

Expiratory Central Airway Collapse, Anesthetic Implications

Ricardo Diaz Milian MD

Assistant Professor, Anesthesiology and Perioperative Medicine
Augusta University

June 30, 2019

Objectives

- Review the anatomy and physiology of the central airways
- Define Expiratory Central Airway Collapse and its anesthetic implications
- Discuss the management of intra-operative airway collapse
- Outline the anesthetic management of Tracheobronchoplasty

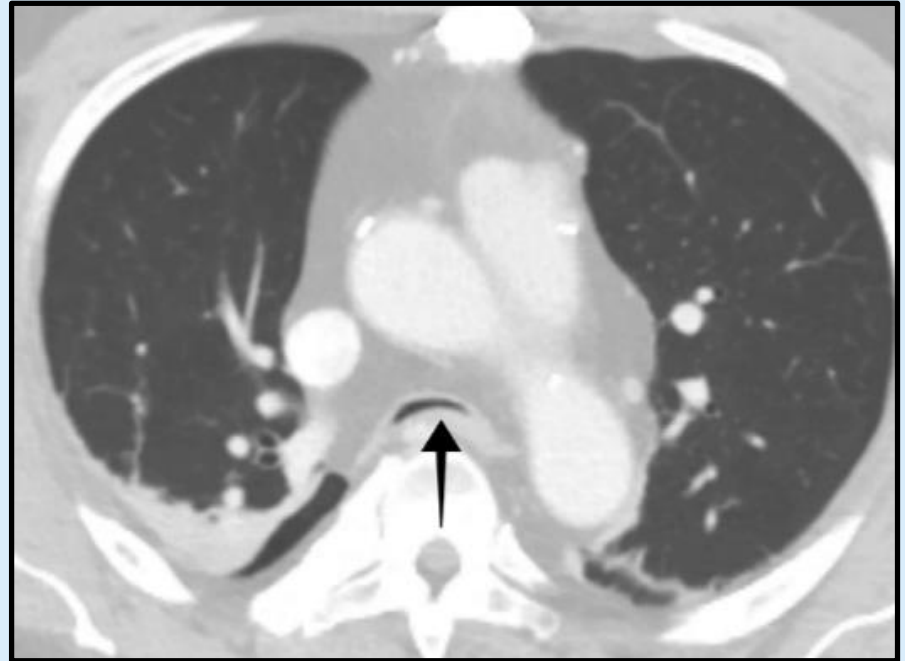
Acknowledgements

- Edward Foley MD
- Maria Bauer MD
- Andrea Martinez-Velez MD
- Manuel Castresana MD
- Sunni Losito (Medical Illustrator)

Disclosures

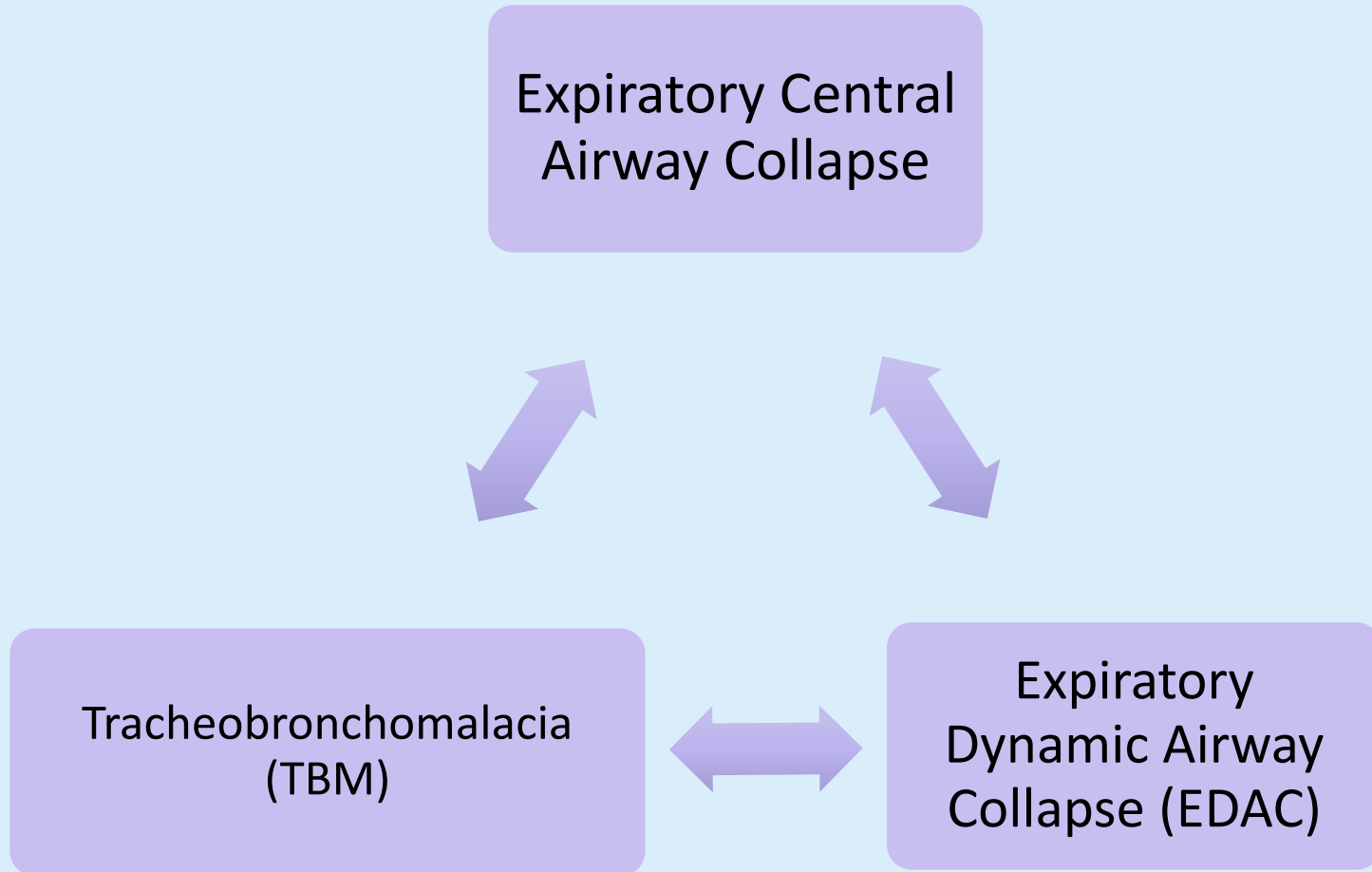
- Boston Medical, provided a photograph of a DUMON Y airway-stent.

Unexpected Airway Collapse

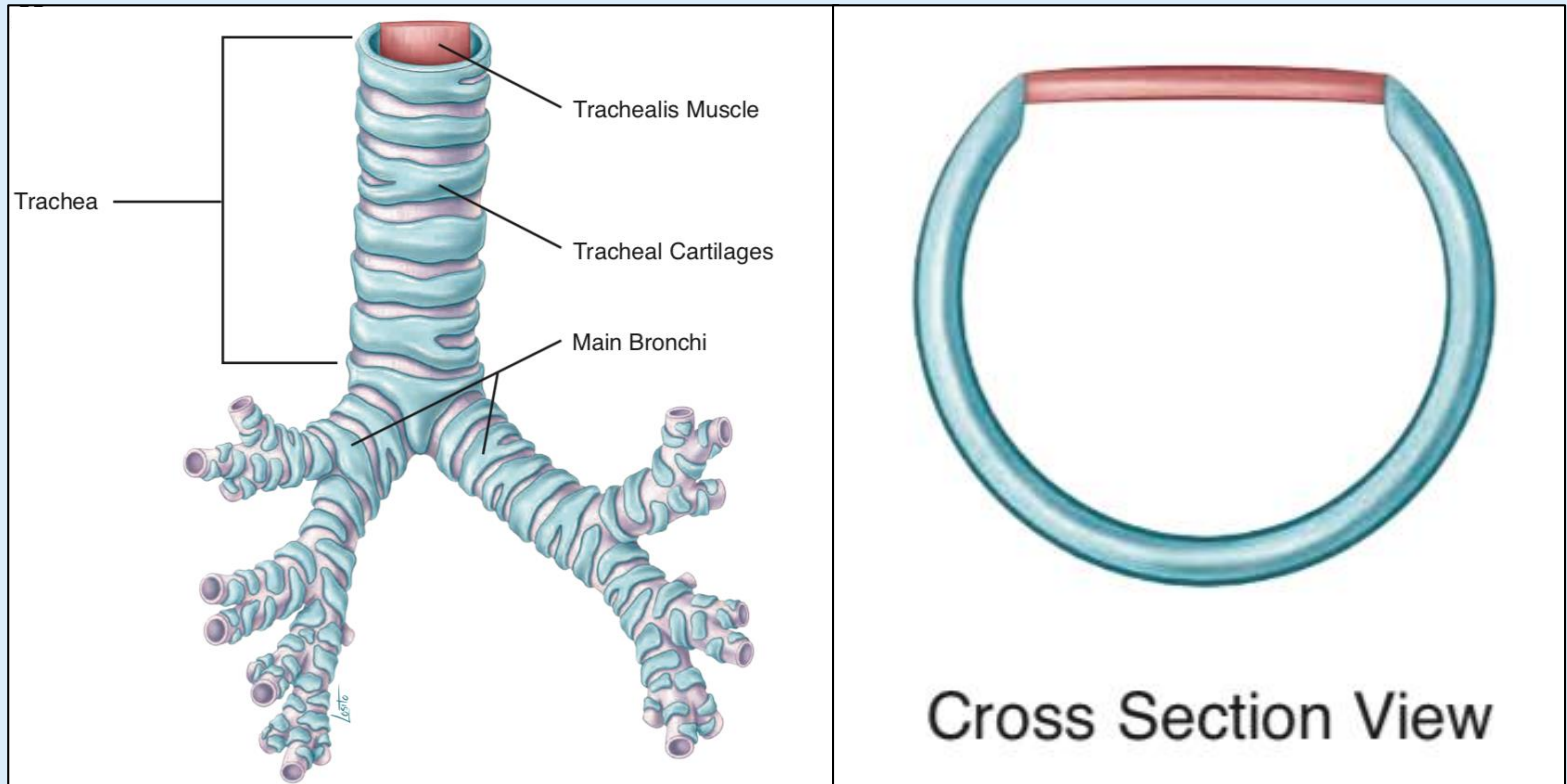


Diaz Milian R, Castresana MR. Recurrent Failure of Positive-Pressure Ventilation: Machine Malfunction or a Rare, Unexpected Cause? *J Cardiothorac Vasc Anesth* 2017; 32:2029-2030

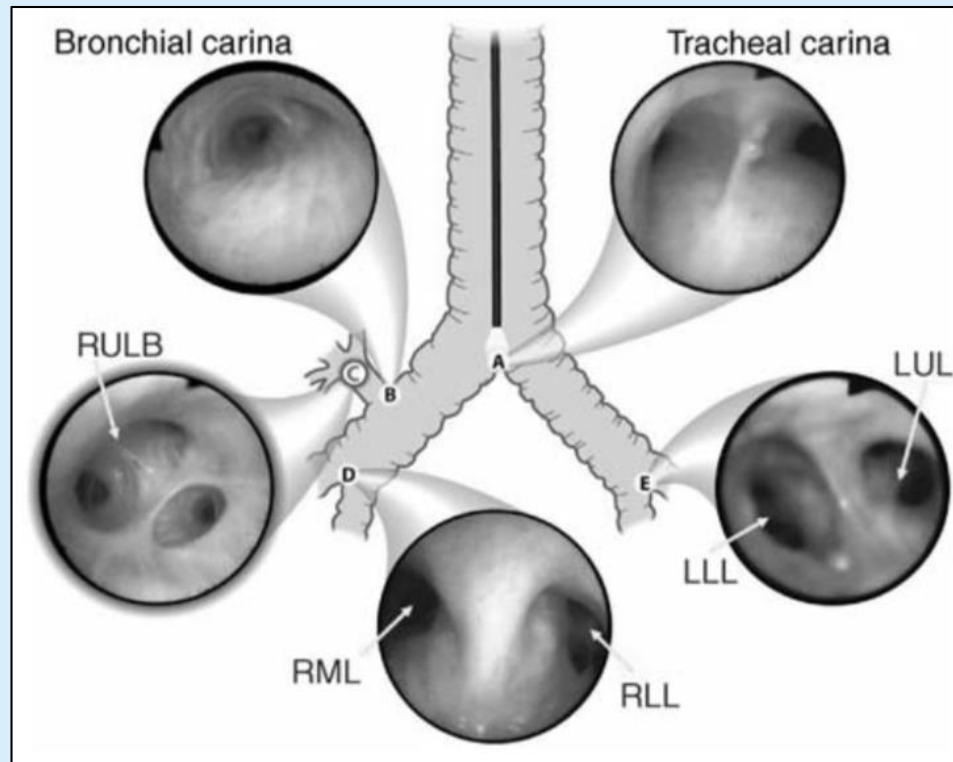
Definition



Anatomy of the Central Airways



Bronchoscopic Anatomy of the Airway

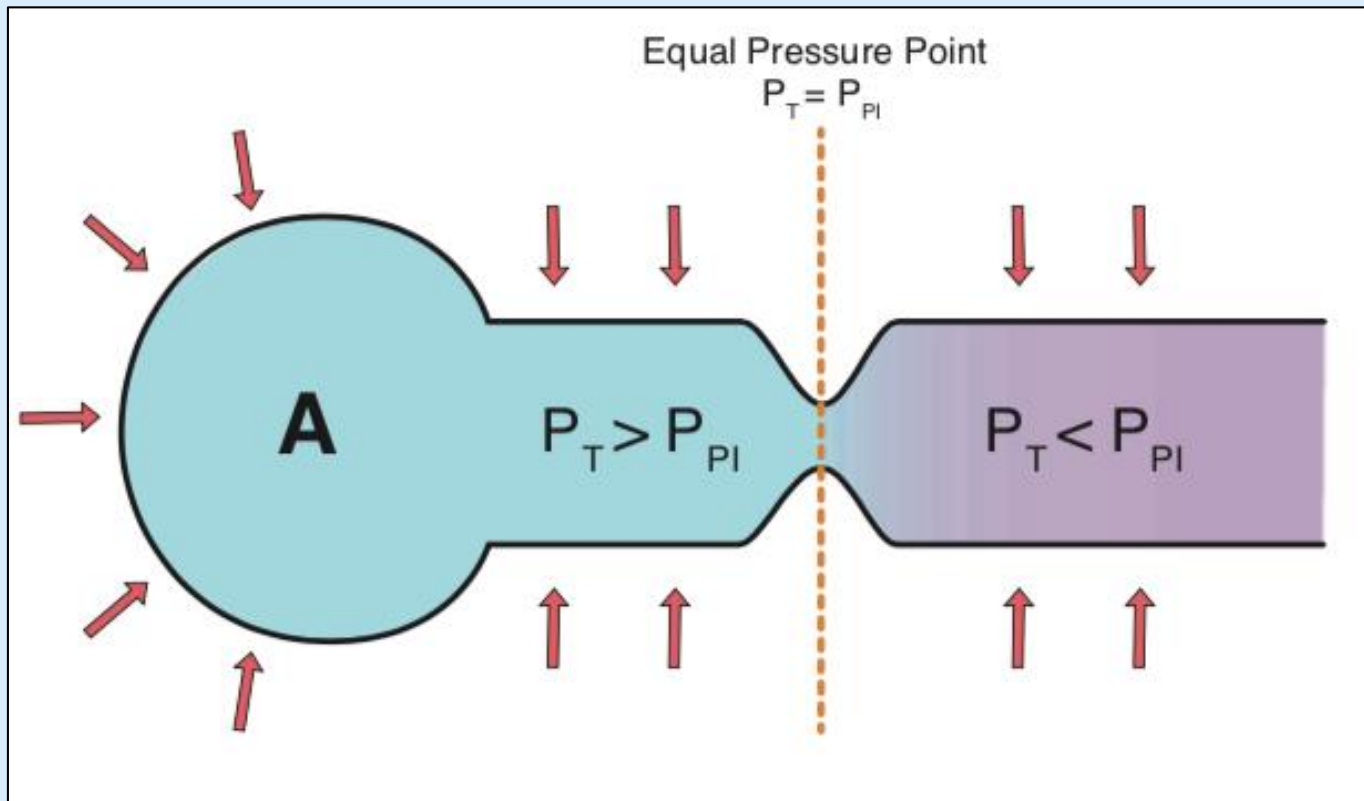


Campos JH. Update on Tracheobronchial Anatomy and Flexible Fiberoptic Bronchoscopy in Thoracic Anesthesia. *Curr Opin Anesthesiol.* 2009;22:4-10

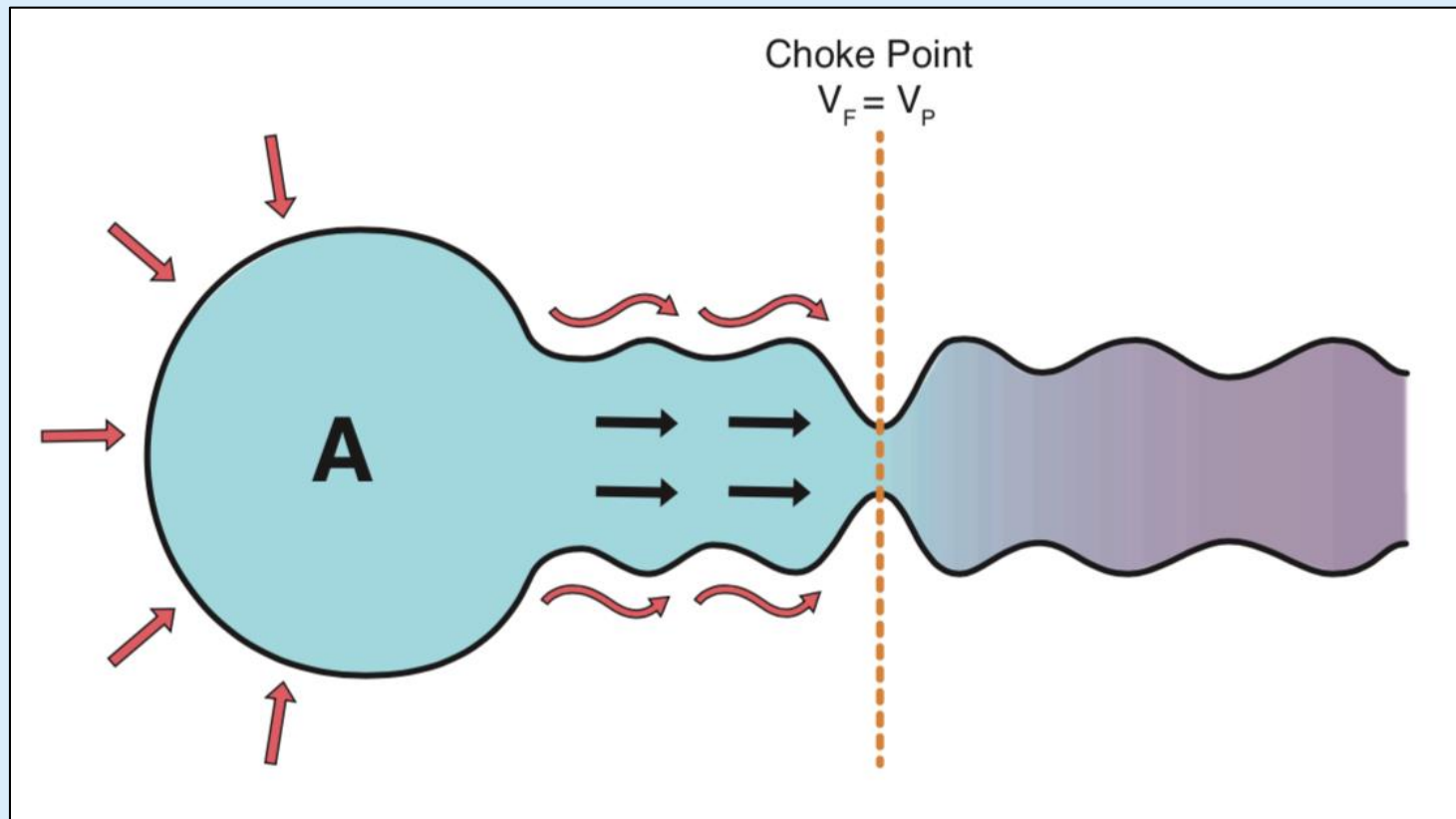
Physiology of Airway Collapse

- Expiratory Flow limitation (EFL)
- 2 theories of EFL
 - Equal Pressure Point Theory
 - Wave Speed Theory

Expiratory Flow Limitation, Equal Pressure Point Theory



Expiratory Flow Limitation, Wave Speed Theory



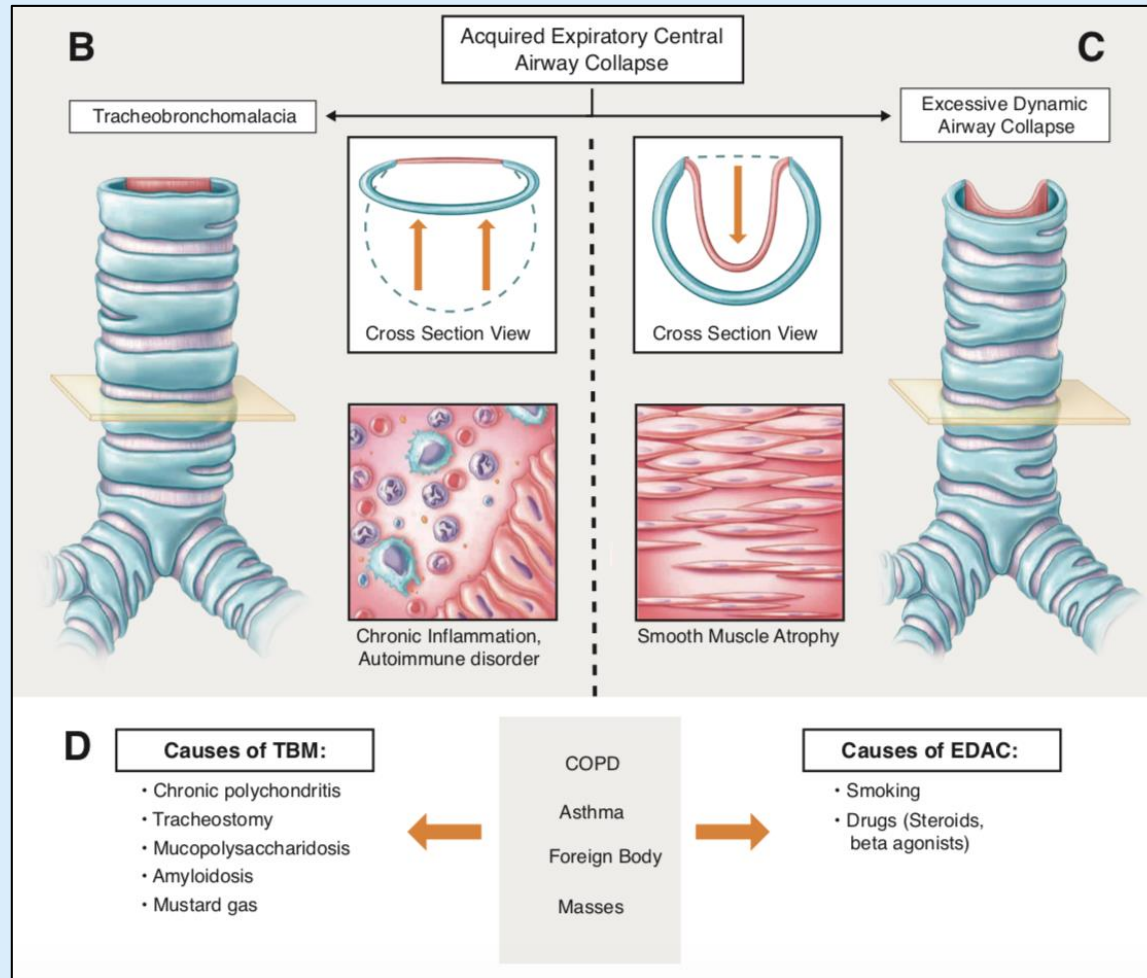
Definition of Pathological Collapse

- The degree of collapse is debatable
- Traditionally, > 50%
 - Incidence
 - 13% in smokers
 - Up to 40% in patients with COPD
- 70 % of collapse correlates better with symptoms
 - Case reports of life-threatening collapse during general anesthesia and monitored anesthesia care

Risk Factors

- Smoking
- Chronic Obstructive Pulmonary Disease
- Females
- Older Age

Pathophysiology



Diagnosis of ECAC

- Clinical Presentation
- Static Testing
 - Chest x-rays
 - Pulmonary Function tests
- Dynamic Testing
 - *Bronchoscopy*
 - Dynamic multi-detector CT scan

Anesthetic Implications of ECAC

Anesthetic Management of Patients with ECAC

- Precipitants of Airway Collapse
 - Induction of General Anesthesia
 - Muscle relaxation
 - Mechanical Ventilation
- The critical degree of collapse is unknown, but likely 70%

Anesthetic Management of Patients with ECAC

< 70% collapse, absence of severe symptoms

Consider alternatives to general anesthesia (regional anesthesia, neuraxial block, monitored anesthesia care)

If general anesthesia is considered, maintain spontaneous ventilation

Consider an emergency plan and prepare the proper equipment

>70% collapse, severe symptoms

Elective surgery: refer for corrective treatment of ECAC beforehand

Emergency surgery: consider mechanical circulatory support before induction

Diaz Milian R, Foley E, Bauer M, et al. Expiratory Central Airway Collapse in Adults: Anesthetic Implications (Part 1). *J of Cardiothorac Vasc Anesth*. 2018 (Epub ahead of print, PMID:30279066)

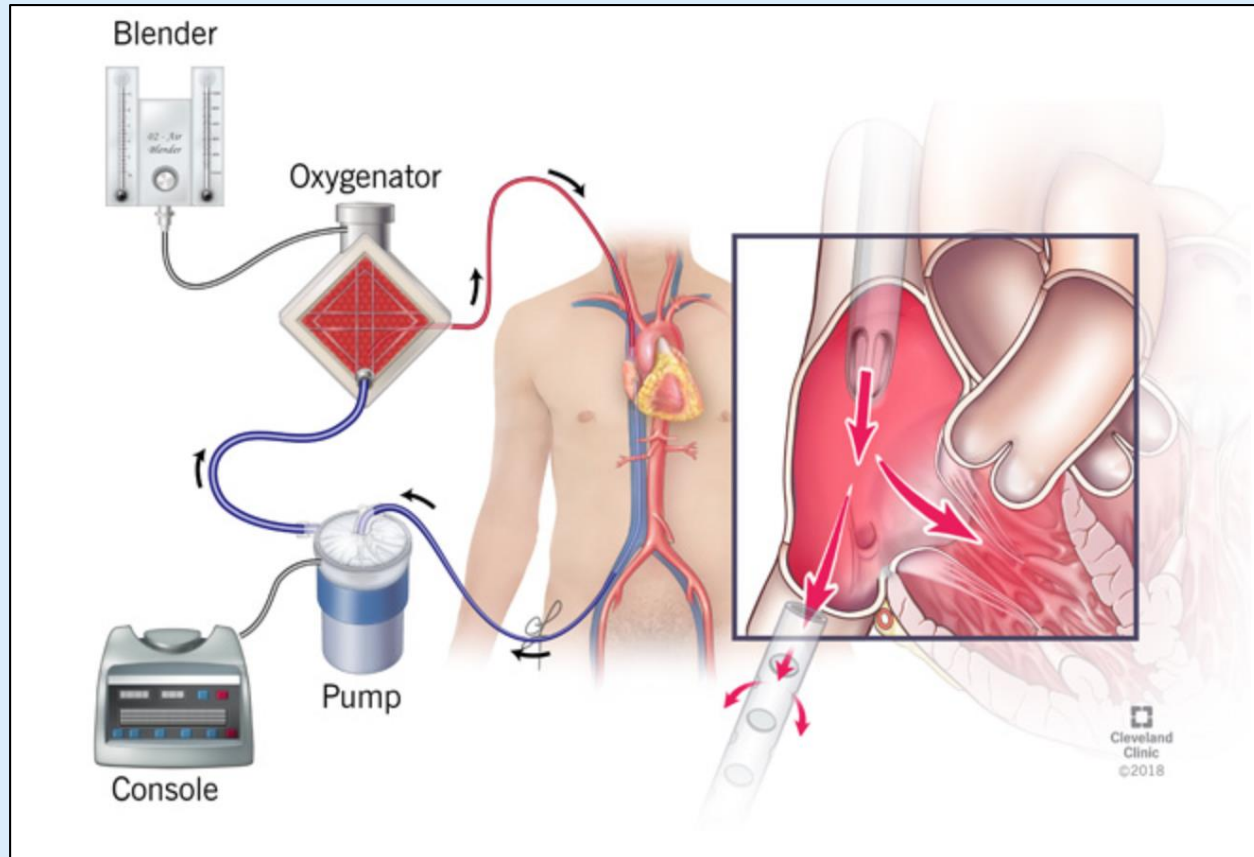
Prevention of Collapse

- Maintain spontaneous ventilation
- Monitored Anesthesia Care
 - Favor drugs that allow spontaneous ventilation (Dexmedetomidine, Ketamine)
 - Consider continuous positive pressure ventilation (CPAP) or high flow nasal cannula (HFNC)
- General Anesthesia
 - Avoid muscle relaxants
 - Prepare emergency equipment

Emergency Airway Equipment

- Endotracheal tube
- Laryngoscope
- Fiberoptic Scope
- Rigid bronchoscope (and operator)
- Jet ventilation
- Helium/Oxygen

Pre-Induction VV-ECMO



Krishan, S. Venovenous Extracorporeal Membrane Oxygenation for Lung Failure. Consult QD. <https://consultqd.clevelandclinic.org>. Published: Jan 7 2019.

Intraoperative Management of Unexpected Airway Collapse

Intra-operative Airway Collapse

- Presentation
 - Sudden increase in peak and plateau pressures (VCV) or decrease in tidal volumes (PCV)
 - Loss of Capnography waveform
 - Difficulty hand-bag ventilation
- Differential diagnosis
 - Tube, circuit occlusion or machine malfunction
 - Bronchospasm
 - Undiagnosed mediastinal mass

Management of Collapse due to ECAC

- Return to spontaneous ventilation
- Positional changes
- Advancement of the tube to a non-collapsed segment
- Pneumatic Stenting
- Jet Ventilation
- Helium:Oxygen
- *ECMO*

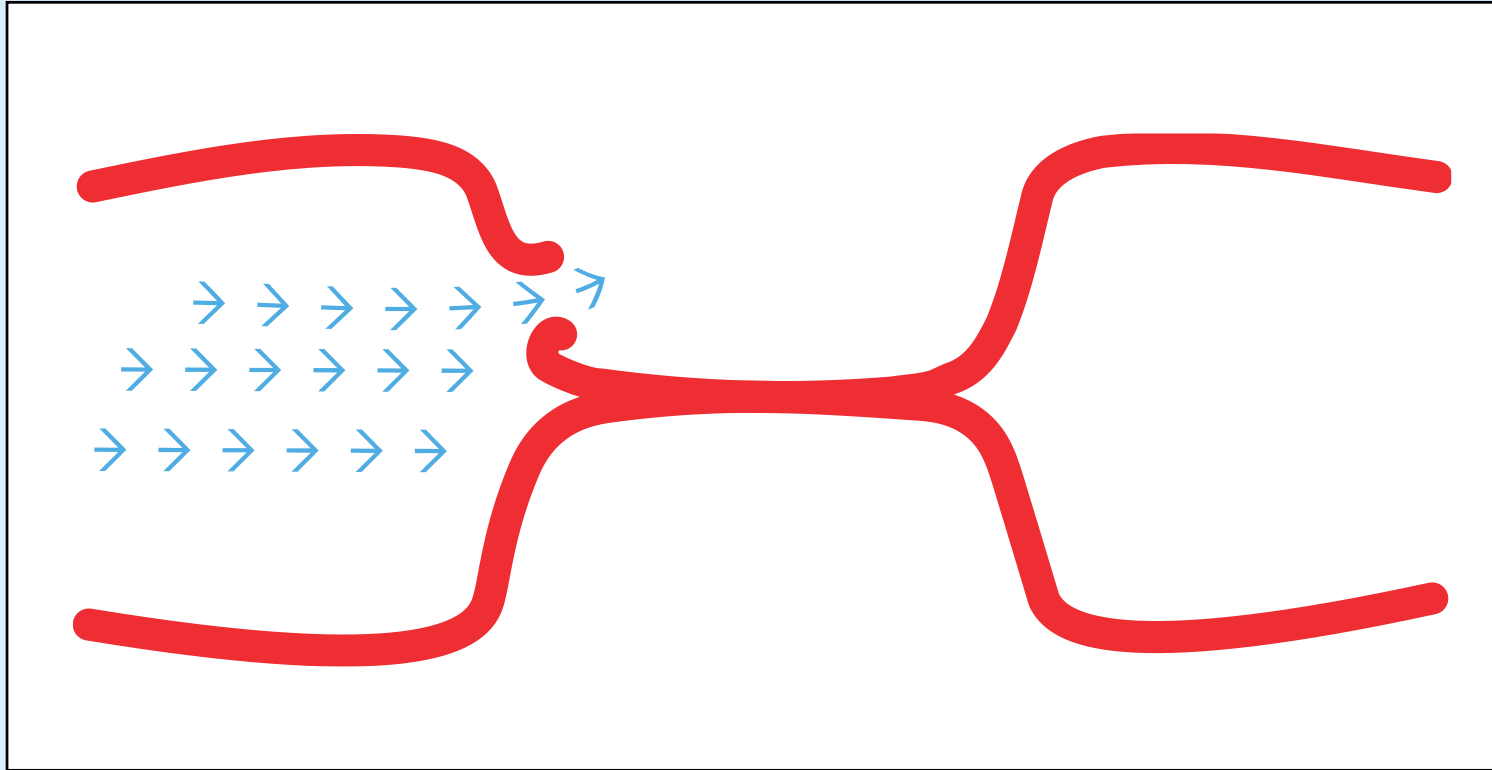
Pneumatic Stenting

- Use of positive pressure to open the airway
- Recruitment maneuver
- Positive end expiratory pressure (PEEP)
 - High PEEP
 - Decreased preload
 - Decreased CO
 - Increased RV afterload
 - Decreased ventricular contractility

Jet Ventilation

- Pressurized oxygen at high respiratory rates
- Oxygenation → Diffusion
- Ventilation → Convection of flow
- Constant PEEP
- Complications
 - Barotrauma
 - Air trapping
 - Ischemia
 - Gastric insufflation
 - Arrhythmias

Jet Ventilation

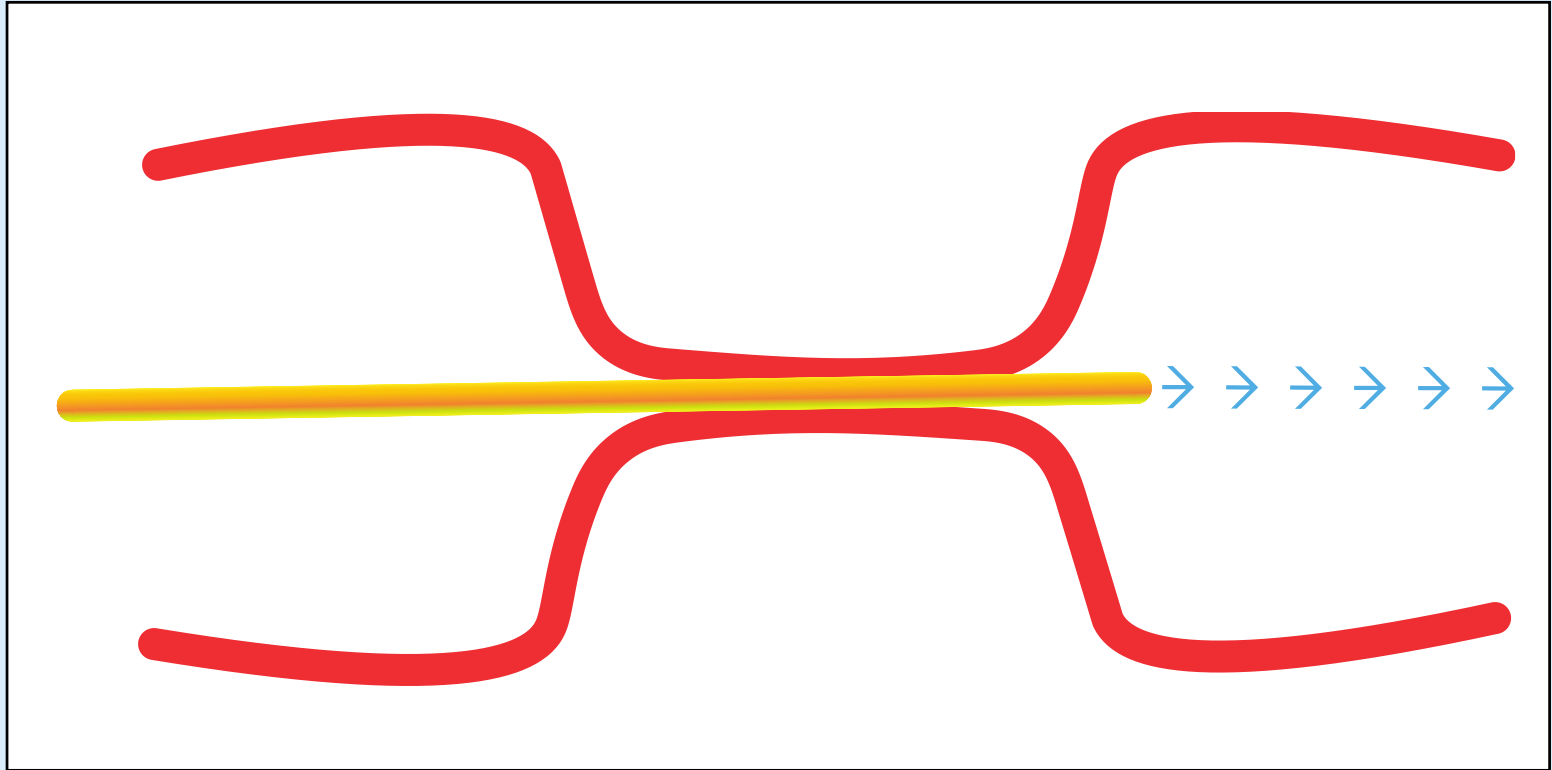


Jet Ventilation



Yang Z, Meng Q, Xu Y, Wang J, Yu D. Supraglottic jet oxygenation and ventilation during colonoscopy under monitored anesthesia care : a controlled randomized clinical trial. *Eur Rev Med Pharmacol Sci.* 2016;20:1168-1173.

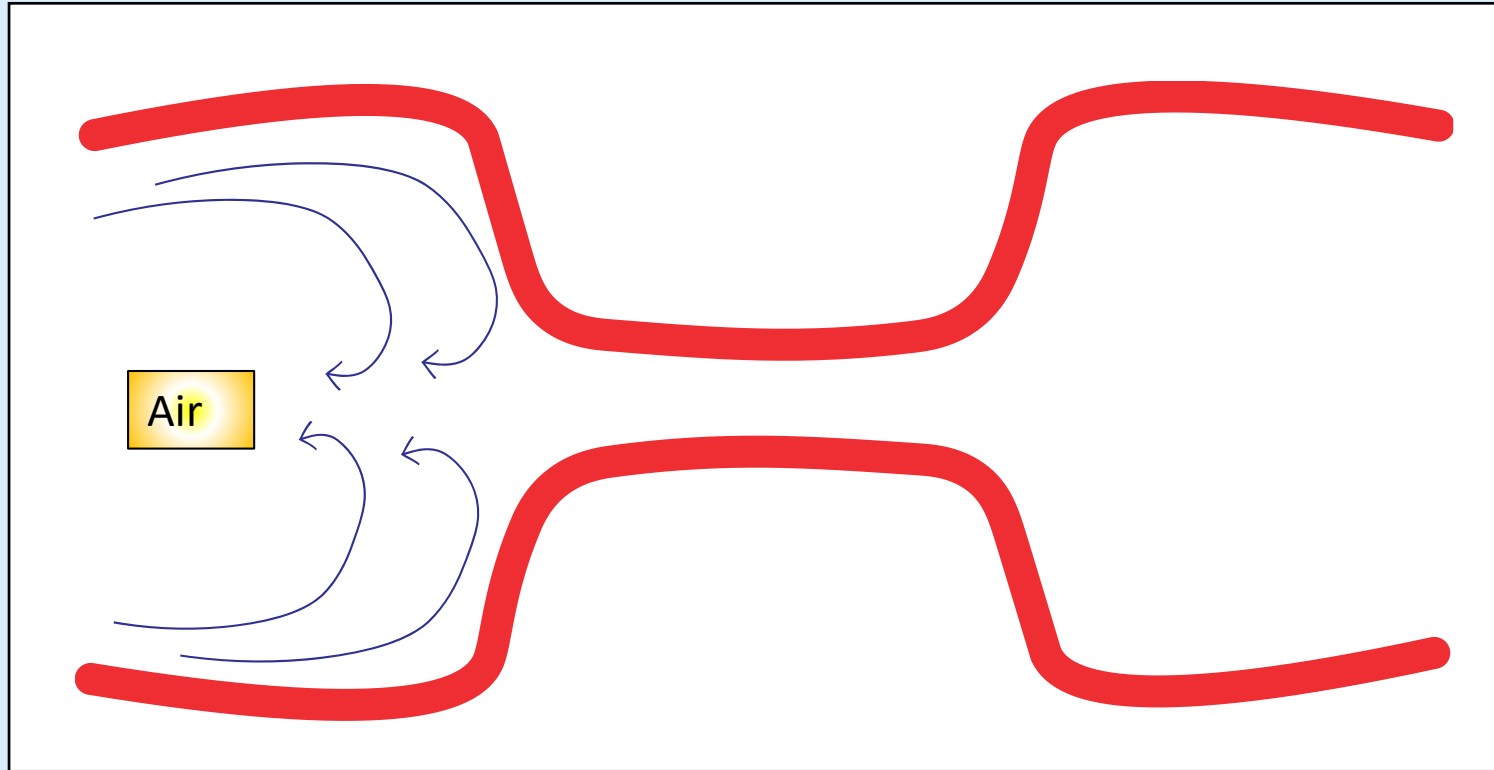
Jet Ventilation



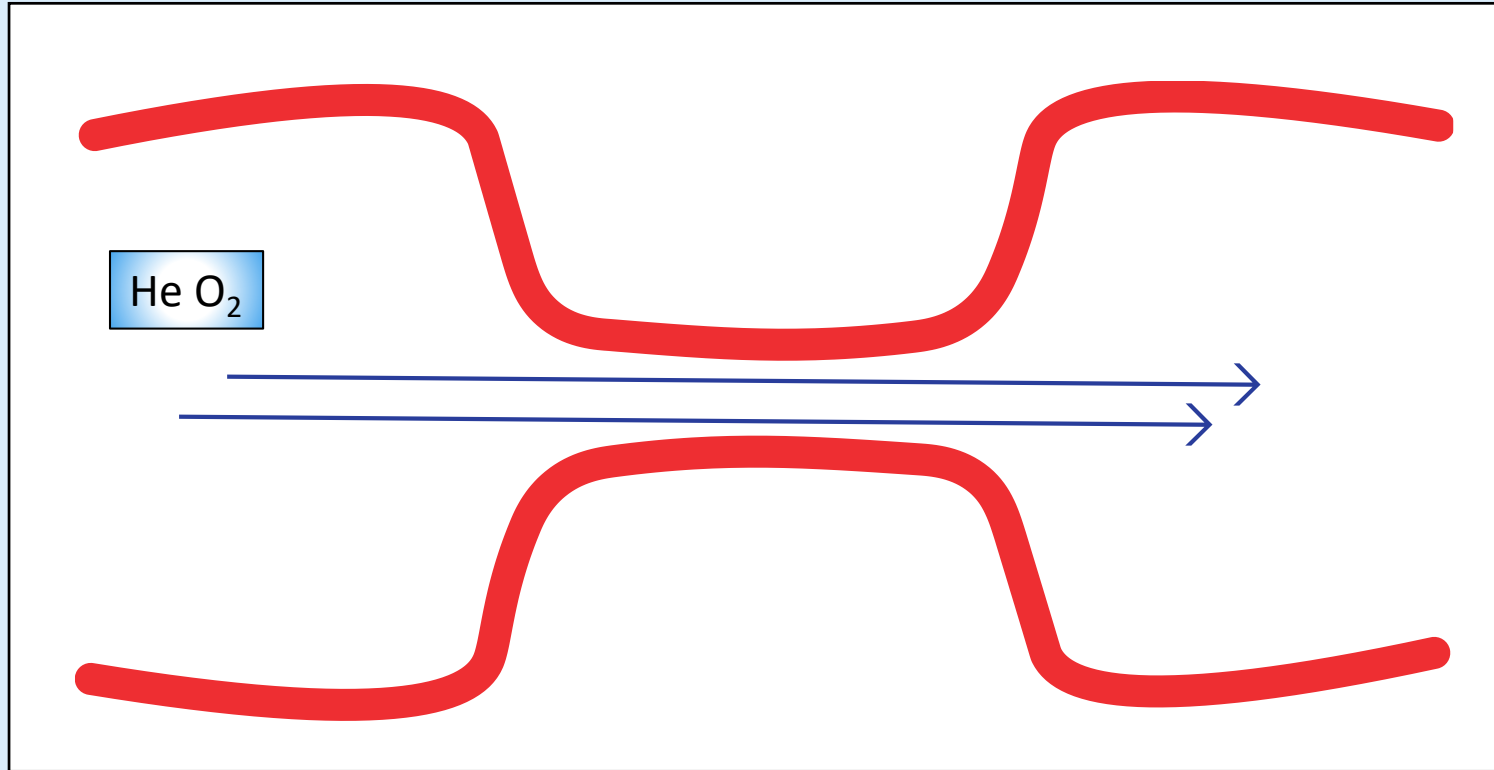
Helium

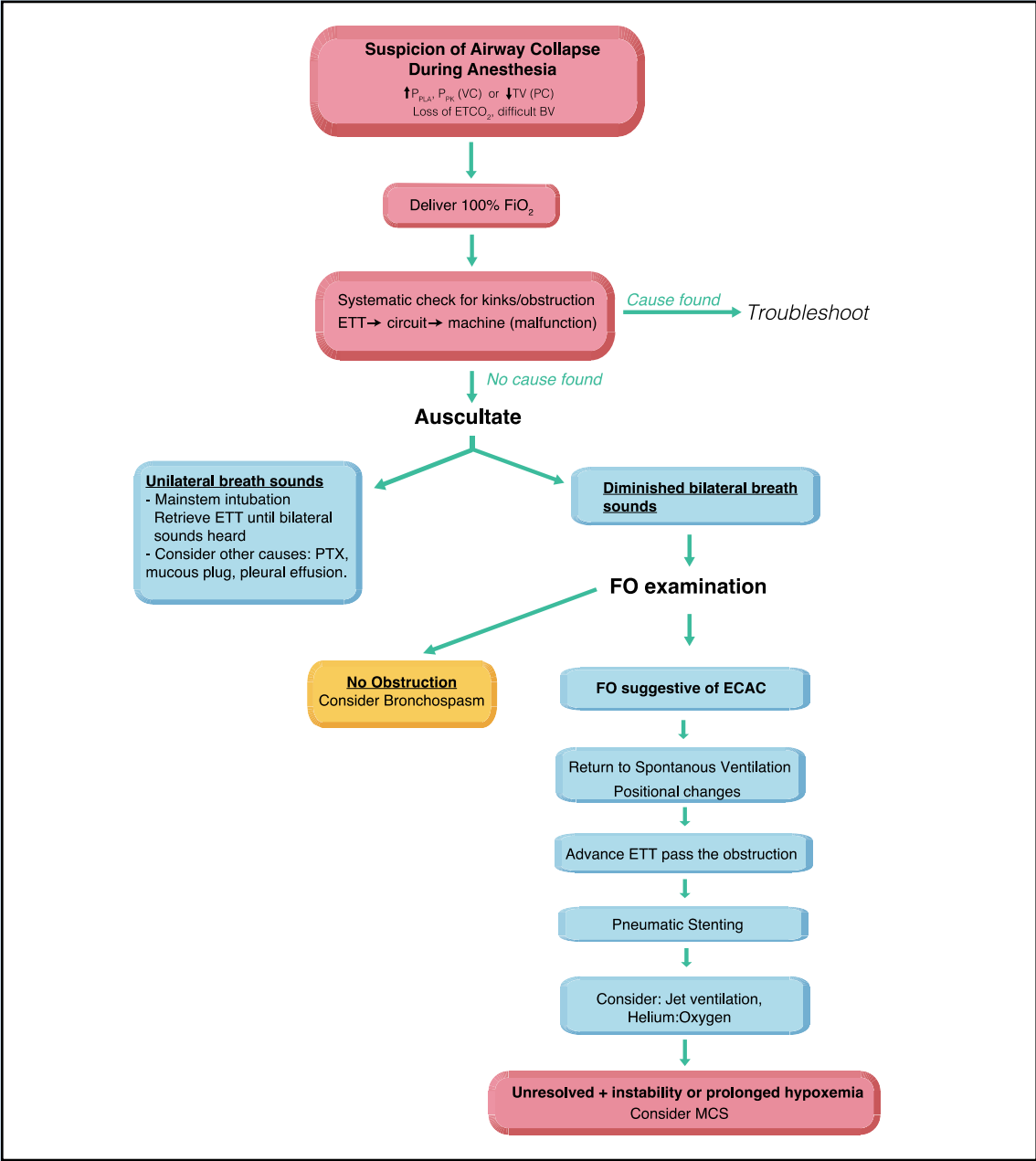
- Light gas
- Available as
 - He:O₂ (79%/21%)
 - He:O₂ (72%/28%)
- More useful with hypercarbia than hypoxemia

Use of Helium



Use of Helium





Emergence and Extubation

- Establish the degree of collapse with FO examination
- High risk of Postoperative respiratory failure
 - Perform a Spontaneous Breathing trial
 - Rapid Shallow Breathing index < 100
 - Oxygen Saturation $> 90\%$
 - Observe for collapse (loss of capnography, increase respiratory pressures)
- Consider extubating to non-invasive ventilation
- Monitor in an intermediate care unit

Corrective Treatment of ECAC

Treatment of ECAC

- Medical Management
- Airway Stent placement
 - Trial
 - Palliative
- Tracheobronchoplasty

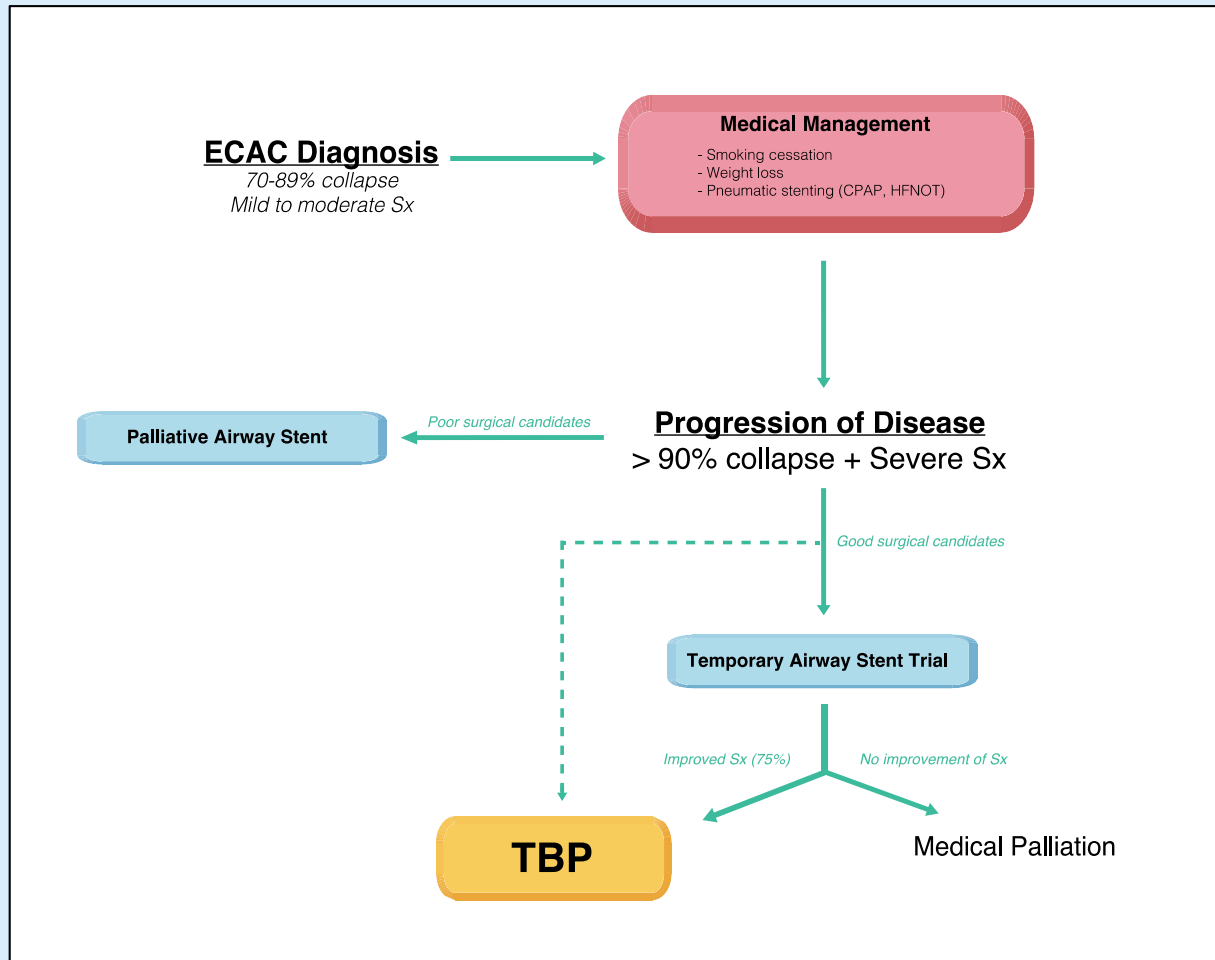
Medical Management of ECAC

- Lifestyle modifications
 - Smoking cessation
 - Weight loss
 - Optimization of comorbidities
- Pneumatic stenting
 - Continuous positive airway pressure (CPAP)
 - Non-invasive positive pressure ventilation
 - High flow nasal oxygen therapy

Corrective Treatment, Patient Selection

- Indication for surgery
 - Presence of severe symptoms (dyspnea and intractable cough) attributed to severe airway collapse (>90%).
 - Respiratory Failure requiring mechanical ventilation
- Poor Surgical candidates
 - Deemed unable to tolerate single lung ventilation
 - Preoperative hypoxemia

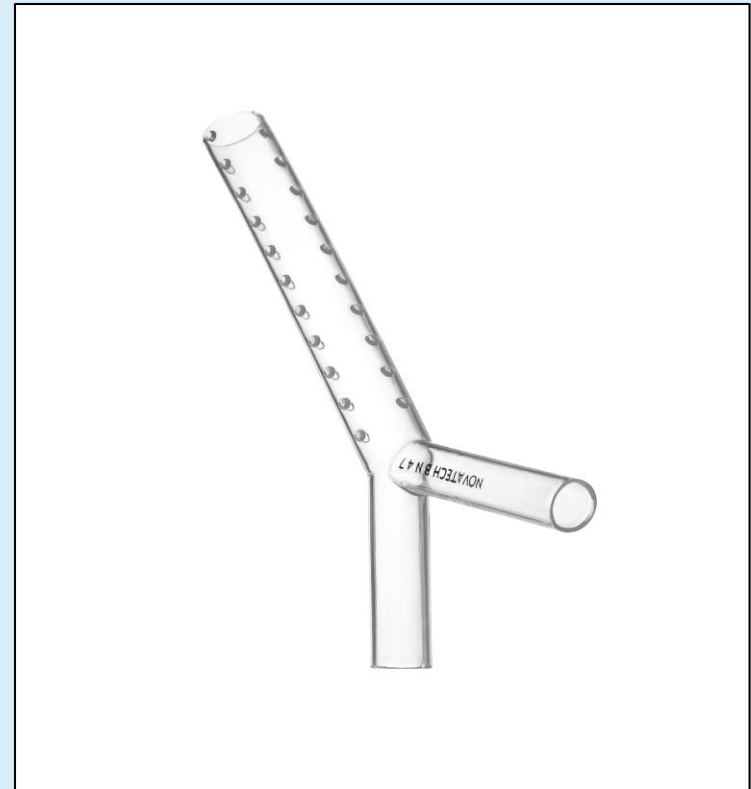
Management Algorithm



Diaz Milian R, Foley E, Bauer M, et al. Expiratory Central Airway Collapse in Adults: Anesthetic Implications (Part 2). *J of Cardiothorac Vasc Anesth.* 2018 (Epub ahead of print, PMID:30279066)

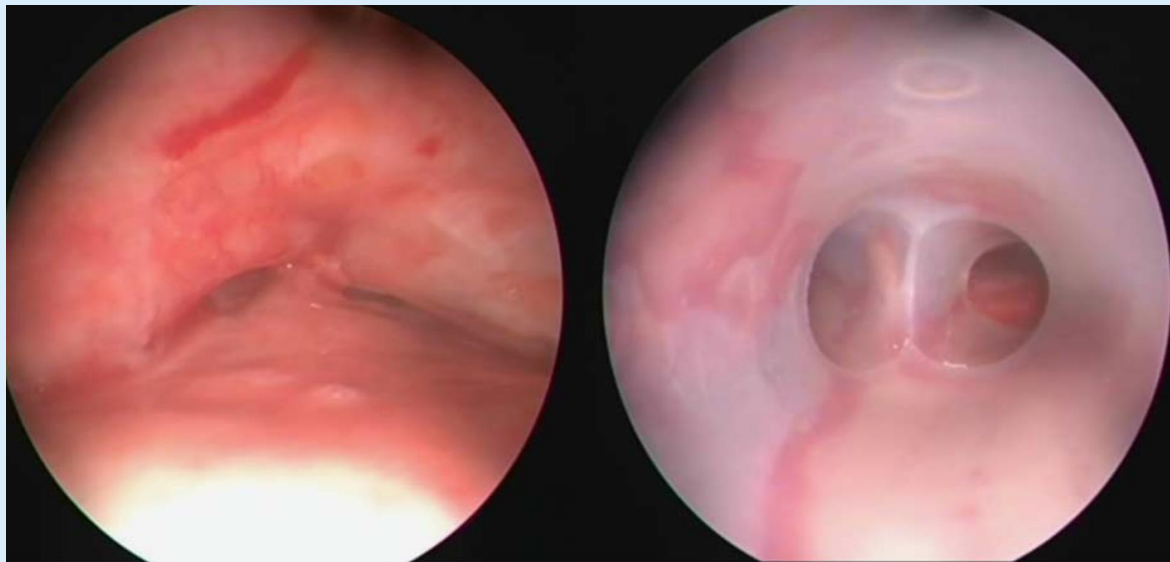
Airway Stent

- “Y” shaped stents
 - Metal
 - Silicone
- Placed via rigid bronchoscope
- Complications
 - Mucus plugging
 - Infection
 - Stent migration
 - Severe cough
 - Subglottic edema
 - Breakage



DUMON Y stent, provided by Boston Medical.
Copyright Novatech SA, France

Airway Stent



Ozgul MA, Cetinkaya E, Cortuk M, et al. Our Experience on Silicone Y-Stent for Severe COPD Complicated with Expiratory Central Airway Collapse. *J Bronchol Interv Pulmonol*. 2017;24(2):104-109.

Anesthetic Management of Airway Stent Placement

- Assess risk of collapse
- Prepare emergency equipment
- Total intravenous anesthesia
- Oxygenation and Ventilation
 - Apneic oxygenation
 - Intermittent ventilation
 - Jet ventilation

Tracheobronchoplasty

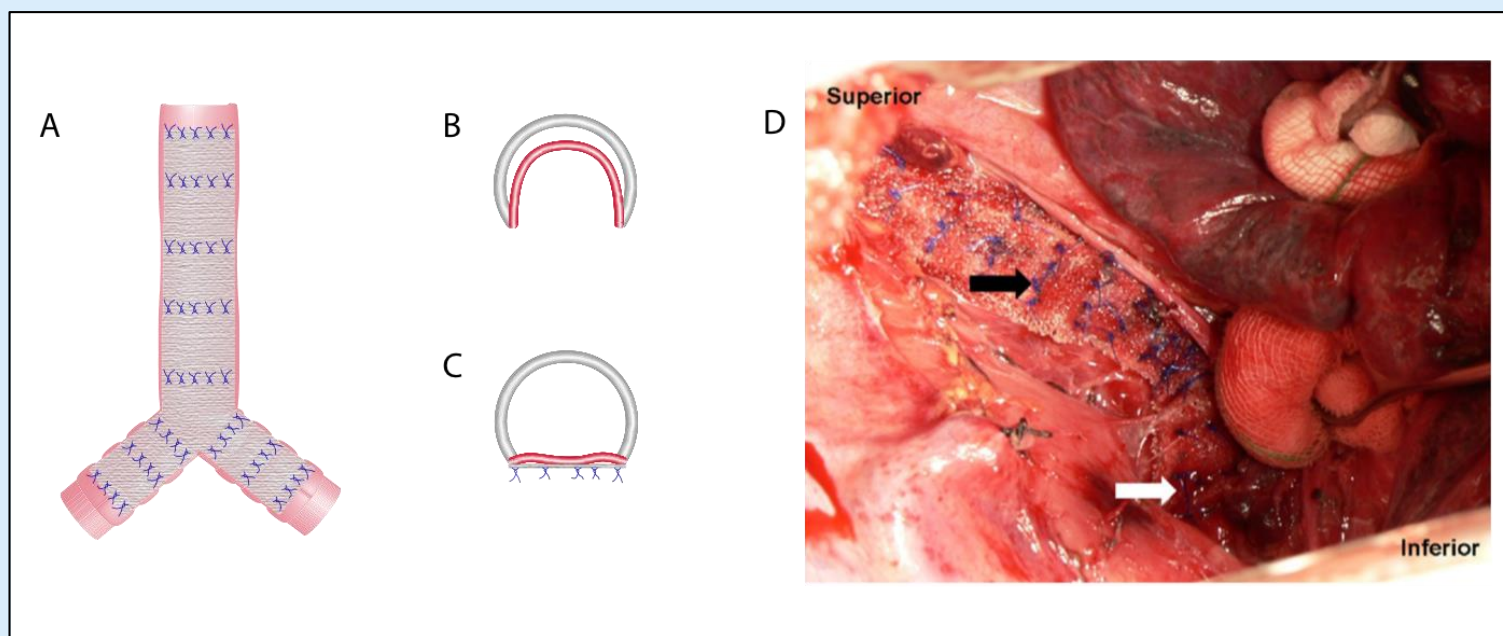
- Stabilization of membranous trachea by plication and mesh placement
- Improvement of symptoms
 - 3 months 77.8%
 - 1 year 75%
 - 2 year 67.6%
 - 5 years 65%

Murgu SD, Egressy K, Laxmanan B, et al. Central Airway Obstruction. *Chest* 2016;150:426-41

Tracheobronchoplasty

- Complications
 - Pneumonia
 - Atrial arrhythmias
 - Pulmonary embolism
 - Renal failure
 - Myocardial infarction
 - Need for tracheostomy
 - Mortality 5.7%

Tracheobronchoplasty



Diaz Milian R, Foley E, Bauer M, et al. Expiratory Central Airway Collapse in Adults: Anesthetic Implications (Part 2). *J of Cardiothorac Vasc Anesth.* 2018 (Epub ahead of print, PMID:30279066)

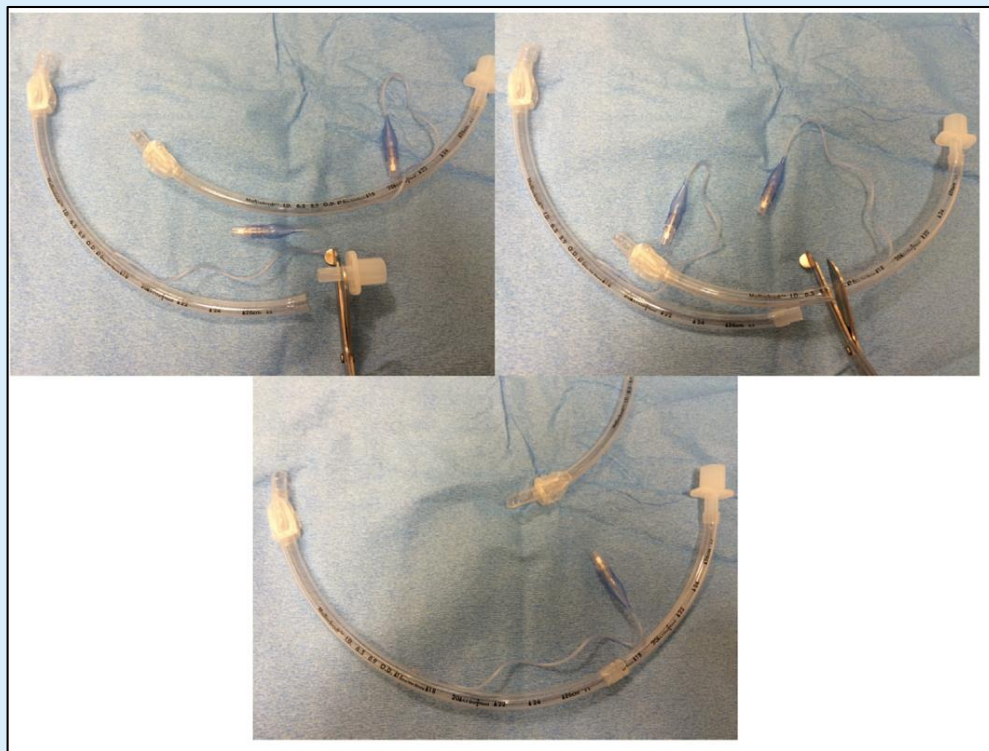
Anesthetic Management of TBP

- Preoperative Evaluation
 - Stress test
 - Poor functional capacity from suspected CAD + surgery can delayed for stent + DAT
 - Functional status
 - E.g. Karnofsky performance status

Anesthetic Management of TBP

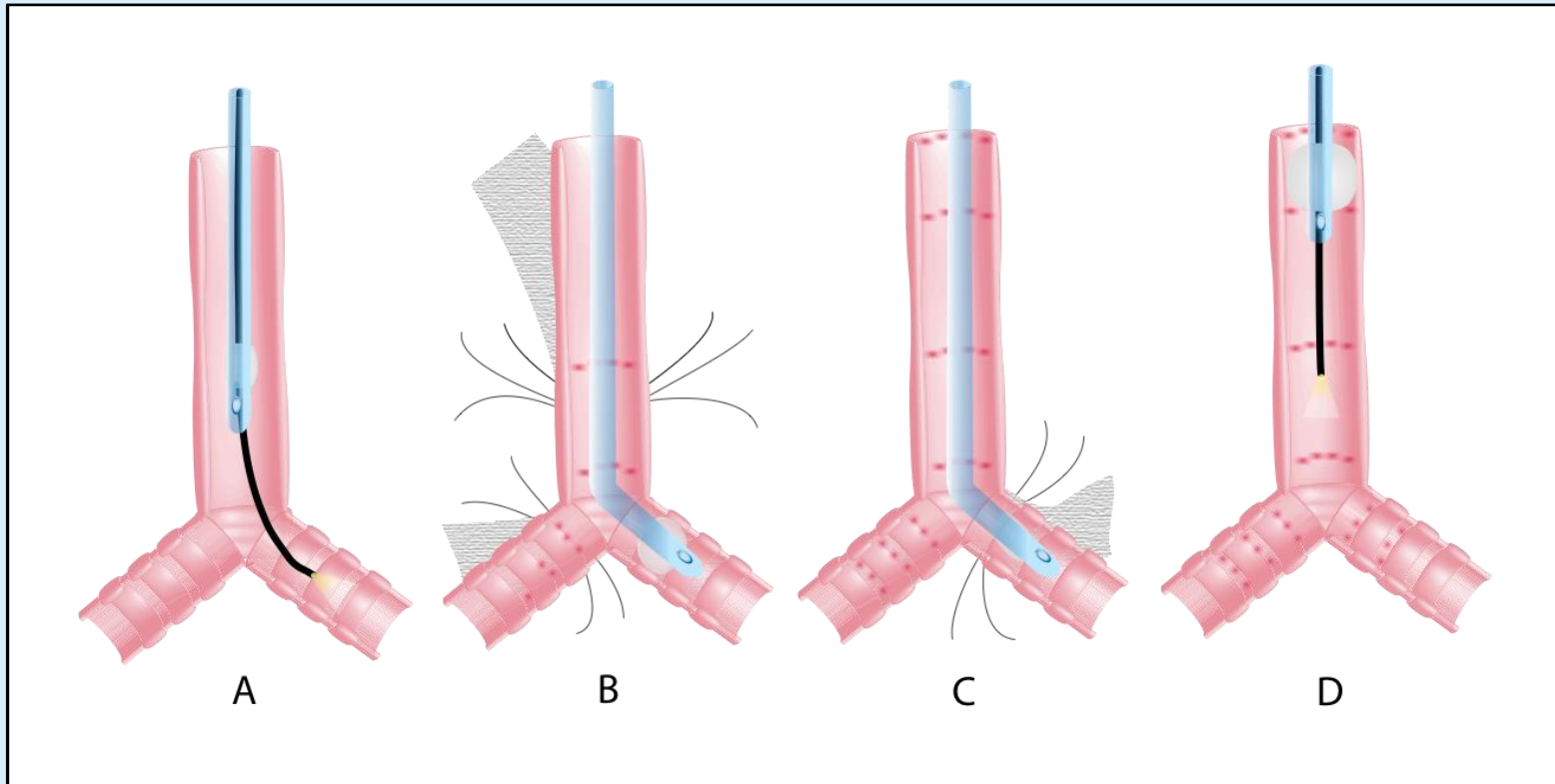
- Induction of general anesthesia
- Maintenance
 - Total Intravenous Anesthesia
 - Brain activity monitor
- Airway
 - Intermittent ventilation
 - Jet Ventilation
 - One lung Ventilation
 - Modified left double lumen tube
 - Endobronchial tube
 - Combination technique

Endobronchial Tube



McLaurin S, Whitener GB, Steinburg T, et al. A Unique Strategy for Lung Isolation During Tracheobronchoplasty. *J Cardiothorac Vasc Anesth.* 2017;31:731-737.

Airway Management of Tracheobronchoplasty



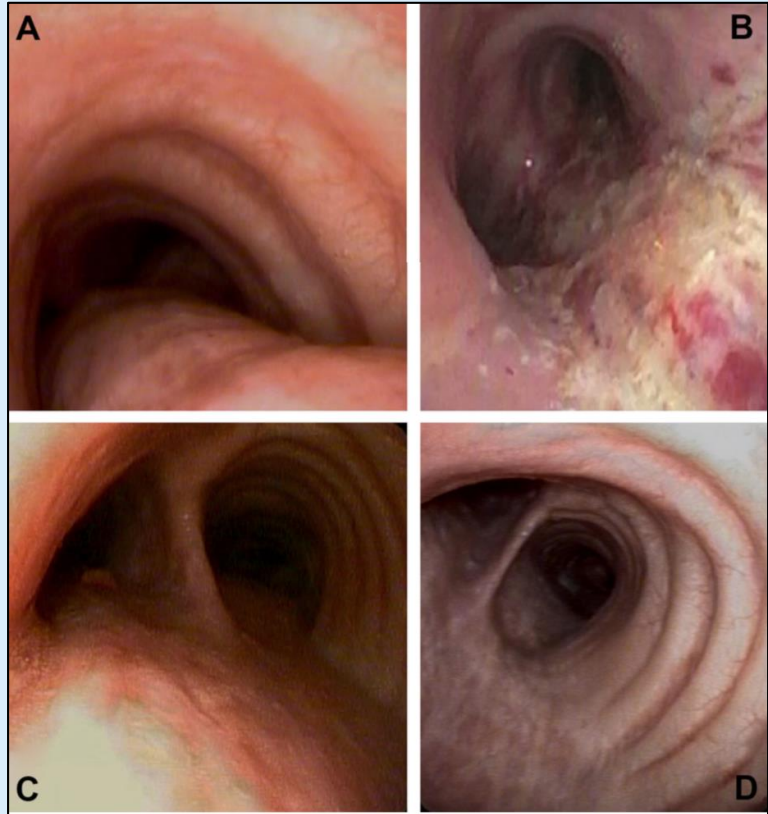
Diaz Milian R, Foley E, Bauer M, et al. Expiratory Central Airway Collapse in Adults: Anesthetic Implications (Part 2). *J of Cardiothorac Vasc Anesth*. 2018 (Epub ahead of print, PMID:30279066)

Anesthetic Management of TBP

- Extubation
 - Muscle reversal
 - Spontaneous breathing trial
 - Respiratory monitoring in an intensive care unit
- Post-operative Pain Control
 - *Thoracic epidural*
 - Paravertebral catheters
 - Ultrasound-guided fascial plane blocks
 - Serratus anterior
 - Erector Spinae block

Laser Tracheobronchoplasty

- Novel approach
- Suspension laryngoscopy
- Single study



Castellanos P, Mk M, Atallah I. Laser tracheobronchoplasty: a novel technique for the treatment of symptomatic tracheobronchomalacia. *Eur Arch Oto-Rhino-Laryngology*. 2017;274:1601-1607.

Conclusions

- ECAC is difficult to recognize
- Significant risk of airway and ventilatory compromise
- > 70% collapse is significant, particularly when associated with symptoms
- > 90% collapse is critical, and an indication for surgical repair

Questions?

Thank you for your time

References

- Diaz Milian R, Castresana MR. Recurrent failure of positive-pressure ventilation: machine malfunction or a rare, unexpected cause? *J Cardiothorac Vasc Anesth*. 2017;32:2029-2030.
- Campos JH. Update on Tracheobronchial Anatomy and Flexible Fiberoptic Bronchoscopy in Thoracic Anesthesia. *Curr Opin Anesthesiol*. 2009;22:4-10
- Krishan, S. Venovenous Extracorporeal Membrane Oxygenation for Lung Failure. Consult QD. <https://consultqd.clevelandclinic.org>. Published: Jan 7 2019.
- Yang Z, Meng Q, Xu Y, Wang J, Yu D. Supraglottic jet oxygenation and ventilation during colonoscopy under monitored anesthesia care : a controlled randomized clinical trial. *Eur Rev Med Pharmacol Sci*. 2016;20:1168-1173
- Ozgul MA, Cetinkaya E, Cortuk M, et al. Our Experience on Silicone Y-Stent for Severe COPD Complicated with Expiratory Central Airway Collapse. *J Bronchol Interv Pulmonol*. 2017;24(2):104-109.
- McLaurin S, Whitener GB, Steinburg T, et al. A Unique Strategy for Lung Isolation During Tracheobronchoplasty. *J Cardiothorac Vasc Anesth*. 2017;31:731-737.
- Castellanos P, Mk M, Atallah I. Laser tracheobronchoplasty: a novel technique for the treatment of symptomatic tracheobronchomalacia. *Eur Arch Oto-Rhino-Laryngology*. 2017;274:1601-1607.
- Diaz Milian Ricardo, Foley Edward, Bauer Maria, Martinez-Velez Andrea, Castresana Manuel. Expiratory Central Airway Collapse: Anesthetic Implications (part 1). *Journal of Cardiothoracic and Vascular Anesthesia*. 2018 (In press)
- Diaz Milian Ricardo, Foley Edward, Bauer Maria, Martinez-Velez Andrea, Castresana Manuel. Expiratory Central Airway Collapse: Corrective Treatment (part 2). *Journal of Cardiothoracic and Vascular Anesthesia*. 2018 (In press)