Expiratory Central Airway Collapse, Anesthetic Implications

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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
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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

- Expiratory Central Airway Collapse
- Tracheobronchomalacia (TBM)
- Expiratory Dynamic Airway Collapse (EDAC)
Anatomy of the Central Airways

Cross Section View
Bronchoscopic Anatomy of the Airway

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

B Acquired Expiratory Central Airway Collapse
- Tracheobronchomalacia

C Excessive Dynamic Airway Collapse
- Cross Section View
- Chronic Inflammation, Autoimmune disorder
- Smooth Muscle Atrophy

D Causes of TBM:
- Chronic polychondritis
- Tracheostomy
- Mucopolysaccharidosis
- Amyloidosis
- Mustard gas

COPD
- Asthma
- Foreign Body
- Masses

Causes of EDAC:
- Smoking
- Drugs (Steroids, beta agonists)
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

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

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 $\rightarrow$ Diffusion
- Ventilation $\rightarrow$ Convection of flow
- Constant PEEP
- Complications
  - Barotrauma
  - Air trapping
  - Ischemia
  - Gastric insufflation
  - Arrhythmias
Jet Ventilation
Jet Ventilation

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

[Diagram showing the flow of HeO₂]
Suspicion of Airway Collapse During Anesthesia

- \( P_{ac}, P_{cm} \) or \( TV \) (PC)
- Loss of ETCO\(_2\), difficult BV

- Deliver 100% FiO\(_2\)

- Systematic check for kinks/obstruction
  - ETT → circuit → machine (malfunction)

  - Cause found: Troubleshoot

  - No cause found

  - Auscultate

  - Unilateral breath sounds:
    - Mainstream intubation
    - Retrieve ETT until bilateral sounds heard
    - Consider other causes: PTX, mucus plug, pleural effusion

  - Diminished bilateral breath sounds

  - FO examination

  - FO suggestive of ECAC

  - Return to Spontaneous Ventilation
    - Positional changes

  - Advance ETT pass the obstruction

  - Pneumatic Stenting

  - Consider: Jet ventilation, Helium:Oxygen

  - Unresolved + instability or prolonged hypoxemia
    - Consider MCS
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

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

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%

Tracheobronchoplasty

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

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

Airway Management of Tracheobronchoplasty

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

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


