Airway Imaging in COPD

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Learning Objectives

- Recognize complementary roles of qualitative and quantitative CT analysis in COPD
- Identify characteristic morphological airway abnormalities associated with COPD on CT
- Understand significance of expiratory tracheal collapse in COPD patients
- Be aware of overlap between health and disease

Quantitative CT (QCT)

- QCT measures of emphysema and airway wall thickening
  - Independently associated with degree of FEV1 impairment in COPD
  - Identify distinct phenotypes for targeted therapy
  - Predict subgroups at risk for COPD exacerbation
    - Han MK et al Radiology 2011;261:274-282

Qualitative Assessment

- Rapid assessment of both large and small airways
- Identification of coexisting lung parenchymal abnormalities
- Detection of causes of QCT errors such as mucous plugging

More Complete Picture

- Rapid imaging phenotype assessment PLUS
- Detection of lung cancer, ILD, pneumonia
- Identification of systemic COPD manifestations and complications
  - Coronary artery calcifications
  - Aortic abnormalities
  - Metabolic syndrome
  - Osteoporosis and compression fractures

Synergy

- Quantitative CT: objective regional information
- Qualitative CT: rapid and clinically meaningful overall picture
CT Protocol
- Volumetric MDCT
- Sub-mm resolution
- Dose reduction methods
- Single breath hold with respiratory coaching
- Supplemental, low-dose forced expiratory or end-expiratory sequence

CT of Airways
- Trachea
- Bronchi

Tracheal Morphology
- Normal
  - Sagittal:Coronal ratio = 1
- Saber sheath
  - Sagittal:Coronal ratio > 2
- Lunate
  - Sagittal:Coronal ratio < 1

Expiratory Tracheal Collapse
- Associated with COPD due to
  - weakness of supporting tracheal cartilaginous structures (tracheomalacia, TM) and/or
  - excessive anterior bulging of the posterior membranous wall of the trachea (excessive dynamic airway collapse, EDAC)

Expiratory Tracheal Collapse in COPD
- Weak but significant correlation between tracheal collapse and respiratory symptoms
- Lack of association between severity of tracheal collapse and GOLD stage
  - Sverzellati et al Eur Radiol 2009;19:1669-1678
- Lack of correlation with physiological parameters fits within context of broad spectrum of collapse in normals
  - Boiselle et al Radiology 2009;252: 255-262

Tracheal Collapse in COPD
Incidental detection of excessive expiratory tracheal collapse in COPD may not necessarily be clinically significant in the absence of co-morbidities such as obesity
**Tracheal Collapse, Obesity and COPD**

- Morbidly obese COPD patients demonstrate significantly greater expiratory tracheal collapse than non morbidly obese COPD patients
  - Michaud G et al Chest 2011;140;4 (abstract)
- No significant difference in tracheal collapse in morbidly obese and non morbidly obese controls without COPD

**Obesity + COPD**

- Relationship between COPD and obesity increasingly recognized
- Potential interaction between abnormal adipose tissue function, systemic inflammation, and COPD
- Obese COPD patients more likely to have airway (chronic bronchitis) phenotype
- Excessive tracheal collapse likely another manifestation of airway phenotype in obese COPD patients

**Mechanism**

- Obese pts likely to have elevated intrathoracic pressures that may predispose to central airway narrowing during ordinary breathing and forced expiration
- Such narrowing could be exacerbated among obese patients with coexisting COPD with weakness of airway walls due to atrophy of elastic fibers in the post membranous wall from chronic inflammation

**Practical Implications**

- Clinicians should consider TM when confronted with a morbidly obese COPD pt with greater quality of life impairment and worse exercise performance than expected based on functional measures
- Radiologists should carefully evaluate airways of obese COPD patients given their propensity for excessive expiratory tracheal collapse and chronic bronchitis

**CT of Airways**

- Trachea
- Bronchi

**Bronchi in COPD**

- Wall thickening
- Irregularity
- Diverticula
- Bronchiectasis
- Bronchomalacia
Bronchial Wall Thickening
- Commonly visible on thin-section CT of COPD patients with chronic bronchitis (CB)
- Pathology: hypertrophy and hyperplasia of bronchial glands, chronic inflammatory cell infiltration of bronchial mucosa, hypertrophy of bronchial wall smooth muscle
- Clinical significance: CB associated with worse respiratory symptoms and higher risk of exacerbations; may require targeted rx

BWT: Beware
- Not pathognomonic of smoking related chronic bronchitis
- Also seen in asthma and infectious airways diseases
- Common “incidental” finding in patients > 75 years of age
  - Copley S et al Radiology 2009;251:566-573

Bronchial Diverticula
- Air-filled outpouchings related to dilation of bronchial gland ducts, which coalesce and herniate through smooth muscle cellular bundles
- Corresponds to classic “accordion-like” appearance at bronchography
- Enhanced depiction at MDCT, especially with thin-section coronal reformations

Bronchial Diverticula
- COPD patients at increased risk due to bronchial wall damage and increased intrabronchial pressure with coughing
- Observed at MDCT in half of smokers
- >3 diverticula associated with
  - More frequent coughing
  - Heavier smoking history
  - More severe functional impairment, emphysema and bronchial wall thickening

Diverticula: Beware
- Not pathognomonic of COPD and not exclusively associated with cigarette smoking
- 40% prevalence in subcarinal region at MDCT in asymptomatic adults without pulmonary disease

Bronchiectasis
- Deficiency of bronchial cartilage in COPD may result in alternating bronchial dilation and narrowing
- Bronchiectasis may also occur due to recurrent infections
- Reported at CT in over half of patients with moderate to severe COPD
Bronchiectasis: Clinical Significance in COPD

- Associated with severe airflow obstruction, isolation of a potentially pathogenic microorganisms from sputum, and at least 1 hospitalization for COPD exacerbation in past year
  - Martinez-Garcia M et al Chest 2011;140:1130-1137

Bronchiectasis: Beware

- Bronchial dilation observed at thin-section CT in 60% of asymptomatic adults > 75 years of age
  - urban dwellers, ex- and non-smokers
- No relationship with smoking
  - Copley S et al Radiology 2009;251:566-573

Small Airways

- Centrilobular opacities reflecting mucous plugging and inflammation
- Expiratory air trapping due to small airway fibrosis and stenosis

Air Trapping

- Air trapping is seen on end-expiration CT scans as parenchymal areas with less than normal increase in attenuation and lack of volume reduction

Air Trapping: Beware

- Air trapping identified in over 60% of 50 healthy asymptomatic individuals with normal PFTs
- No correlation with smoking history
  - Tanaka et al Radiology 2003;227:776-785

Summary

- Visual assessment of airways is an important aspect of interpreting CT scans of COPD patients
- May assist in phenotyping of COPD patients with potential therapeutic and prognostic value
- Complementary information to QCT
- Incidental detection of expiratory tracheal collapse in COPD may not be significant in absence of other comorbidities
Additional References

- Kauczor H-U et al. CT imaging of the airways in COPD & asthma. J Thorac Imaging 2011;26:290-300

Question:

True or False:

Bronchial diverticula are exclusively associated with COPD.

Answer: False