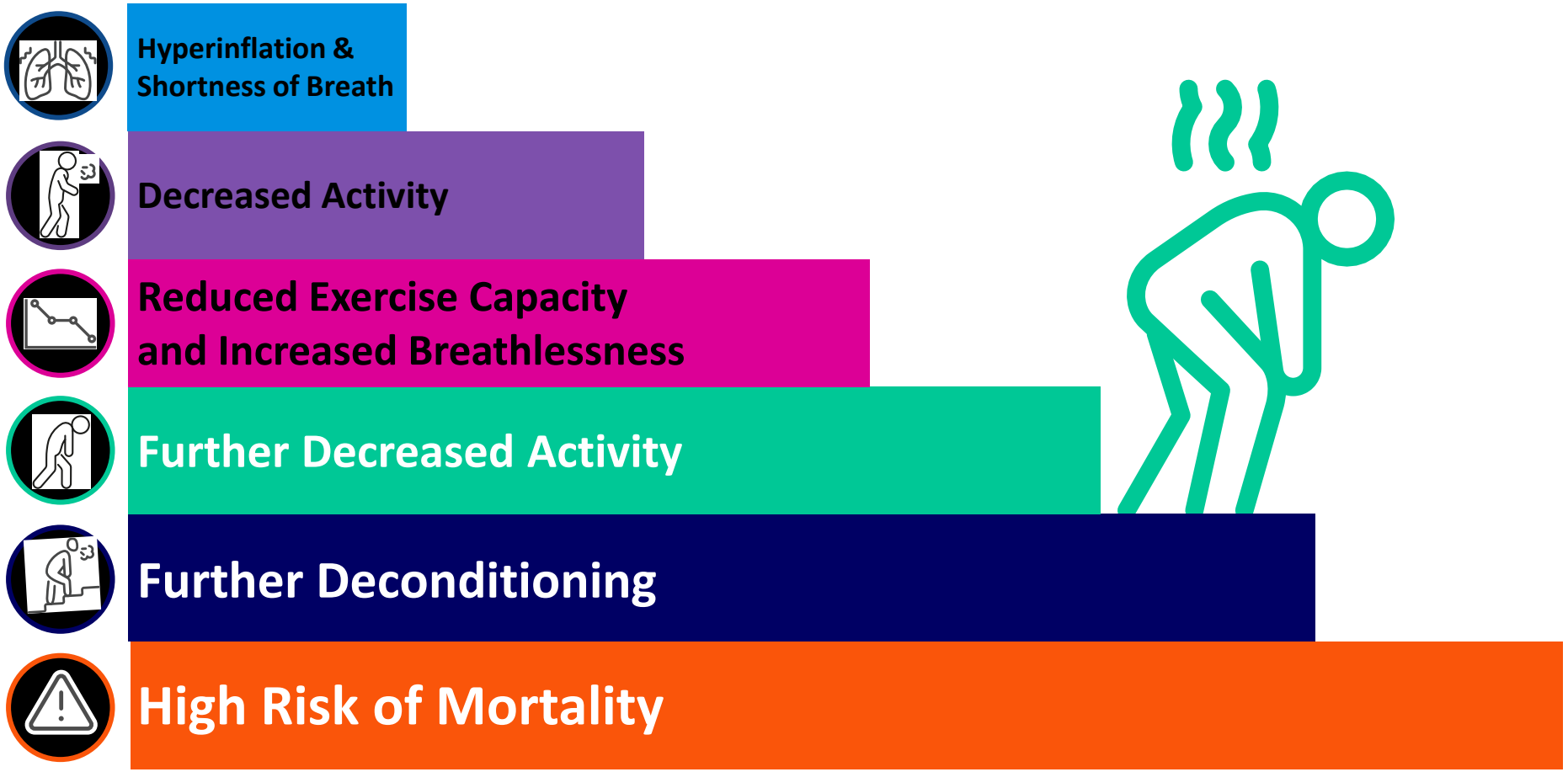
Irreversible destruction of the alveolar wall from inhalation of a noxious particles resulting in:

- Reduced elastic recoil (respiratory muscle overstretch)
- Progressive lung hyperinflation (flattening of diaphragm)
- Gas trapping in distal air spaces (measures by increased residual volume on complete pulmonary function testing)



Casanova. Am J Respir Crit Care Med. 2005;171:591. Pahal. StatPearls. 2023.

What Your Patient Experiences



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Casanova. Am J Respir Crit Care Med. 2005;171:591. Dubé. COPD Res Pract. 2016;2:1.

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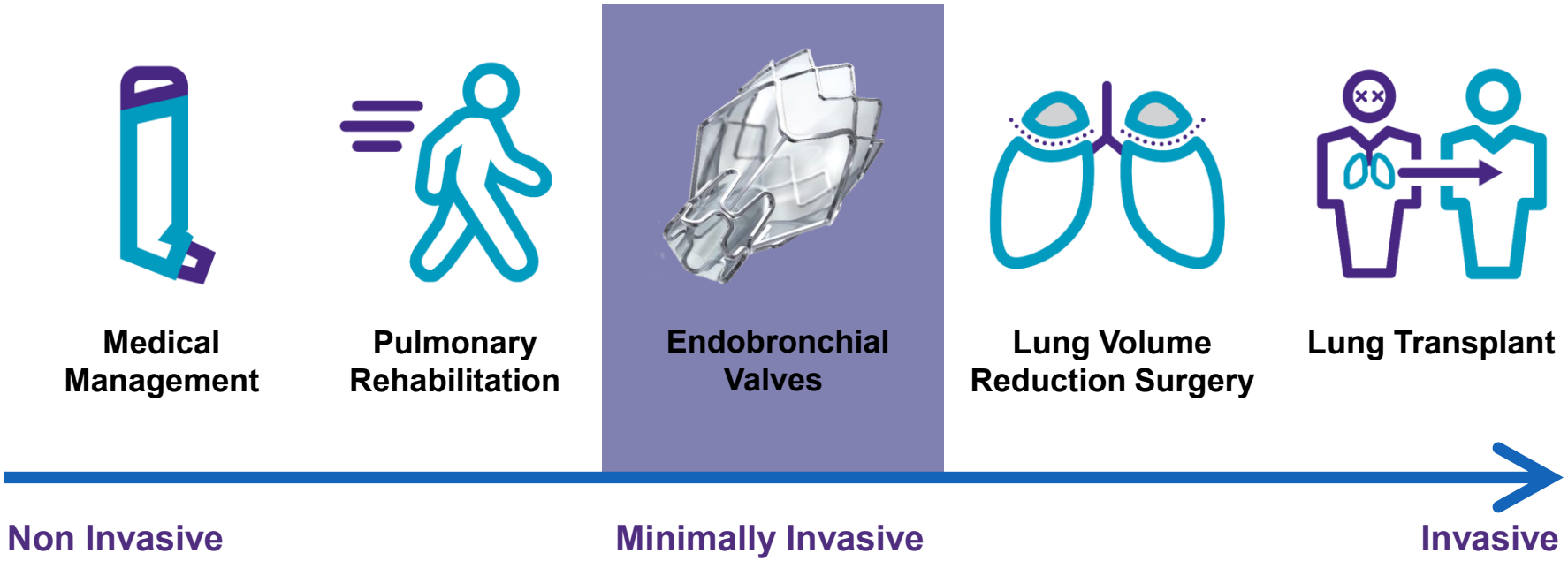
GOLD Spectrum of Treatment Options



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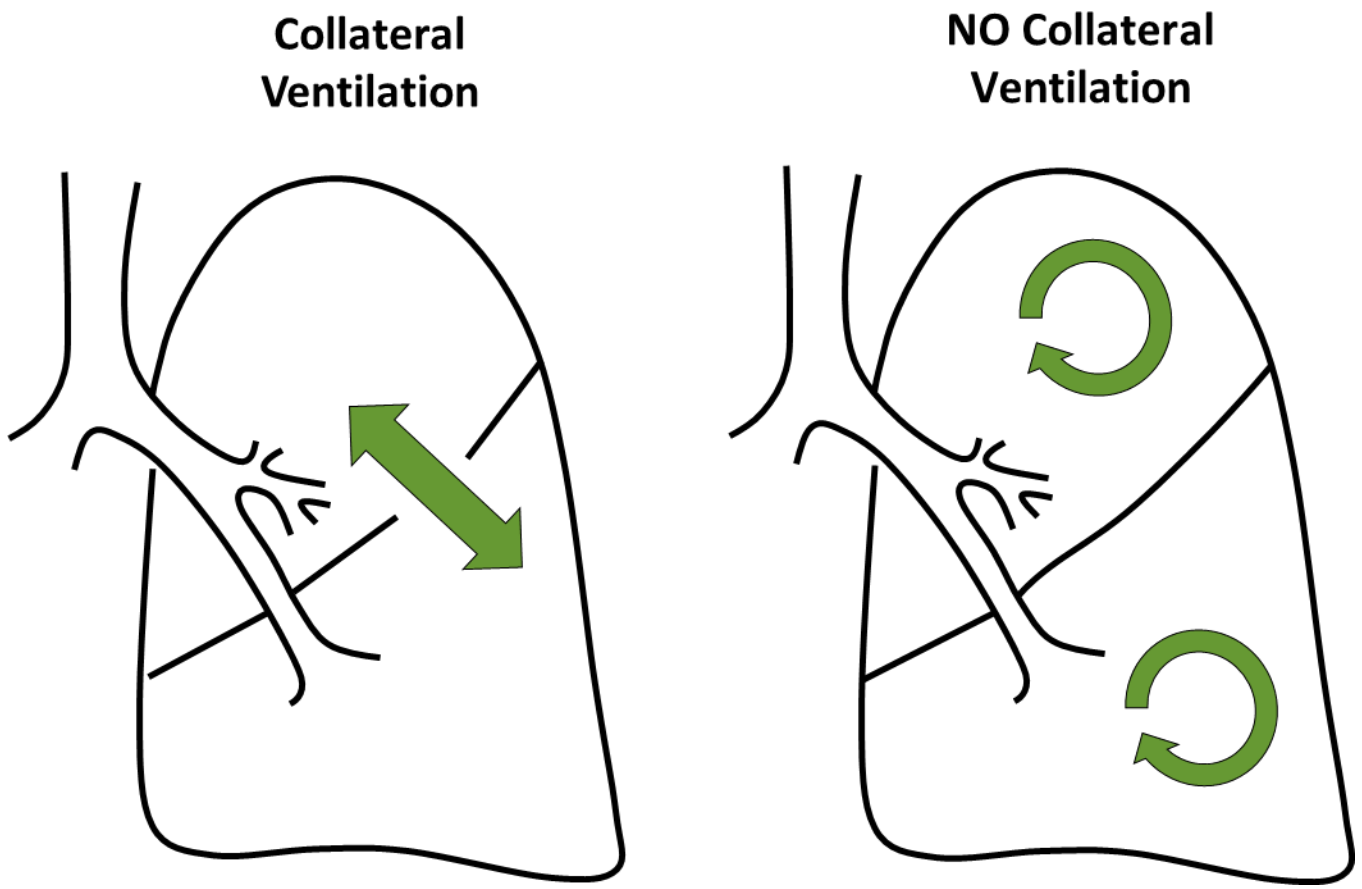
Candidacy

- Diagnosis of severe emphysema on pulmonary function tests
  - FEV_1 15% to 45%, RV ≥175%, and TLC >100% predicted
- 6-minute-walk distance between 100 to 500 m
- ABG without significant hypercapnia
- Echocardiogram without HFrEF or severe pulmonary hypertension
- Quantitative CT analysis without collateral ventilation and with enough gas trapping to benefit from the procedure
  - Voxel density >50% in 1 lobe, fissure completeness >80%

Candidacy varies among treatment centers.
Criner. Am J Respir Crit Care Med. 2018;198:1151.

Collateral Ventilation

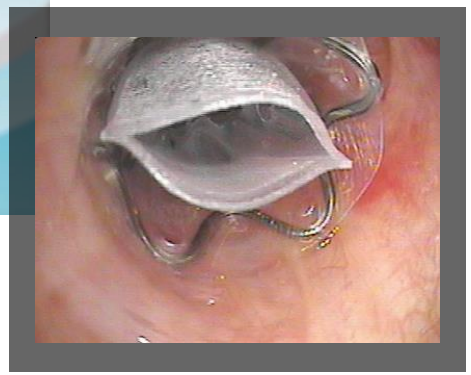
- **Prevents complete lobar collapse**
- **Reduces the effect of the procedure outcome**



Criner. Am J Respir Crit Care Med. 2018;198:1151.

Image credit: Pulmonx.

How it Works



Criner G et al, AJRCCM, 2018, Published on 22-May-2018 as 10.1164/rccm.201803-0590OC

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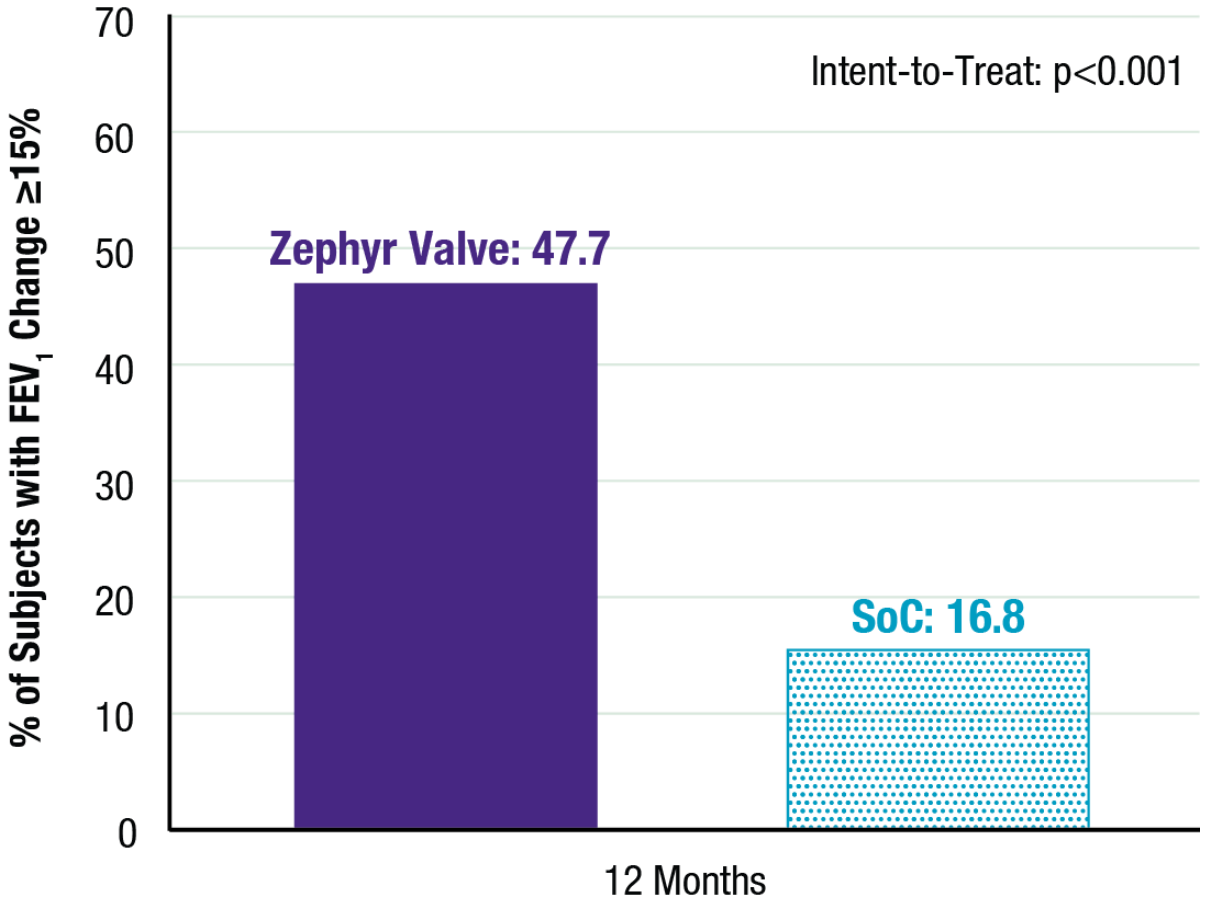
Outcomes of the Procedure (LIBERATE Study)

- **Improved Lung Function**
- **Difference in FEV1 of ≥ 15% between the valve group and those just receiving standard medical care**
- **Decrease in gas trapping of at least 50%**



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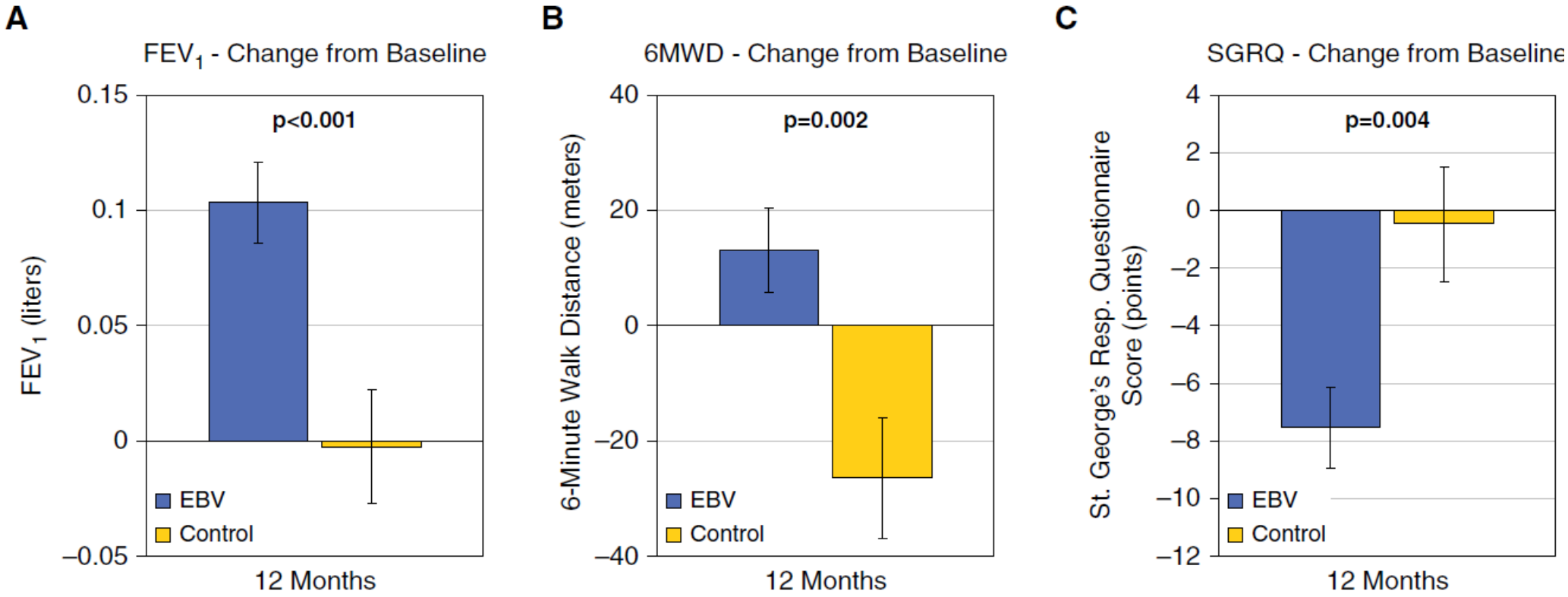
LIBERATE Secondary Outcomes



17.96% for change in FEV1

39.3 m = 128.9ft

-7.05 points

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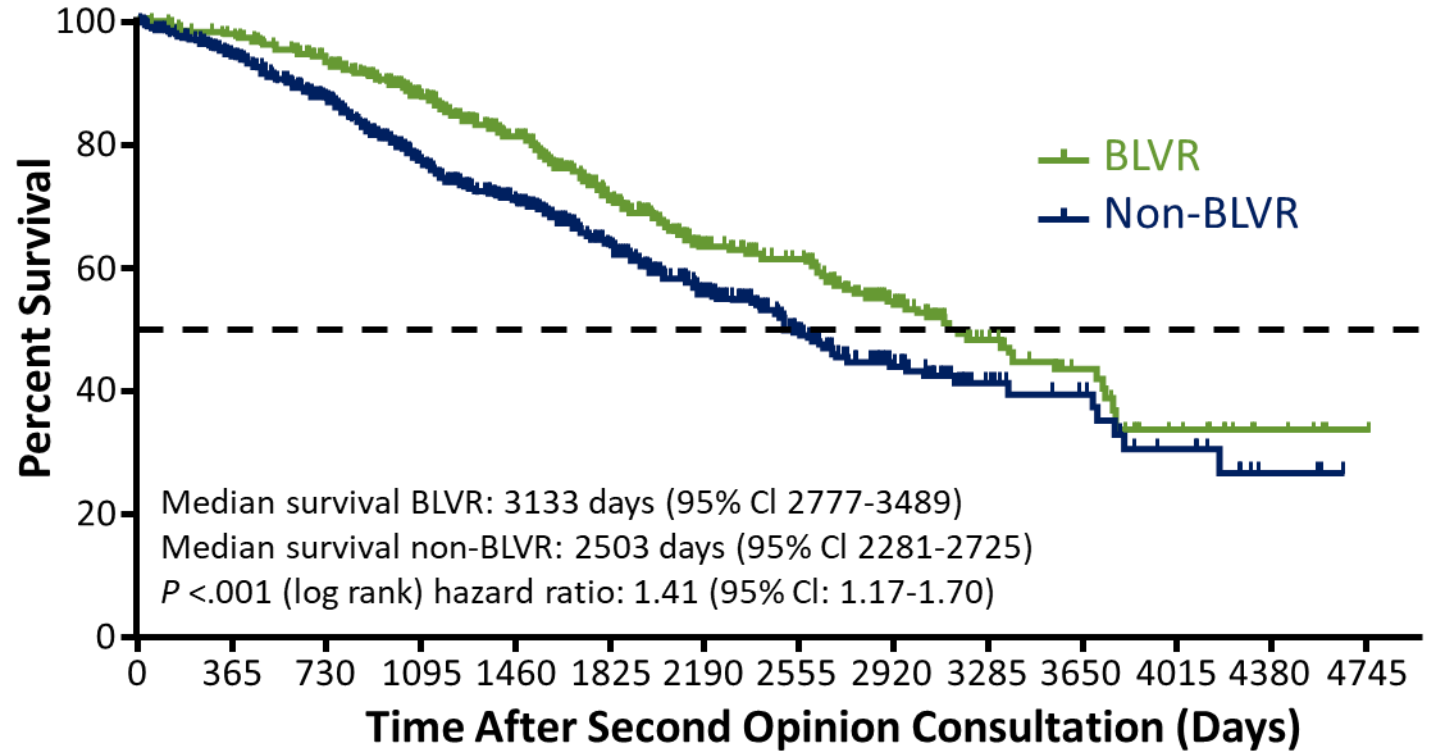
Survival Benefit

- **Study from the Netherlands**
- **Median survival time of patients treated with BLVR vs those not treated with BLVR**
  - **3133 days vs 2503 days, respectively**



Numbers at Risk (censored)

Yr:	1	2	3	4	5	6	7	8	9	10	11	12	13
BLVR	483(0)	472(8)	445(61)	358(56)	277(51)	196(37)	139(19)	116(21)	83(28)	47(15)	28(8)	14(9)	5(4)	1(1)
Non-BLVR	988(0)	934(33)	830(145)	599(99)	453(114)	298(74)	194(62)	115(40)	64(32)	29(9)	19(4)	11(7)	3(3)	

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Hartman. Respir Med. 2022;196:106825.

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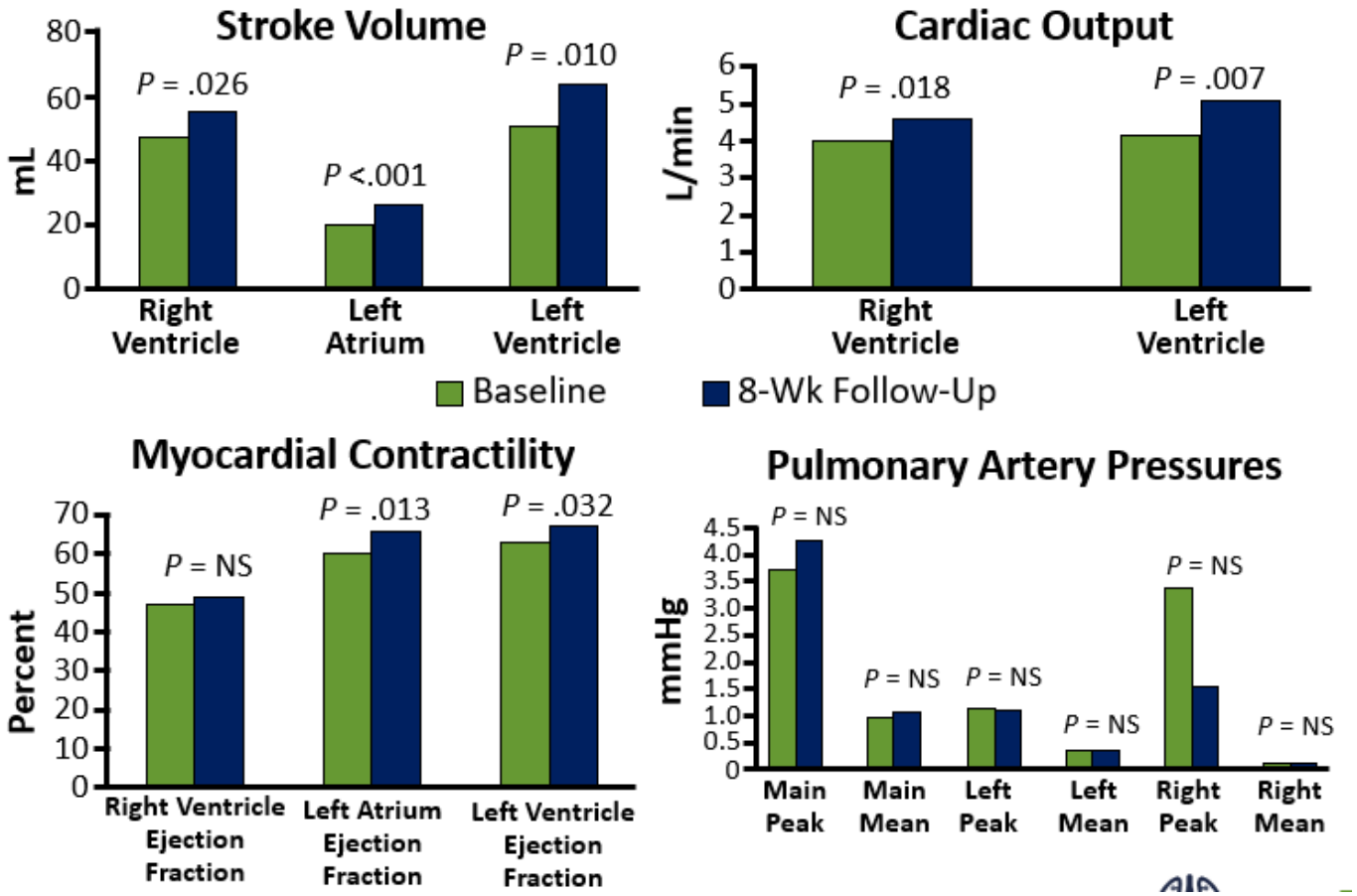
Improved Cardiac Physiology

- Study from Sweden
- Evaluated 24 patients at 8 wk post-BLVR
- Improvement in:
  - Stroke volume
  - Cardiac output
  - Myocardial contractility



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van der Molen. Am J Respir Crit Care Med. 2022;206:704.

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Positive Collateral Ventilation Treatment

ClinicalTrials.gov BETA

NIH National Library of Medicine
National Center for Biotechnology Information

Record 1 of 1

RECRUITING

ClinicalTrials.gov Identifier: **NCT04559464**

Fissure Closure With the AeriSeal System for CONVERTing Collateral Ventilation Status (CONVERT) (CONVERT)

Information provided by Pulmonx Corporation (Responsible Party)

Last Update Posted: 2022-08-29

A trial to evaluate the safety and effectiveness of AeriSeal® System to block collateral ventilation and convert a severe emphysema patient from CV+ to CV- status.

Positive Collateral Ventilation Treatment

- **CONVERT phase I:**
  - **Multicenter study 2019-2020 France**
  - **101 patients**
  - **Results: 77% conversion rate**

- **CONVERT phase II Enrolling**
  - **Multicenter study 2024 - ?**
  - **35 centers: USA, EU, Australia**
  - **Goal: 200 patients**

AeriSeal® System

- **Device:** AeriSeal® System
- **Manufacturer:** Pulmonx Corporation, Redwood City, California, U.S.A.
- **CE Mark status:** Received 2015
- **FDA status:** Investigational
- **Components:**

AeriSeal Foam Components Vials
(to be stored at 2-8 °C)

AeriSeal Balloon Catheter

AeriSeal Balloon Catheter Accessories Kit

- **Proposed CONVERT II Trial Intended Use:**

The AeriSeal System functions by physically occluding small airways and/or collateral air channels to limit the collateral ventilation in a target lobe. The AeriSeal System when used with Zephyr Valves is indicated for bronchoscopic lung volume reduction (BLVR) in adult patients with hyperinflation associated with severe emphysema who have collateral ventilation.

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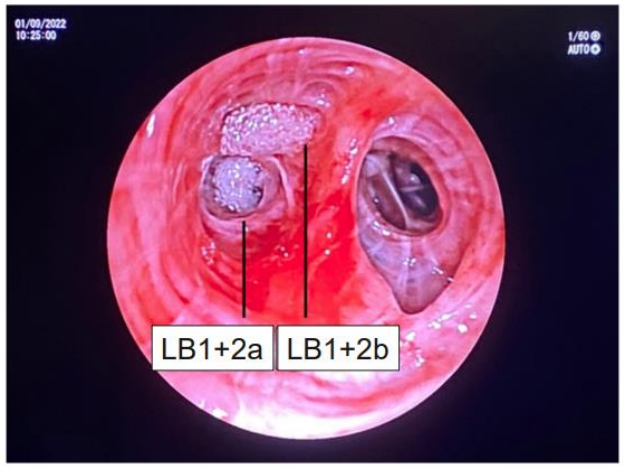
Study Treatment

AeriSeal® Foam



Stage 1: AeriSeal Index Procedure
(All subjects)

Stage 1-R: AeriSeal Repeat Procedure
(Non-converters)

Objective: closure of lobar fissure gaps to block collateral ventilation (conversion of the CV+ target lobe to CV-) confirmed by Chartis

AeriSeal application volume:

- **10 mL** per segment or subsegment
- Maximum **40 mL** in up to 3 segments

Conversion to CV- confirmed by Chartis at 45-days

A repeat procedure allowed, if conversion unsuccessful after the index procedure

Total volume not to exceed 40 mL

Stage 2: Zephyr Valve Procedure
(All converters)

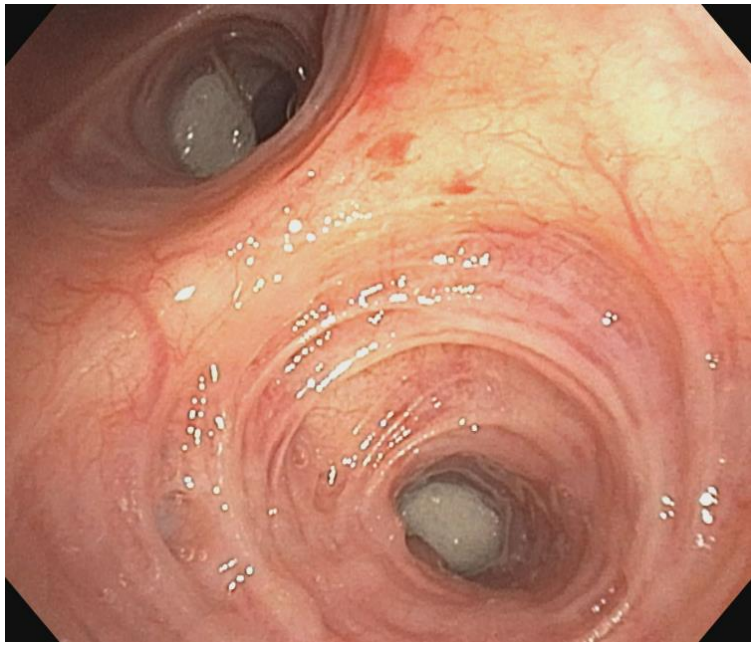
Objective: perform Bronchoscopic Lung Volume Reduction (BLVR) with Zephyr Valve

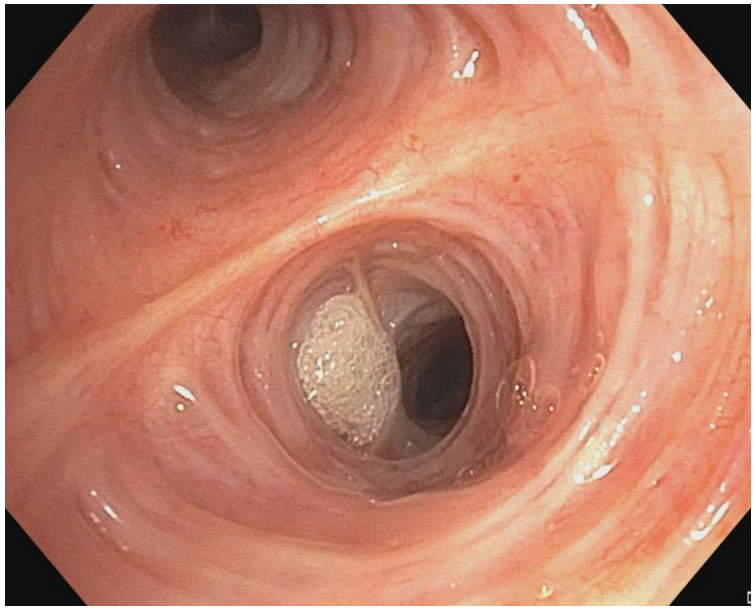
Only subjects successfully converted CV- in Stage 1

BLVR using Zephyr Valve per IFU

Same lobe is treated in Stage 1 and Stage 2


TOWER





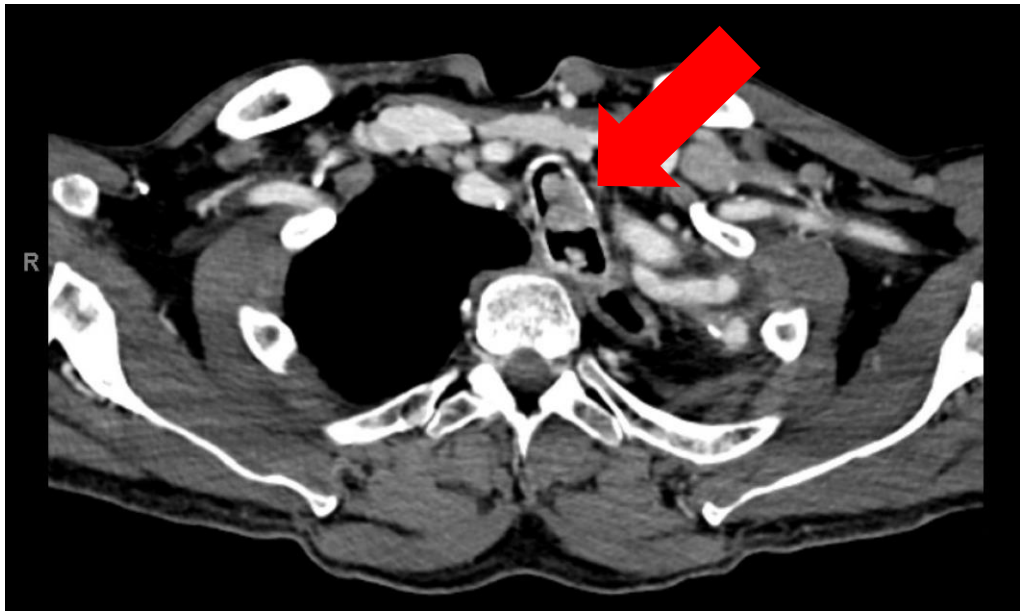
Major Side Effect with AeriSeal

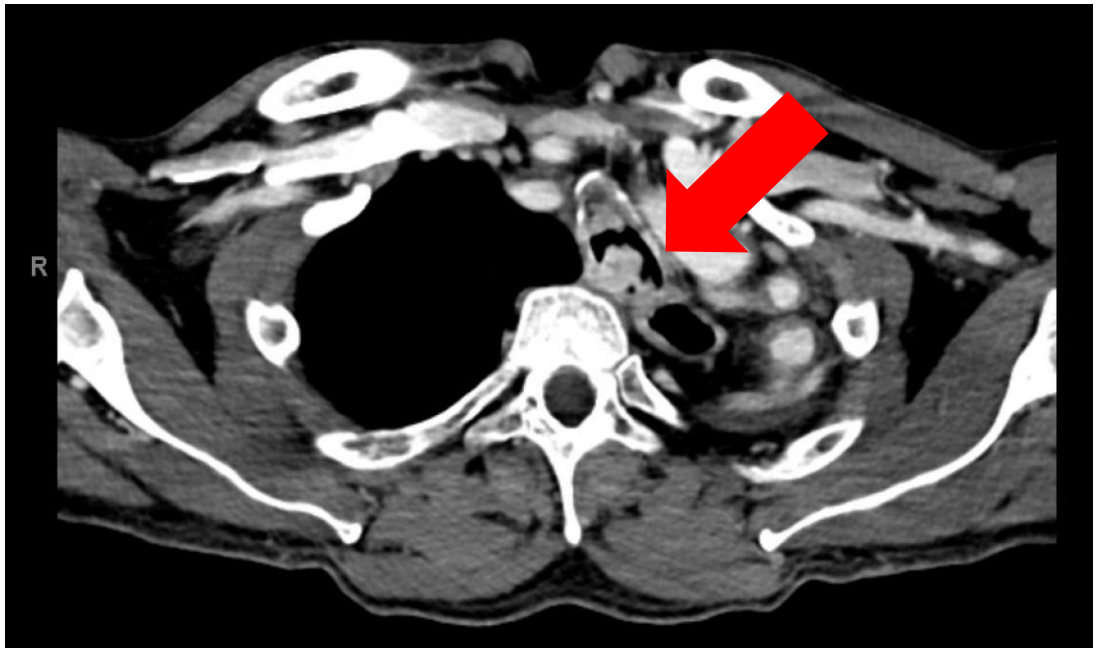
- **<u>PAIRS response: Post-AireSeal inflammatory response syndrome</u>**
  - **Within 12 to 24 hours of study treatment with the AeriSeal**
  - **Chest wall pain**
  - **Cough**
  - **Shortness of breath**
  - **High blood markers of inflammation (C-reactive protein, erythrocyte sedimentation rate, fibrinogen, procalcitonin)**
  - **Fever / chills**
  - **Lower than normal oxygen level (Hypoxemia)**
  - **Increased white blood cell count (Leukocytosis)**
  - **Loss of appetite**
  - **Feeling of general discomfort (Malaise)**

Complex Airway Case

Case Study

- 61 year old male
- Hx Limited stage Small Cell Lung cancer of the left lung (2021) s/p left pneumonectomy in Greece, followed by adjuvant chemo
- Presented to OSH 3/26/25 for SOB x 3 weeks refractory to Abx.
- CT chest = 2 tracheal masses causing airway obstruction



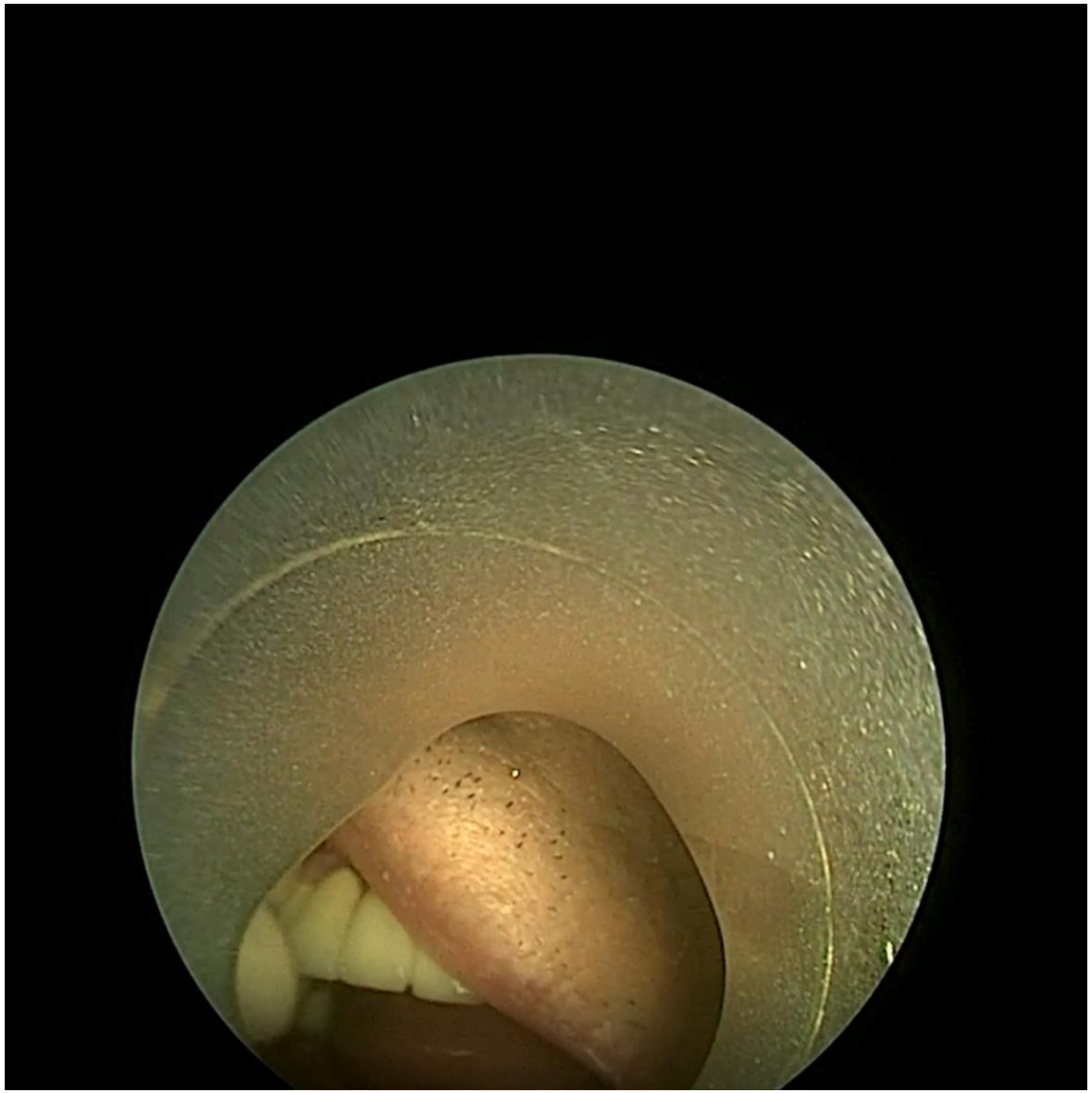


Case continued..

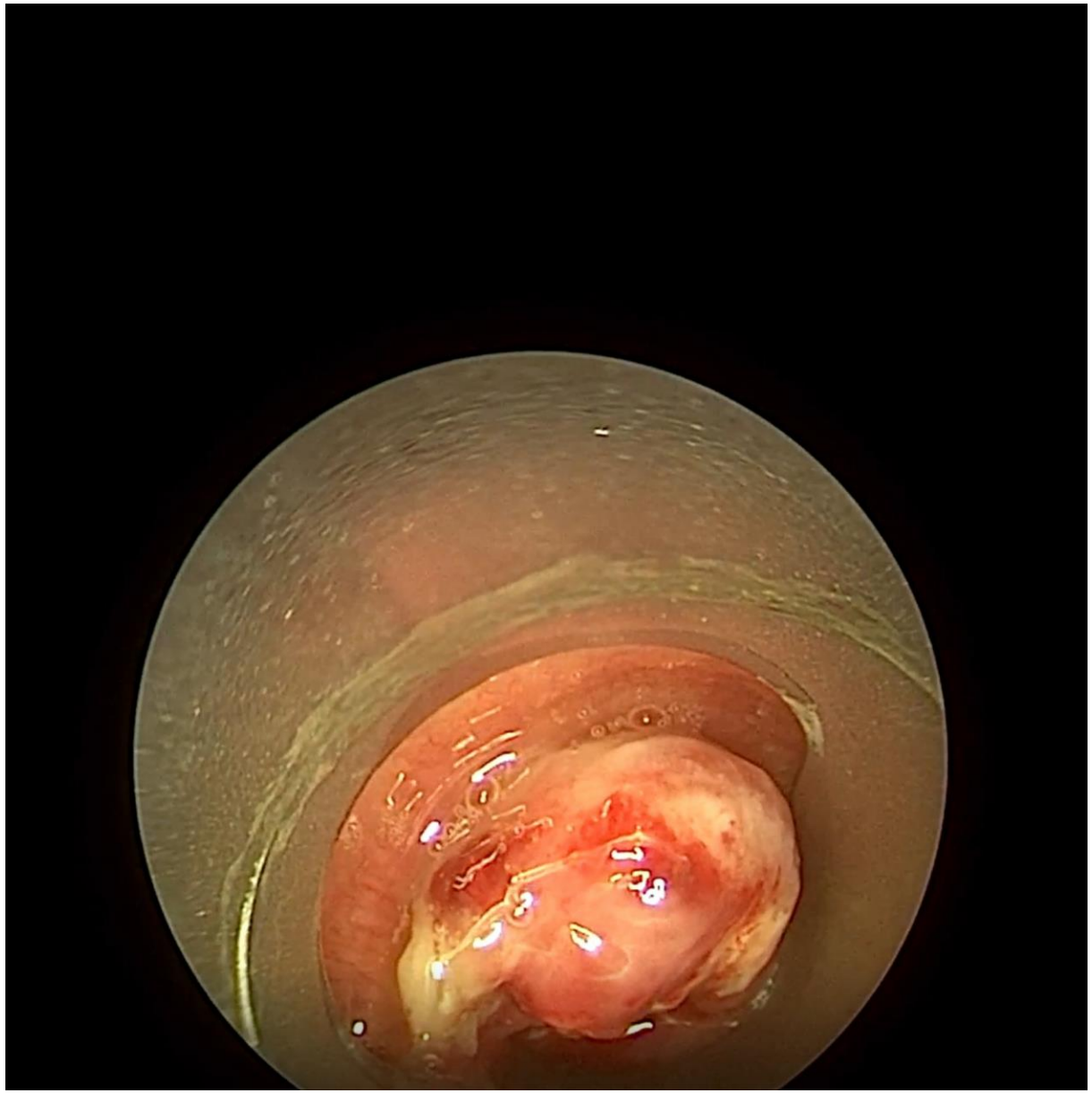
Considerations with a difficult airway due to significant obstruction:

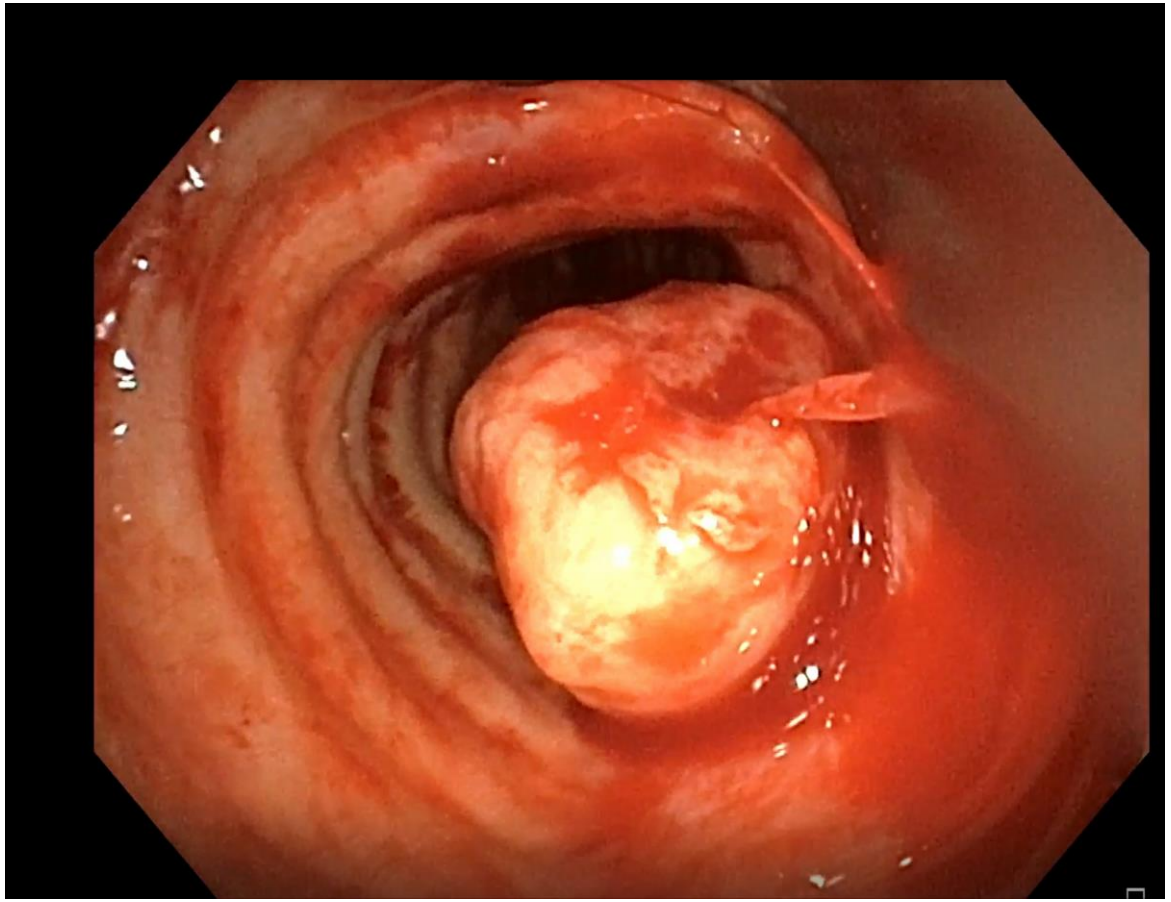
- **Heliox is your friend**
- **Patient should be at a level 1 trauma center with advance airway teams**
- **Intubation (if needed) requires multidisciplinary teams in OR**
- **Ventilation: Allow for prolonged exhalation due to gas trapping**
- **Prepare a back up plan (?ECMO)**
- **If malignant, be prepared for bleeding**
- **Chart should have a difficult airway flag**

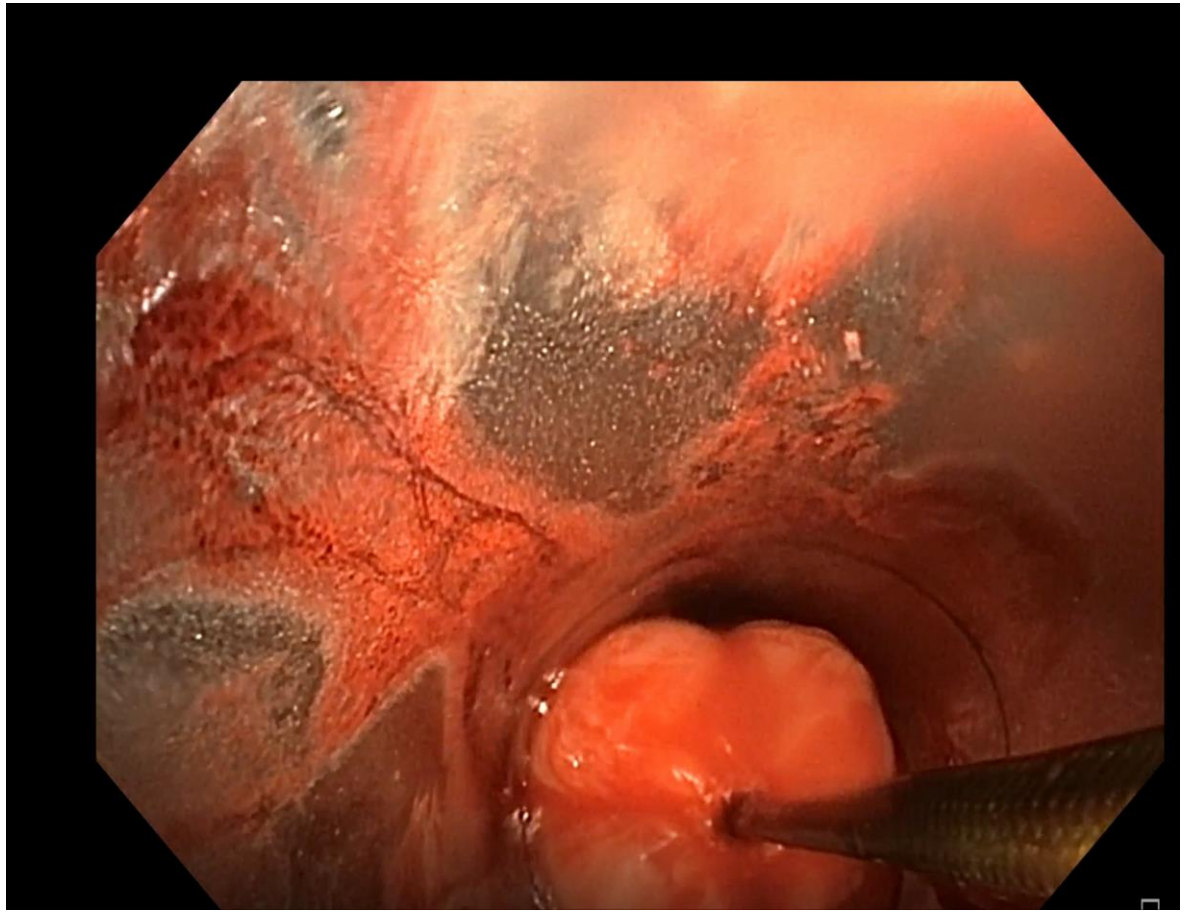
OR: Rigid bronchoscopy with airway

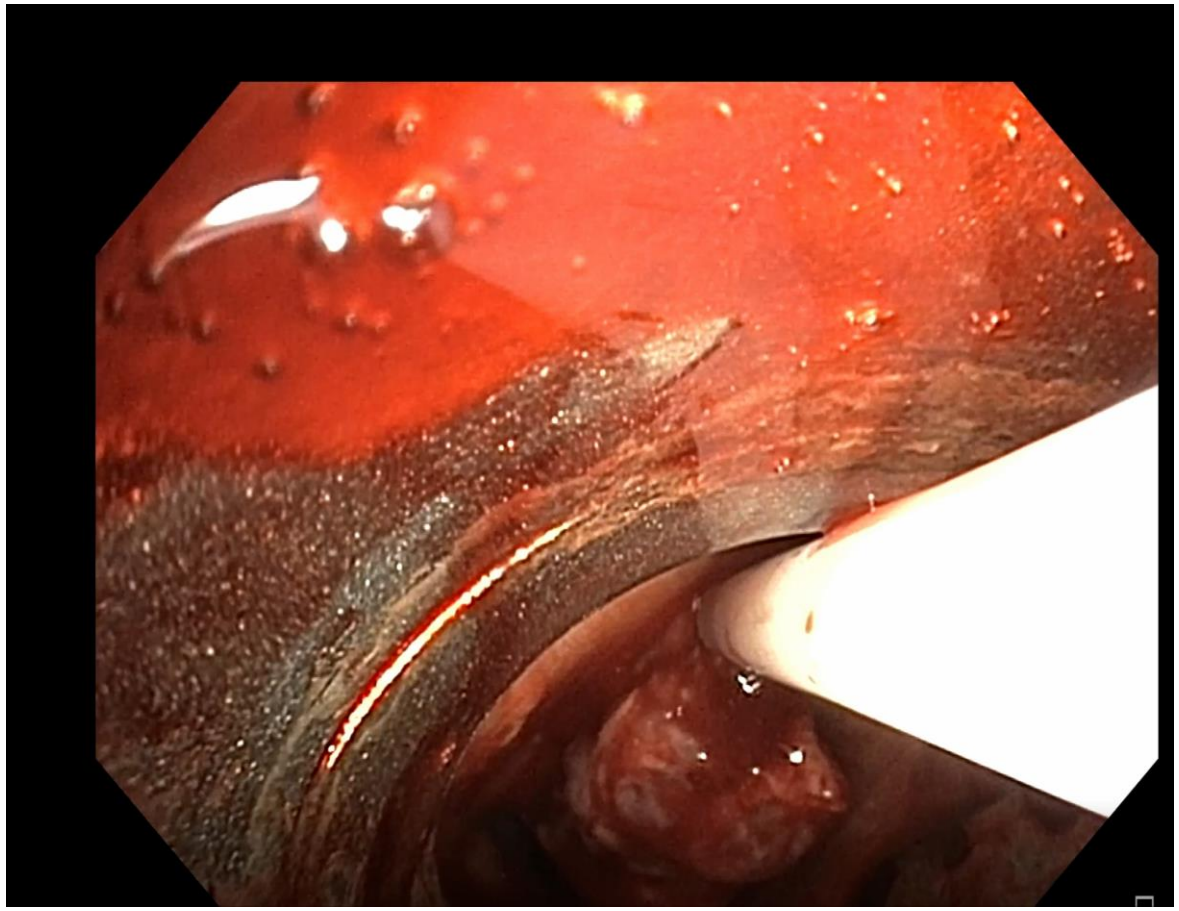


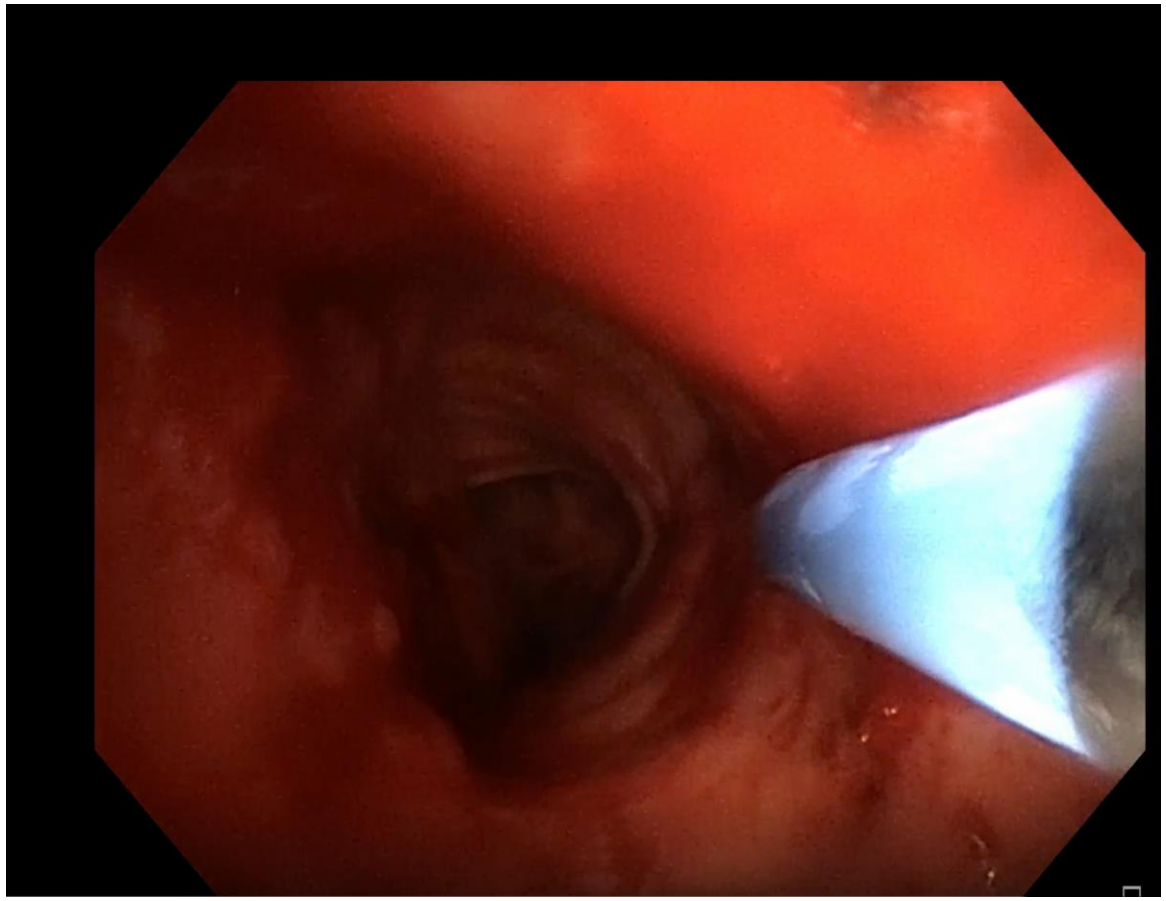
Tumor coring & mechanical tumor debulking to establish ventilation



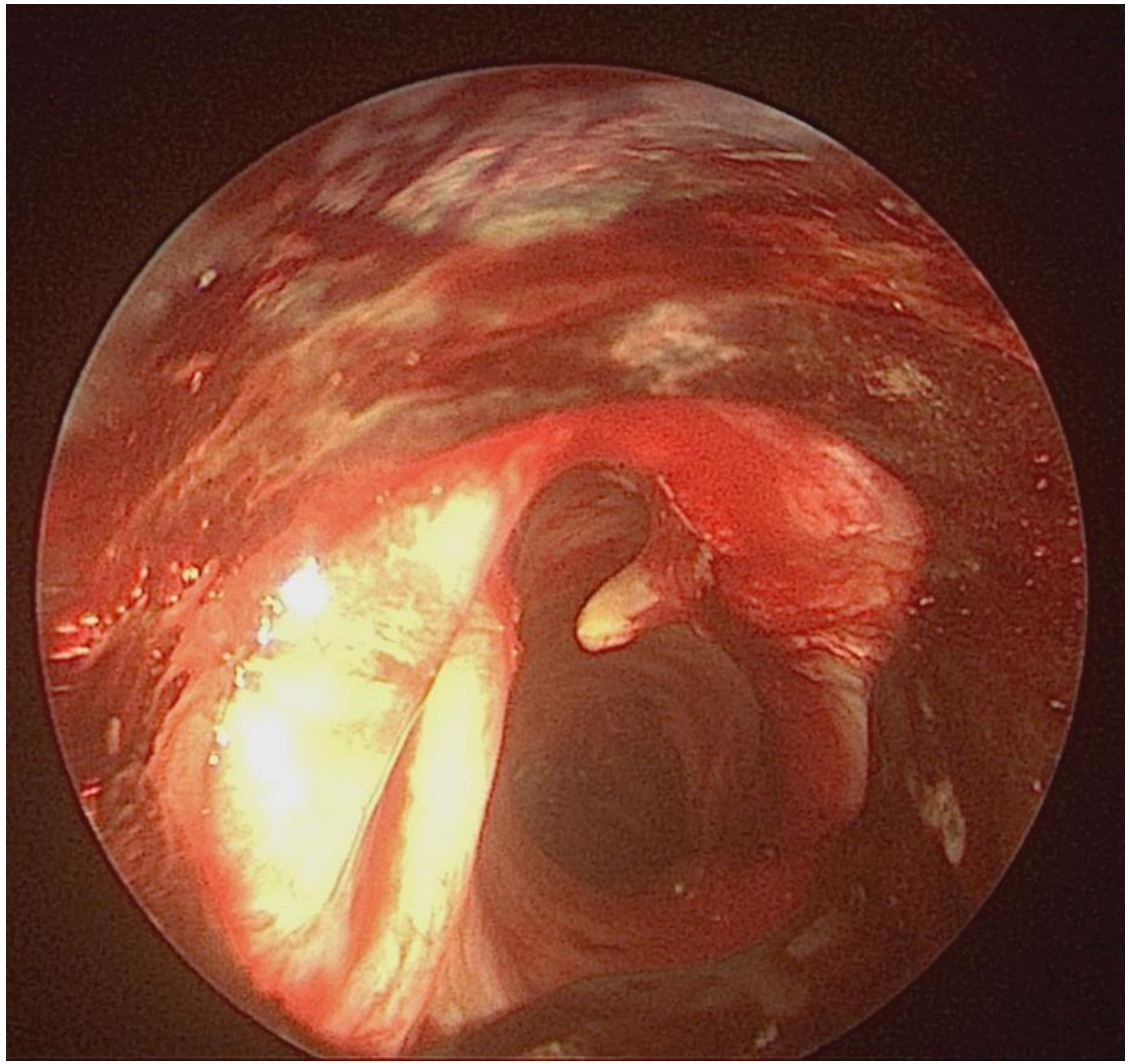


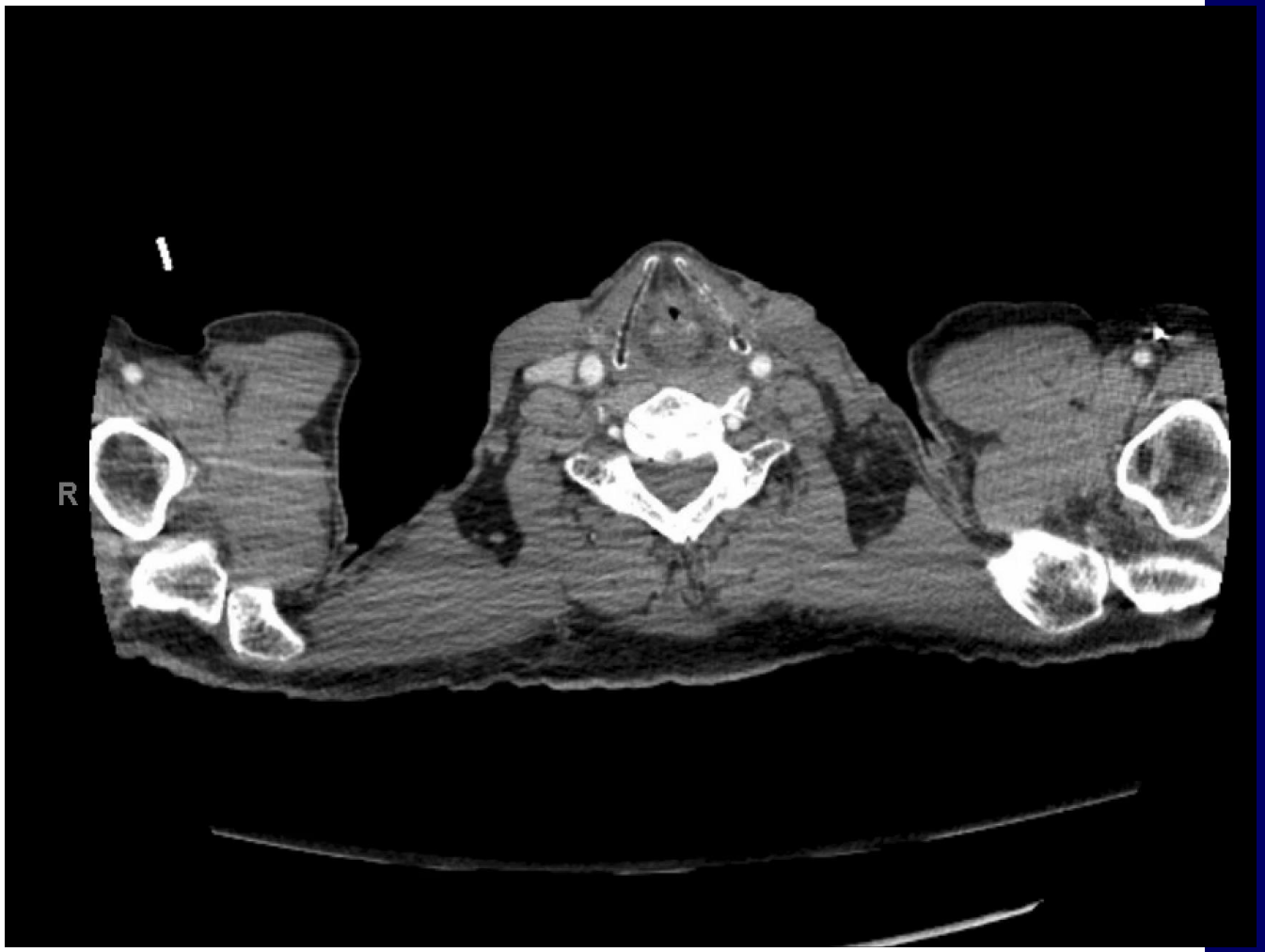






Final results





Thank You

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