Obstructive Pulmonary Physiology From the Imaging Perspective: Balloons, Airway Inflammation or Dynamic Collapse

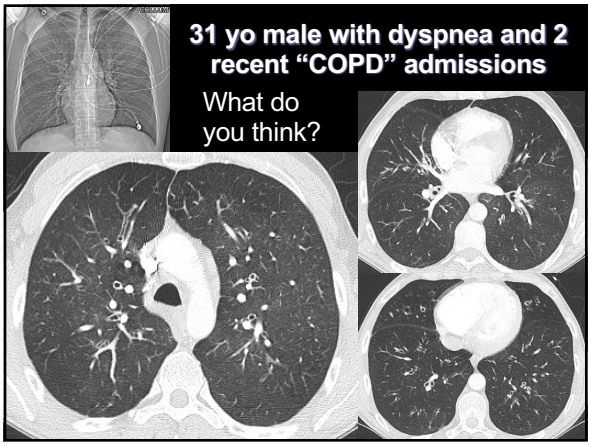
Marc V. Gosselin, MD
Vision Radiology
OHSU School of Medicine

1

Lecture Objectives

- Introduce the differential of 'COPD'
- Use of imaging to demonstrate the underlying physiology and pathology to help explain the clinical manifestations
- Clinical **'Red Flags'** to alert the possible presence of other common, but often not clinically diagnosed cause of 'COPD'
- **"Where all think alike, no one thinks very much"** Walter Lippmann

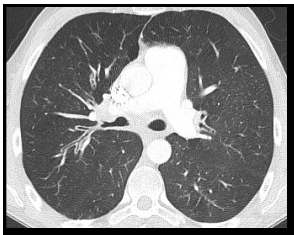
2



31 yo male with dyspnea and 2 recent "COPD" admissions

What do you think?

3



Question #1:

What would your report impression likely say?

- 1. Findings consistent with 'COPD'/emphysema
- 2. Findings consistent with acute bronchitis
- 3. No acute pulmonary disease
- 4. Findings consistent with Constrictive Bronchiolitis

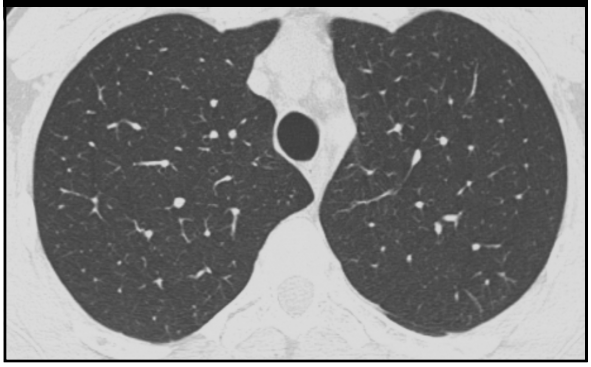
4

"The Greatest Obstacle to Discovery is not Ignorance, but the *Illusion* of Knowledge."

Daniel J. Boorstin

5

Normal Thin Section CT



6

Normal Thin Section CT: Cardiac Motion

7

Normal Inspiration and Expiration

8

'COPD' = Algorithm "Thinking"

- Chronic obstructive pulmonary disease (COPD) is a general term lumping emphysema, chronic bronchitis and asthma together
- 'COPD' leads to ***reflexive*** treatment algorithms
- Disadvantages of using the term COPD:
  - *Other obstructive conditions* are often over-looked.
  - Pathologic and physiologic mechanisms of these diseases are different.
  - Prognosis and treatment are disease specific.

*Try to **avoid** using the term 'COPD' in your reports*

9

Algorithmic Medicine

10

Misconceptions about 'COPD' are very common:

- 'Hyperinflation of lungs with smoking history means emphysema' (Pulmonologist)
- 'Lungs that extend below 10th ribs is hyper inflated and represents COPD' ((Pulmonologist & Radiologist)
- 'Emphysema is not diagnosed with imaging, *it is a PFT diagnosis.*' (Pulmonologist)

11

Misconceptions about 'COPD' are often taught with confidence:

- 'Patient has emphysema, she was exposed to second hand smoke' The response *by a pulmonologist* when informed the patient likely has another cause for their obstructive lung disease given her recurrent admissions and not improving on treatment.
- 'Hyperinflated lungs consistent with Emphysema' – *Radiology report and agreement by physician* in a patient without any smoking history. Lost their insurance '*For lying about smoking*'

"We can be Absolutely Certain *Only* about Things We Do *Not* Understand." Eric Hoffer

12

13

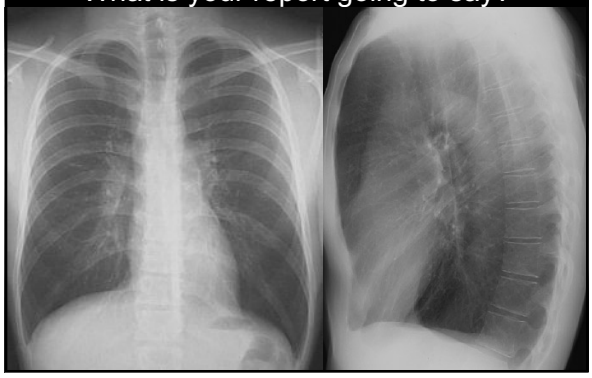
"COPD": What You *Should* Be Considering

- ***6 different pathologies*** can manifest with severe obstructive disease:
  - -Emphysema ('Balloons')
  - -Chronic Bronchitis
  - -Asthma
  - -Tracheobronchomalcia ('Dynamic')
  - -Constrictive Bronchiolitis ('Balloons')
  - -Bronchiectasis (via Constrictive bronchiolitis)

The *persistence or recurrence* of symptoms should alert you that a diagnosis is being missed

14

Hyperinflated lungs and Cachexia
What is your report going to say?



15

Obstructive Pulmonary Disease

- **Inflammatory:** Chronic bronchitis (Hypoxic), bronchiectasis and asthma (post viral or antigenic) (Shunt-like)
- **Balloons**: Space occupying diseases: (Increase in 'Dead Space') Emphysema and Constrictive bronchiolitis
- **Dynamic collapse:** Tracheobronchomalacia and/or Dynamic redundant posterior wall collapse (>70%)

16

What is the V/Q abnormality with Shunt Physiology?

- *Persistent perfusion with decreased or absent* ***ventilation*** = *Shunt*
- This induces ***hypoxia***
- **Chronic Bronchitis** is an example - Hence the term 'Blue Bloater'
- Also why ***Pulmonary Hypertension*** (Chronic Hypoxia induced) occurs so commonly with Chronic Bronchitis

17

What is Dead Space Physiology?

- *Persistent ventilation with decreased/absent* ***perfusion***
- *No to mild hypoxia*
- Pulmonary embolus is a perfect example of a Dead Space Physiology
- Emphysema (*'Pink Puffer'*), Constrictive Bronchiolitis and Tracheobronchomalacia often have a relatively balanced V/Q ratio at the alveolar levels (***Surface area*** becomes more an issue with Emphysema)

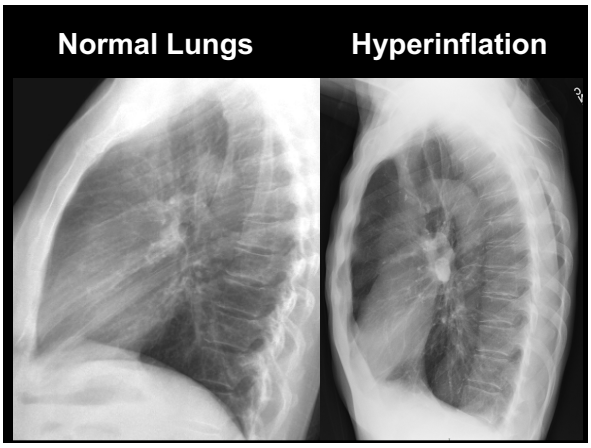
Quinn & Rizzo. Anatomy, Anatomic Dead Space:https://www.ncbi.nlm.nih.gov/books/NBK442016/ Dec 2018

18

Radiographic Signs of Hyperinflation

- **Flat diaphragm** (*Increased trapped RV*)
- Sterno-diaphragmatic angle ***approaches 90 degrees*** on lateral
- Increased width of retrosternal air space
- Increased AP diameter
- **Note**: Lungs extending below 10th rib is ***NOT*** a reliable criteria – 'People are like Snowflakes'

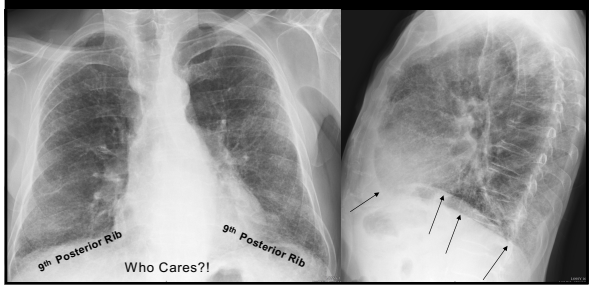
19



20

Is There Hyperinflation?

Do Not Count the Ribs!



21

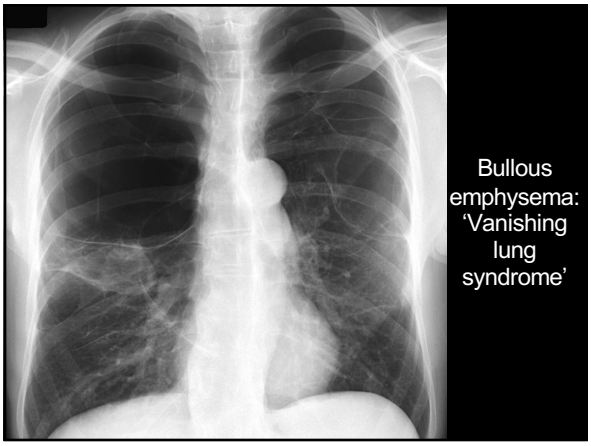
Emphysema: Radiographic Imaging

- Vascular attenuation and depletion with increasing branch angles approaching 90 degrees
- Hilum are 'pushed' inferior and medial
- Vascular crowding along the medial and lower lobes
- Check pulmonary artery size if advanced (Pulmonary hypertension)
- Cachexia may be present (Reason?)

22

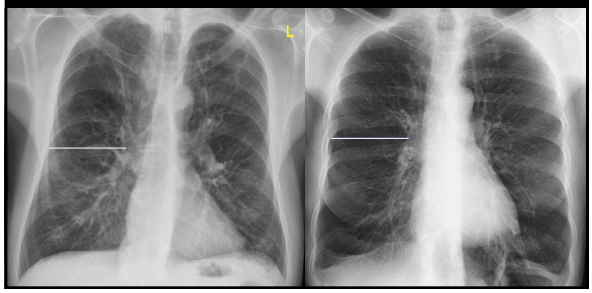
Radiograph Characteristic for Advanced Emphysema

23



24

Two examples of Obstructive Pulmonary disease: *Both represent emphysema* – Why do they look different? What differential might you offer?



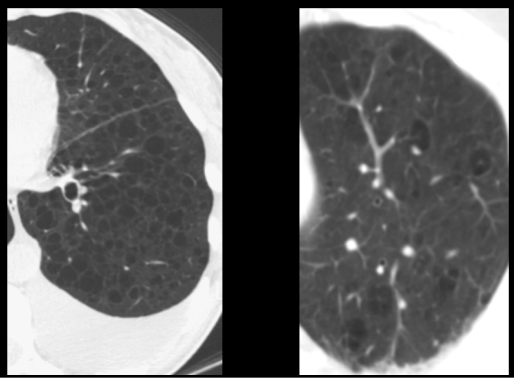
25

Emphysema: CT Imaging

- Different types such as Centrilobular (most common), Panlobular, Bullous and Paraseptal
- No visible wall and has a central/peripheral 'Dot' representing the residual Central bronchovascular bundle
- Cysts have *no* central/peripheral 'Dot' and often have walls
- Call it emphysema ***when you see it***

26

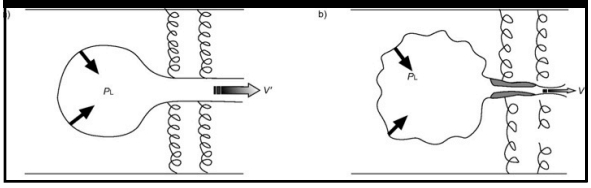
LAM (Cysts) Emphysema



27

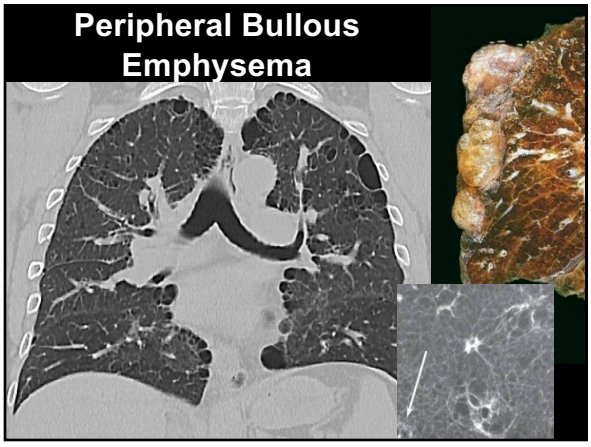
Hypothetical mechanism on how the expansion occurs

When filled…It is *Non-dynamic*



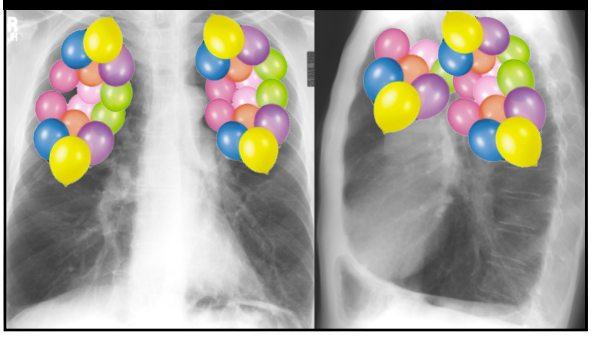
28

Peripheral Bullous Emphysema

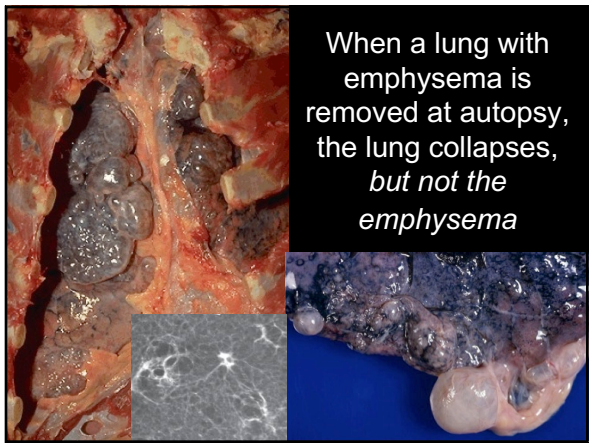


29

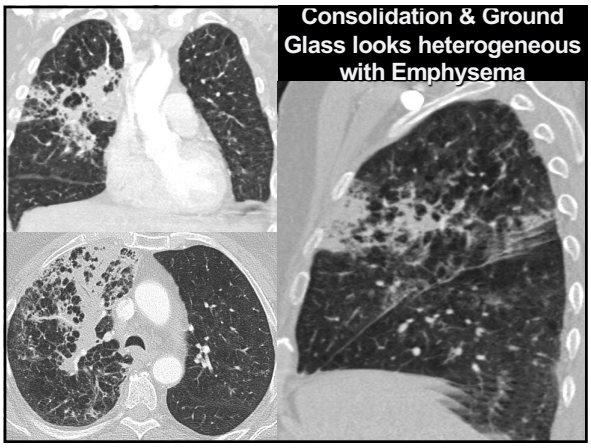
Minimal *Dynamic* Changes:
Increase in End-Tidal Residual Volume



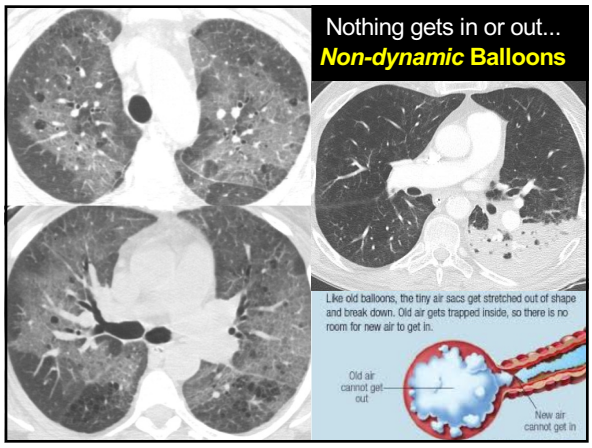
30



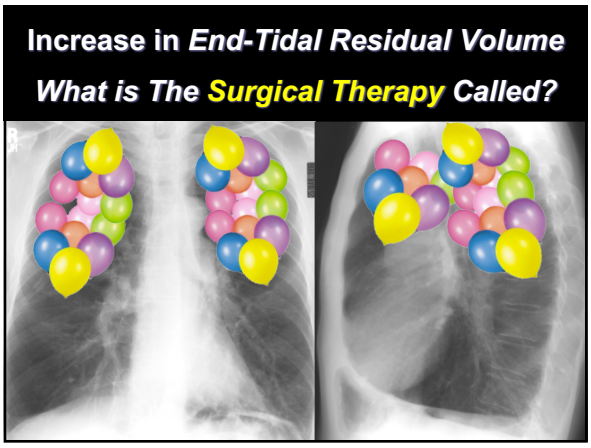
31



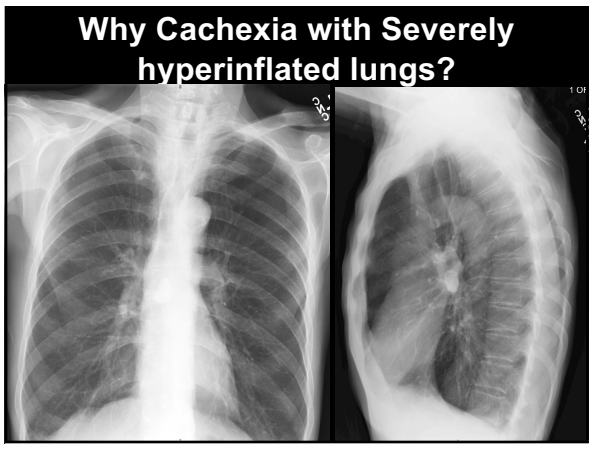
32



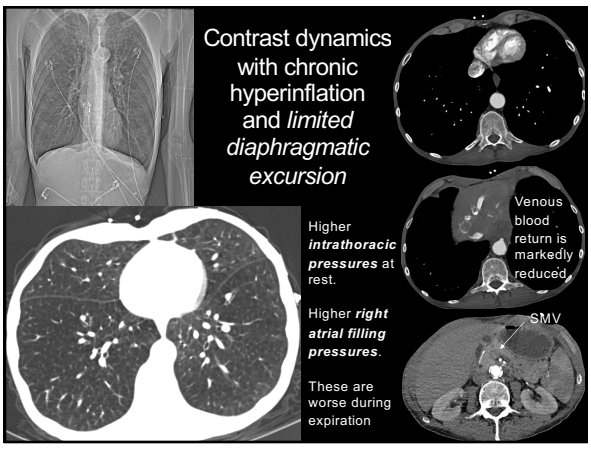
33



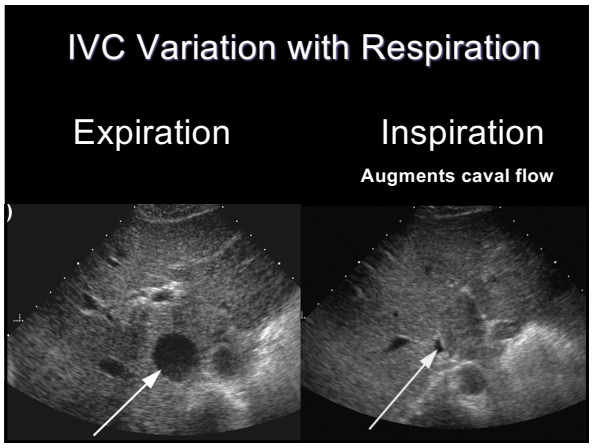
34



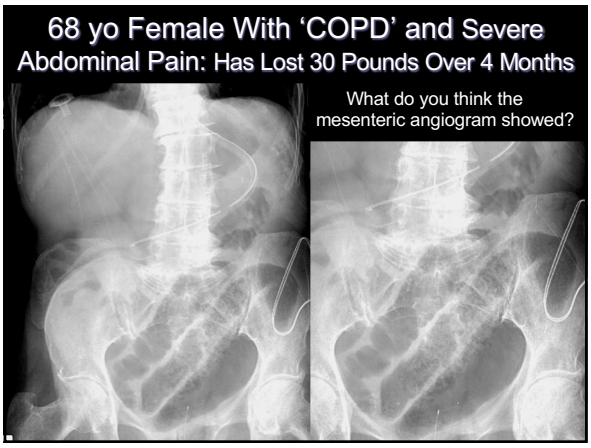
35



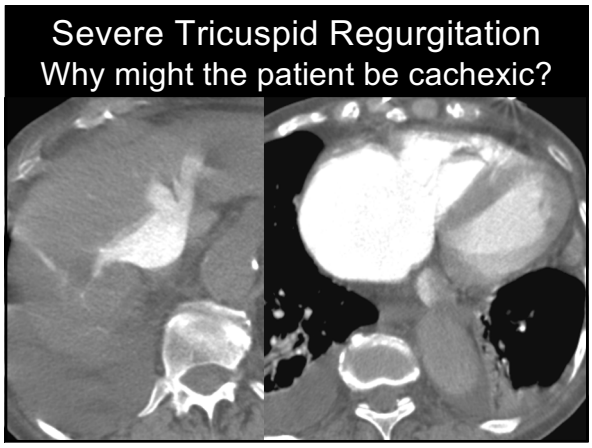
36



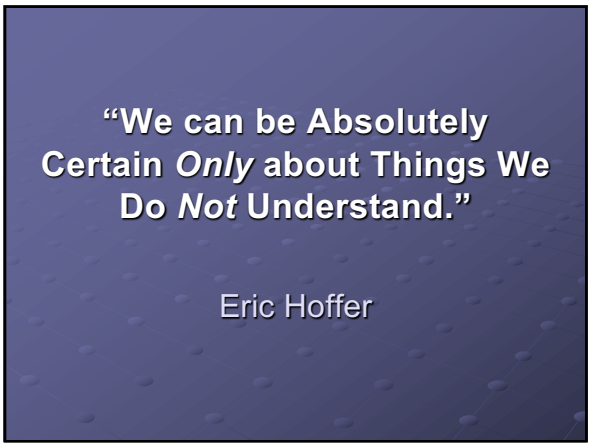
37



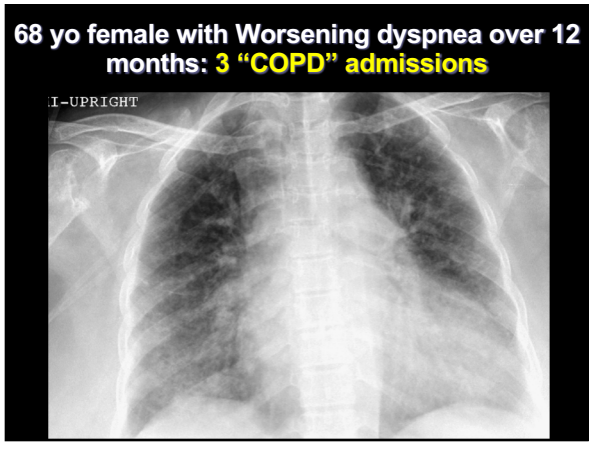
38



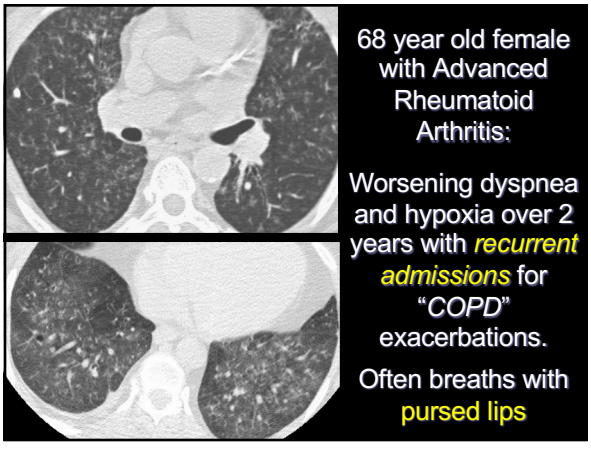
39



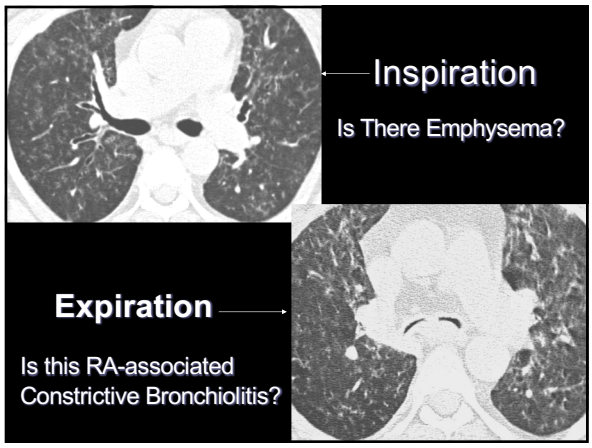
40



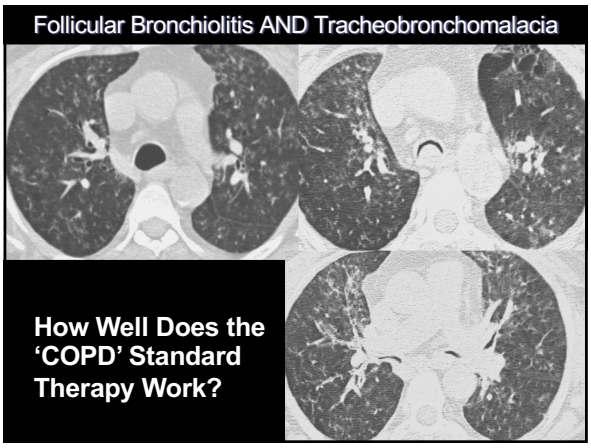
41



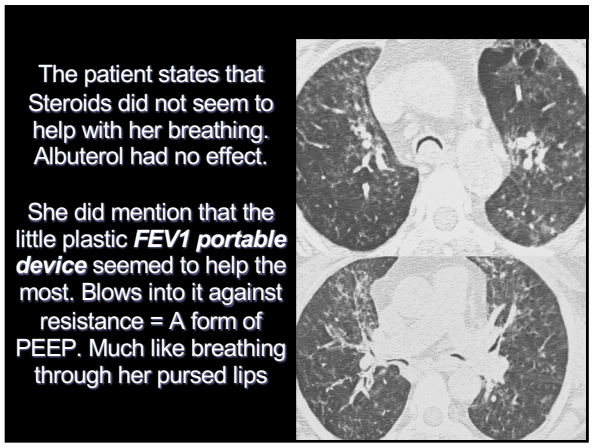
42



43



44

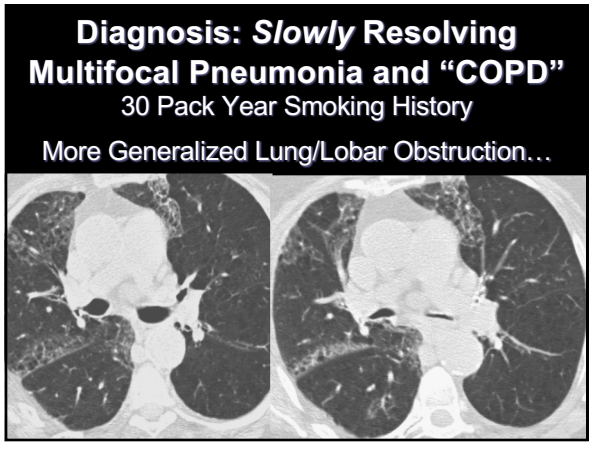


45

Tracheobronchomalacia

- Collapsing (>70%) of the Trachea and/or Bronchi with global air trapping
- Cartilage weakness
- Excessive Dynamic Tracheal collapse (EDTC)
- Pursed lip breathing
- Vocal cord dysfunction
- Chronic cough, often 'difficulty clearing secretions', Dyspnea, Exercise intolerance, wheezing

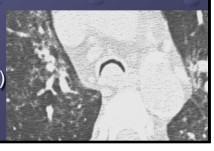
46



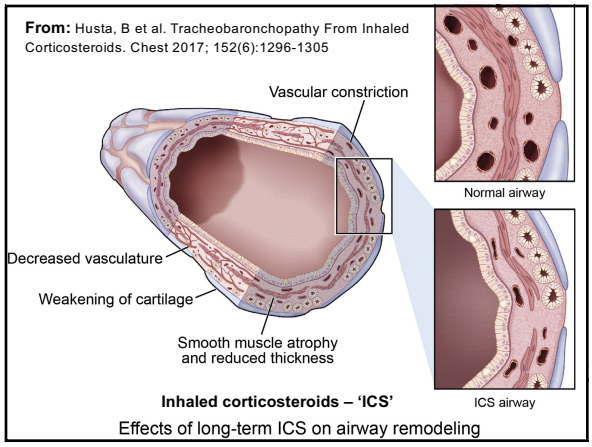
47

Tracheobronchomalacia

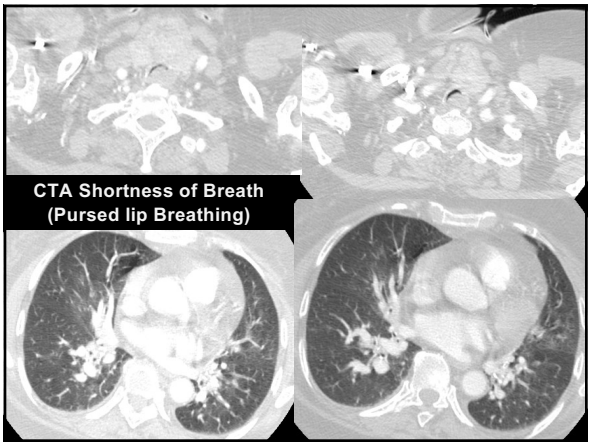
- 'Poorly responsive' Asthma/COPD
- *Recurrent 'COPD' exacerbations* (Not treating the correct diagnosis)
- **Associations:**
- Chronic Steroids (Autoimmune diseases)
- Constrictive Bronchiolitis → Tracheobronchiomalacia
  (Likely secondary to Chronic Steroids)
- Sleep Apnea



48



49



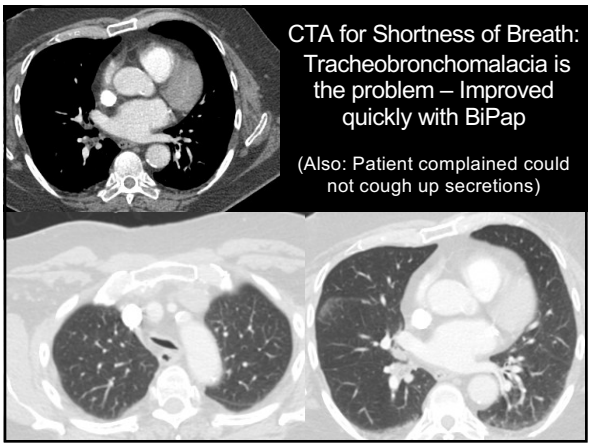
50

Incidence of Tracheobronchomalacia

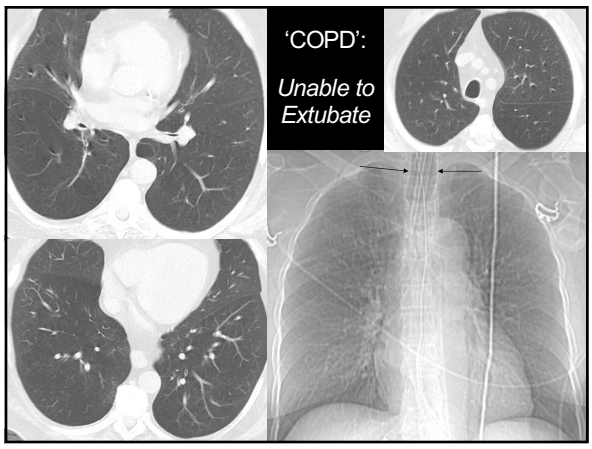
- Tracheobronchomalacia Incidence on ***ALL Pulmonary CTA's*** is about ***1 out of 10***
- **Red Flag Indications:** ***Shortness of Breath***, Persistent cough, unable to clear secretions, 'COPD', Severe 'Asthma'
- Need expiratory imaging or Respiratory motion during exam
- *2 out of 10* with 'COPD' diagnosis
- *7 out of 10* with 'Severe Asthma' diagnosis

Hasegawa et al: AJR December 2003;181:1505–1509

51



52

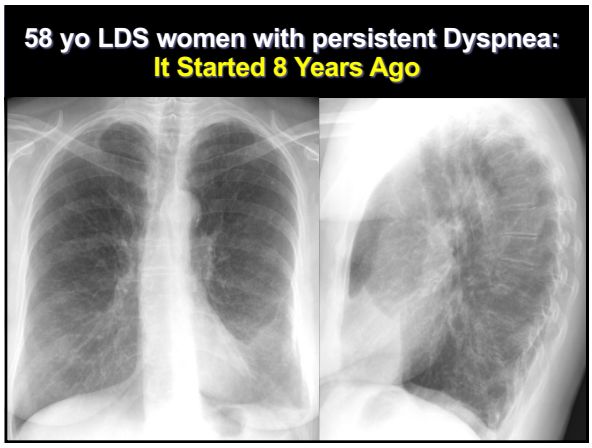


53

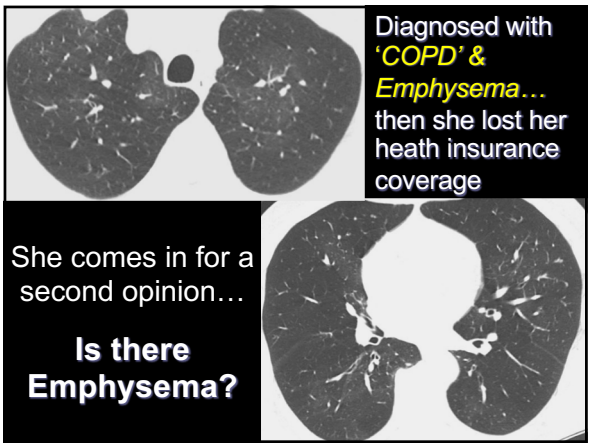
"Education is the progression from a cocky ignorance to a miserable uncertainty."

Mark Twain

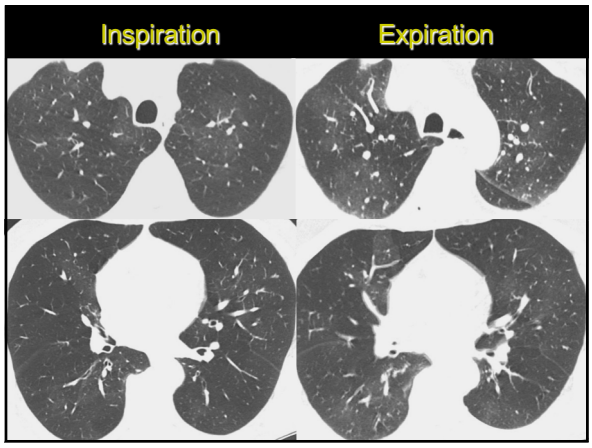
54



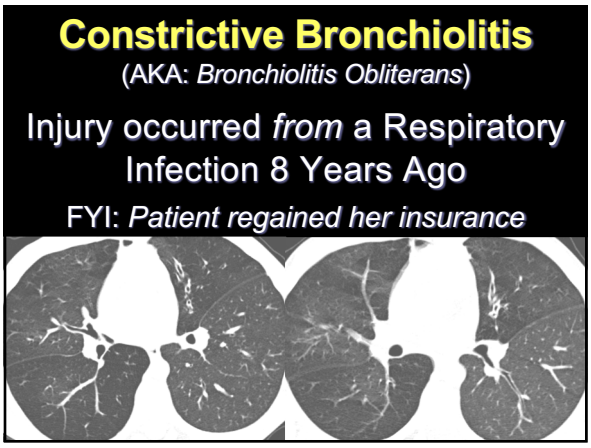
55



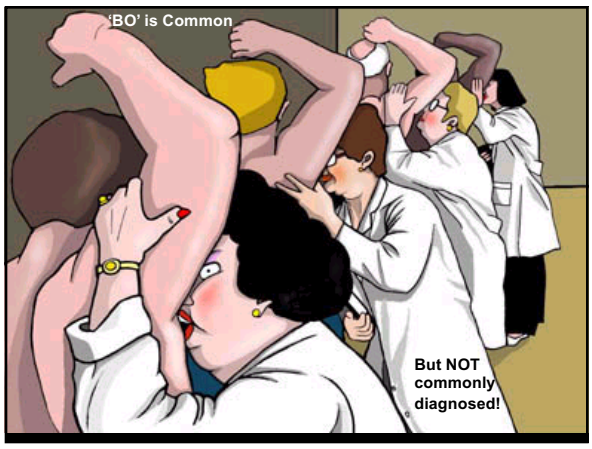
56



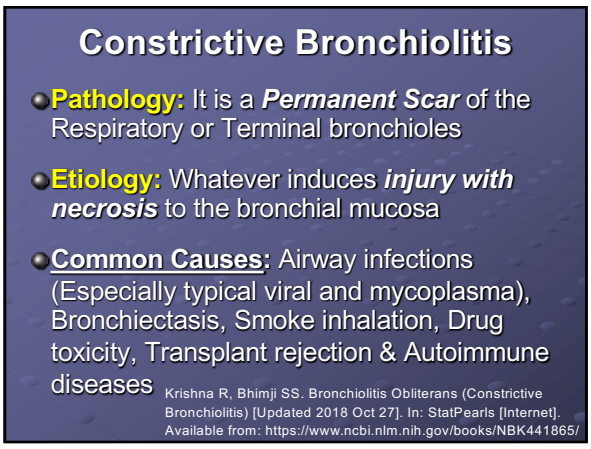
57



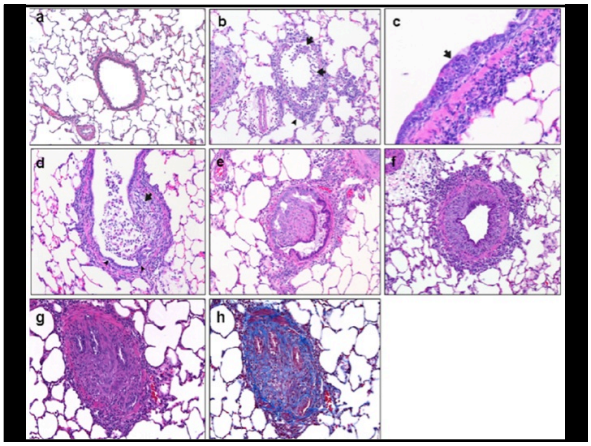
58



59



60

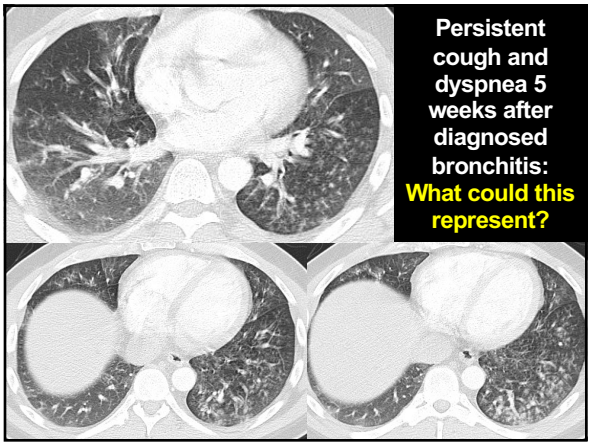


61

Constrictive Bronchiolitis

- **Symptoms:** ***Persistent*** Dyspnea/cough not responsive to steroids/albuterol
- *Not episodic* (Asthma)
- **Clue: OFTEN** a patient can tell you ***WHEN*** their breathing difficulties began
- **Example:** *Post RSV infection* ***2 yo*** *– 'Increase risk of Asthma, but often grows out of it'* – Is it Asthma? Why do they improve with age?
- What if the child was a **15 yo** with mycoplasma?

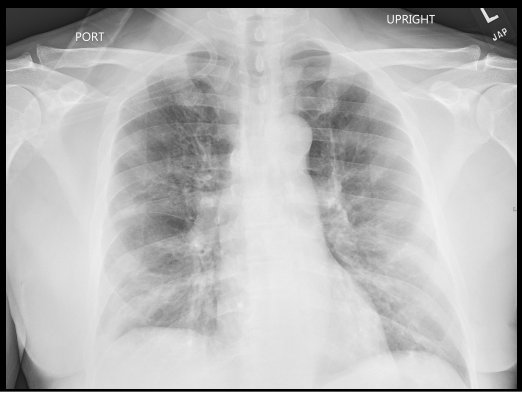
62



Persistent cough and dyspnea 5 weeks after diagnosed bronchitis: What could this represent?

63

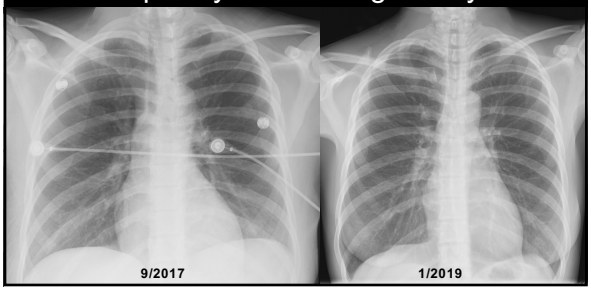
50 yo Persistent 'Non-responsive Asthma'



64

41 year old female with persistent dyspnea, difficulty with exercise and weight loss over a 2 year period.

14 pack/year smoking history.



65

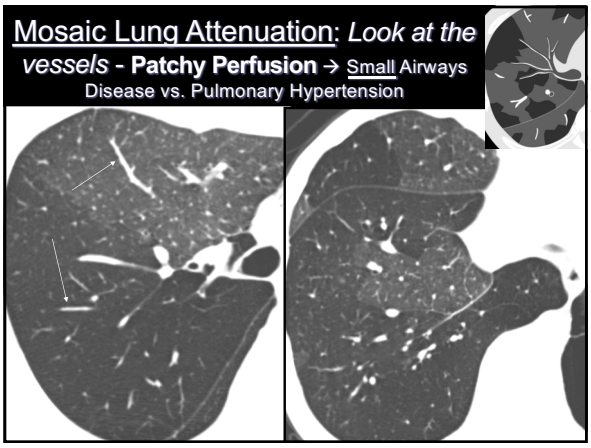
Dyspnea started in late 2017 after waking up in a house fire accident. Diagnosis?

66

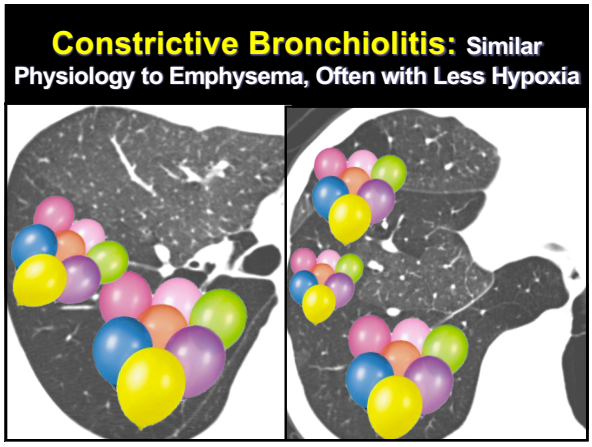
Constrictive Bronchiolitis

- **Imaging:** ***Patchy areas of air trapping on expiration thin section CT imaging***
- Contrast with Tracheobronchomalacia which has more *global areas of air trapping* since the obstruction is more central
- **Confounding:** Bronchomalacia involving the more segmental bronchi can be more difficult to distinguish
- ***Note:** Constrictive Bronchiolitis and Tracheobronchomalacia ***can coexist*** (Especially if on *Chronic* Steroids for misdiagnosed Constrictive Bronchiolitis)

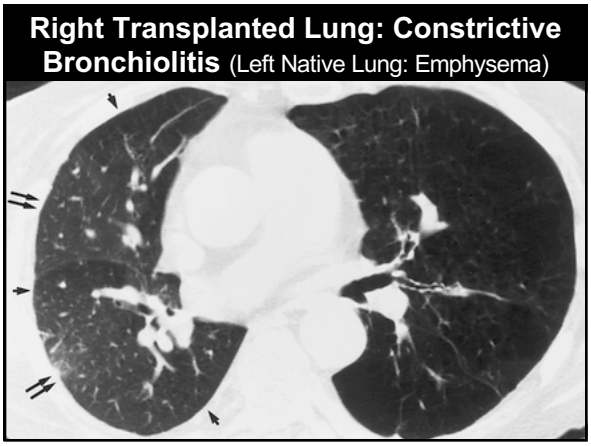
67



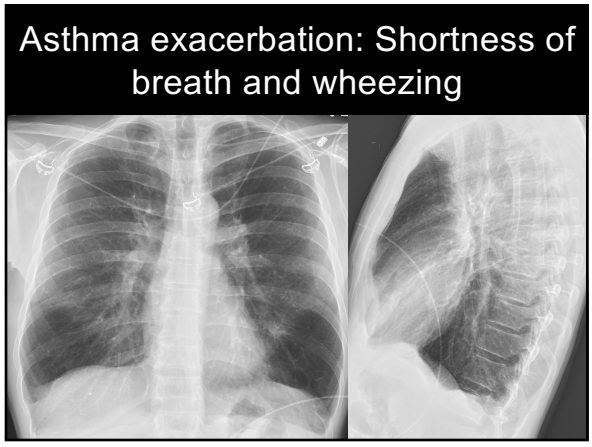
68



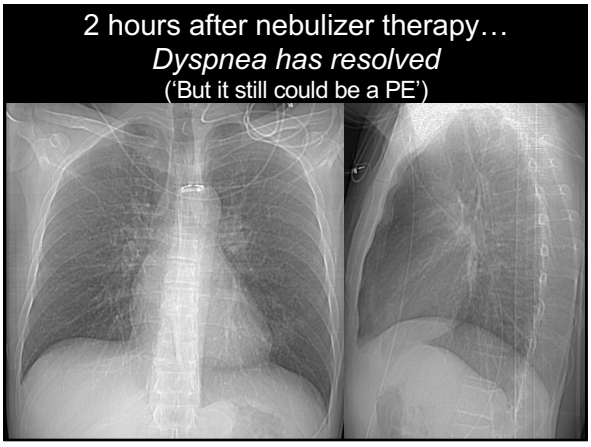
69



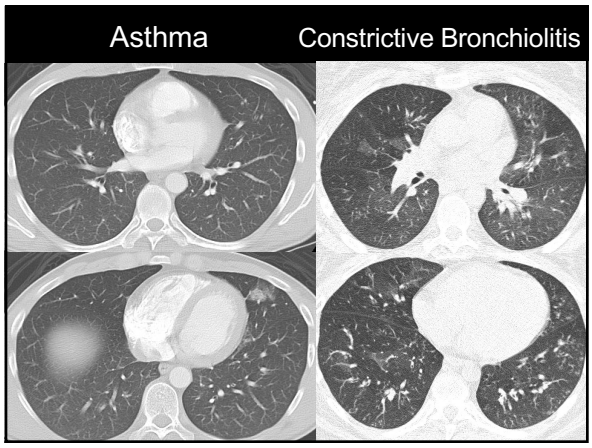
70



71



72



73

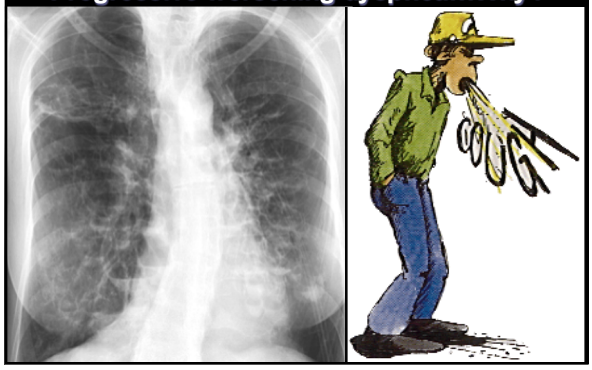
Truth pass through 3 stages:

***First*, It is ridiculed. *Second*, It is violently opposed. *Third*, It is eventually accepted as being Self Evident.**

Arthur Schopenhauer

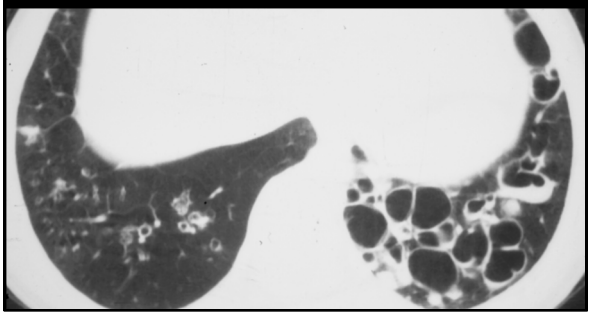
74

Bronchiectasis:
Progressive worsening dyspnea…Why?



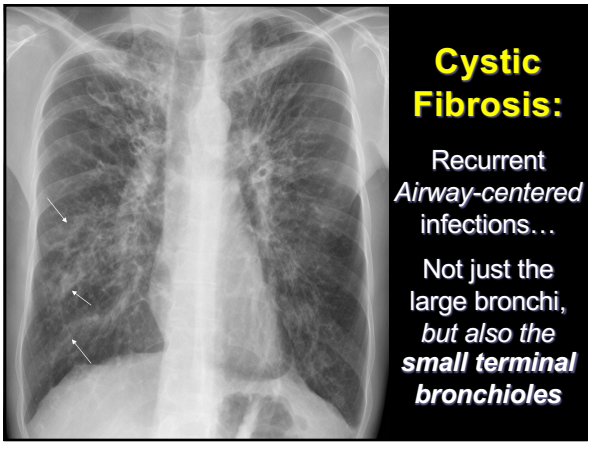
75

Bronchiectasis *with air-trapping* is often secondary to Constrictive bronchiolitis



76

77



78

Cystic Fibrosis and Constrictive Bronchiolitis

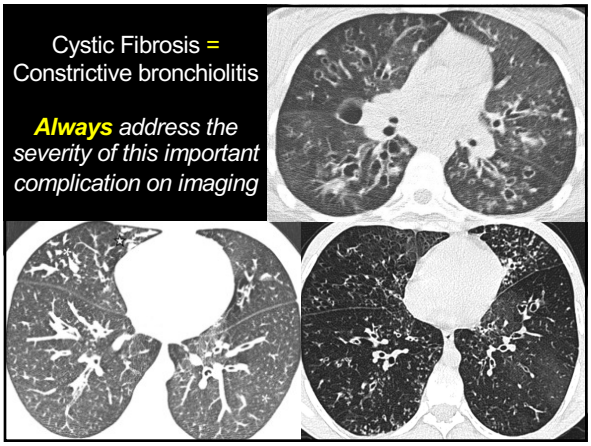
- Constrictive Bronchiolitis is an ***expected complication*** of CF patients
- Evolving as a *common cause* of mortality
- **Always** mention its presence and/or extent in your reports
- Look for it on all other chronic airway diseases, especially with bronchiectasis

Harris et al. Constrictive Bronchiolitis in Cystic Fibrosis Adolescent with refectory pulmonary decline. Ann Am thorac Soc. 2016 Dec; 13(12) 2174-2183

79

Cystic Fibrosis = Constrictive bronchiolitis

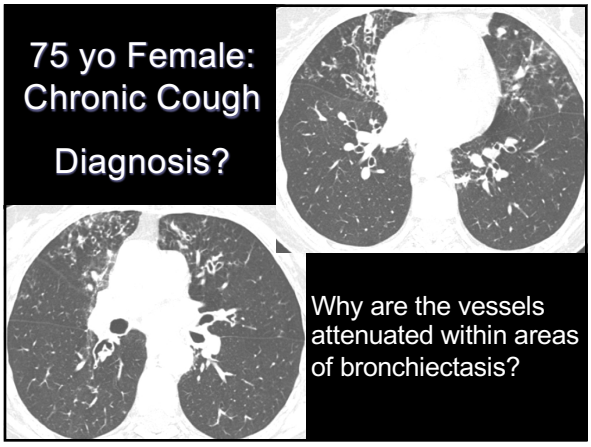
Always *address the severity of this important complication on imaging*



80

75 yo Female: Chronic Cough

Diagnosis?

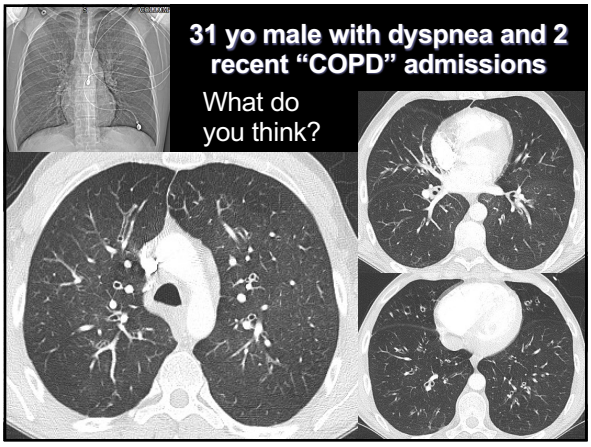


Why are the vessels attenuated within areas of bronchiectasis?

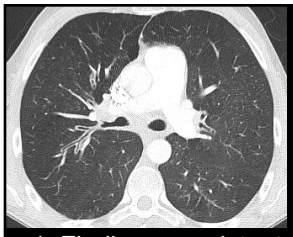
81

31 yo male with dyspnea and 2 recent "COPD" admissions

What do you think?



82



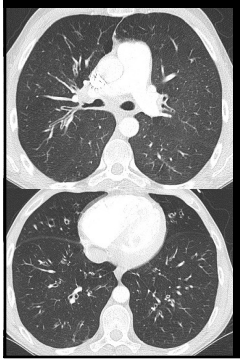
Question #1:

What would your report impression likely say?

- 1. Findings consistent with 'COPD'/emphysema
- 2. Findings consistent with acute bronchitis
- 3. No acute pulmonary disease
- 4. Findings consistent with Constrictive Bronchiolitis

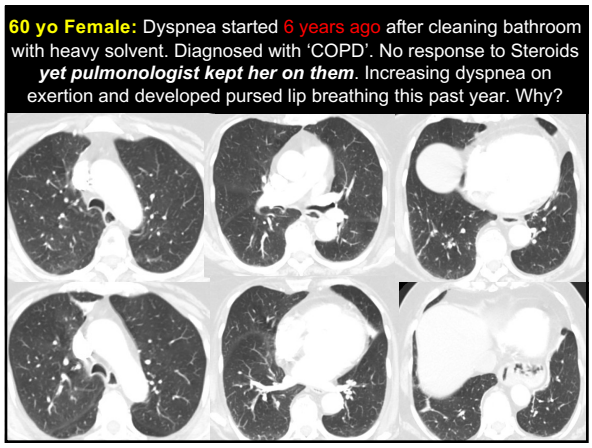
83

Answer #4: Constrictive Bronchiolitis



- Mosaic lung attenuation with airway thickening, vascular attenuation and decreased number of visualized vessels in hypodense regions along with a some bronchiectasis.
- **Expiratory scan could confirm if desired**
- Please ***avoid*** using term 'COPD' in your reports

84



85

Clinical 'Red Flags'

- Persistence or Recurrence of symptoms & signs – i.e. *Multiple 'COPD' admissions*
- Patient can identify time period or event when the breathing difficulties began
- Breathing through pursed lips or a concurrent diagnosis of "vocal cord dysfunction"
- Do not fully respond to steroid/albuterol therapy

86

87