Pulmonary Workshop

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Objectives

Interpret	Interpret pulmonary function studies and sleep studies for obstructive and restrictive lung diseases and sleep apnea
Assess	Assess mortality risk for obstructive and restrictive lung diseases using clinical and diagnostic findings
Classify	Classify sleep apnea risk and evaluate mortality risk and treatment effectiveness
Apply	Apply underwriting principles through case studies
Integrate	Integrate clinical and diagnostic findings for informed underwriting decisions

Case #1

47-year-old female executive asking for $1 million WL

- She denies any history of cigarette smoking or use of illicit drugs
- BMI 35
- She takes 2 anti-hypertensive drugs with good control of her BP
- Her only hospitalization was 6 years prior to application for a ‘viral URI with wheezing’ resolved with corticosteroids
- She has been ‘stable’ once placed on inhaled corticosteroid with a long-acting beta-agonist twice daily
- Chest x-rays 6 years ago and prior to application were normal

Case #1 (continued)

Spirometry done pre-application while she was asymptomatic revealed:

- FVC 81% of predicted post-bronchodilator
- FEV1 53% of predicted post-bronchodilator (+2% over pre-bronchodilator finding)
- FEV1/FVC 65%
- FEV25-75 47% of predicted post-bronchodilator

1. What is the spirometry diagnosis?
2. What conclusion is drawn by the lack of reversibility following inhalation of a bronchodilator?
3. How would the severity of your diagnosis be classified?
4. What are the considerations regarding her mortality assessment?

Case #1 (answers)

1. Airway obstruction without reversibility
2. Patient likely has adult-onset asthma that has transitioned to COPD
3. Moderate COPD (COPD confirmed by FEV1/FVC <70% and FEV1%p >50 but <79%)
4. First, she is female, with both asthma and COPD having worse morbidity and mortality for any level of obstruction. She is also obese and hypertensive, both signals for CVD, a common cause of death for adults with asthma and COPD. CHF would also be a consideration. Had her COPD shown some reversibility (i.e., ?10% improvement post bronchodilator), that would be another sign of increased mortality. Her obesity and hypertension would also raise a question of metabolic-associated steatotic liver disease (MASLD).

Case #2

65-year-old physician applying for $2 million WL

- Review of his APS revealed applicant was seen by his physician 6 months previously for a persistent dry, non-productive cough and shortness-of-breath while playing golf
- A 2-view Chest X-Ray revealed ‘mild bibasilar infiltrates’
- Spirometry post-bronchodilator revealed
  - FVC 56% of predicted
  - FEV1 54% of predicted
  - FEV1/FVC 96%
  - FEV25-75 51% of predicted

Case #2 (continued)

Again, spirometry revealed:

- FVC 56% of predicted
- FEV1 54% of predicted
- FEV1/FVC 96%
- FEF25-75 49% of predicted

- 1. What is the spirometry diagnosis?
- 2. Is further lung function testing indicated? And if so, what test would be sought in his medical records?

Case #2 (continued)

Because of the spirometry results, the applicant was referred to a university hospital for pulmonary function testing (PFTs). Spirometry was repeated and was essentially the same.

- Lung function studies revealed:
  - Total Lung Capacity (TLC) 72% of predicted
  - Functional Residual Capacity 79% of predicted
  - Lung diffusion of carbon monoxide (DLCO) 42% of predicted

3. What diagnosis would these findings suggest?

4. What radiographic imaging would be indicated?

5. Would your diagnosis change if the TLC remained at 72% but the FRC was 90% and the DLCO was 75%?

Case #2 (answers)

1. Restriction (FEV1/FVC ratio normal, FVC%p and FEV1%p reduced similarly)
2. To confirm actual disease, further testing is needed—suboptimal patient effort will read as ‘restriction.’ Normally, complete pulmonary function testing (PFTs) would include measurement of TLC %p (total lung capacity), FRC %p (functional residual capacity), and DLCO%p (lung diffusion of carbon monoxide)
3. These findings would strongly suggest interstitial lung disease calling for complete PFTs
4. High-resolution computed tomography (HRCT) confirming interstitial lung infiltrates, especially in the lower lung zones. Note that predominant scarring in the upper lung zones might suggest Stage IV Sarcoidosis scarring
5. The TLC is effort-dependent (tidal breathing in a body plethysmgraphy box, with following instructions to “breath in as high as you can”); lack of effort may reduce the true result. The FRC is effort independent (derived from just tidal breathing in the body box) and therefore less likely to be altered by patient not following instruction. This may also suggest pulmonary vascular disease (normal lung volumes with decreased DLCO%p, but usually the DLCO is much less than 70%.

Case #3

- 61-year-old male accountant applying for $1 million ‘key-man’ policy
- 30 pack-year history of smoking, quitting 15 years ago with negative cotinine study
- FVC 94%p, FEV1 76%p, FEV1/FVC 81 %
- APS revealed applicant underwent screening low-dose CT lung imaging 6 months prior to application, with a 7mm nodule found in his right upper lung zone

Case #3 (continued)

- FVC 94%p, FEV1 76%p, FEV1/FVC 81%p, FEF25-75%p 70%
- What is the spirometry diagnosis?
- With regard to the solitary pulmonary nodule in the right upper lung zone, what findings might allow underwriting to proceed with a potentially favorable rating decision?
- Would a normal Positron Emission Tomography (PET)-CT be helpful?
- Fiberoptic bronchoscopy with transbronchial needle aspiration and biopsy and brushings were all negative – would that help with a favorable rating?
- Assuming CT surveillance, when might a favorable decision be made?
- Would any feature of the nodule call for a significantly long observation period than usual?

Case #3 (answers)

1. FVC 94% is normal, the FEV1 76% (low--mildly impaired), and FEV1/FVC 81% is normal (i.e., preserved ratio) Preserved Ratio Impaired Spirometry measurement (PRISm), which one study correlated to an adjusted hazard ratio 1.6 for mortality. If the FVC is reduced such that the spirometry meets criteria for restriction, the all-cause mortality risk rises to an adjusted hazard ratio of 4.5. References:
   - Higbee et al. Lancet Resp Med. 2022. DOI: 10.1016/S2213-2600(21)00369-6, PMID: 34739861
   - Backman et al. Chest 2025 DOI: 10.1016/j.chest.2025.02.015. PMID: 40058579,
   - Kaira et al. Chest 2025: DOI: 10.1016/j.chest.2025.02.025. PMID: 39947315.
2. Nodules <3 cm (the smaller the better, ignore 0.3 ml and smaller), various calcifications (popcorn, laminar, central, calcium adjacent to fat), smooth contour, lack of change in size on repeat CT imaging at 9-12 months, nodule 'negative' on PET imaging (especially PET-CT imaging). Note that eccentric calcification and spiculated nodules are likely malignant. Upper lung zone nodules have a higher likelihood of malignancy than lower lung zones, and likelihood of malignancy rises with advancing age.
3. PET imaging is not reliable with any nodule <8 mm in size, but is the imaging modality of choice at 8 mm
4. Fiberoptic bronchoscopy is evolving and improving, but not with nodules <10 mm
5. One year if no change in size or appearance unless nodule has ground glass configuration
6. Ground glass within the nodule requires much longer follow up. These nodules were formerly known as bronchioloalveolar cell cancers; they are now called adenocarcinoma in situ cancers.

Case #4

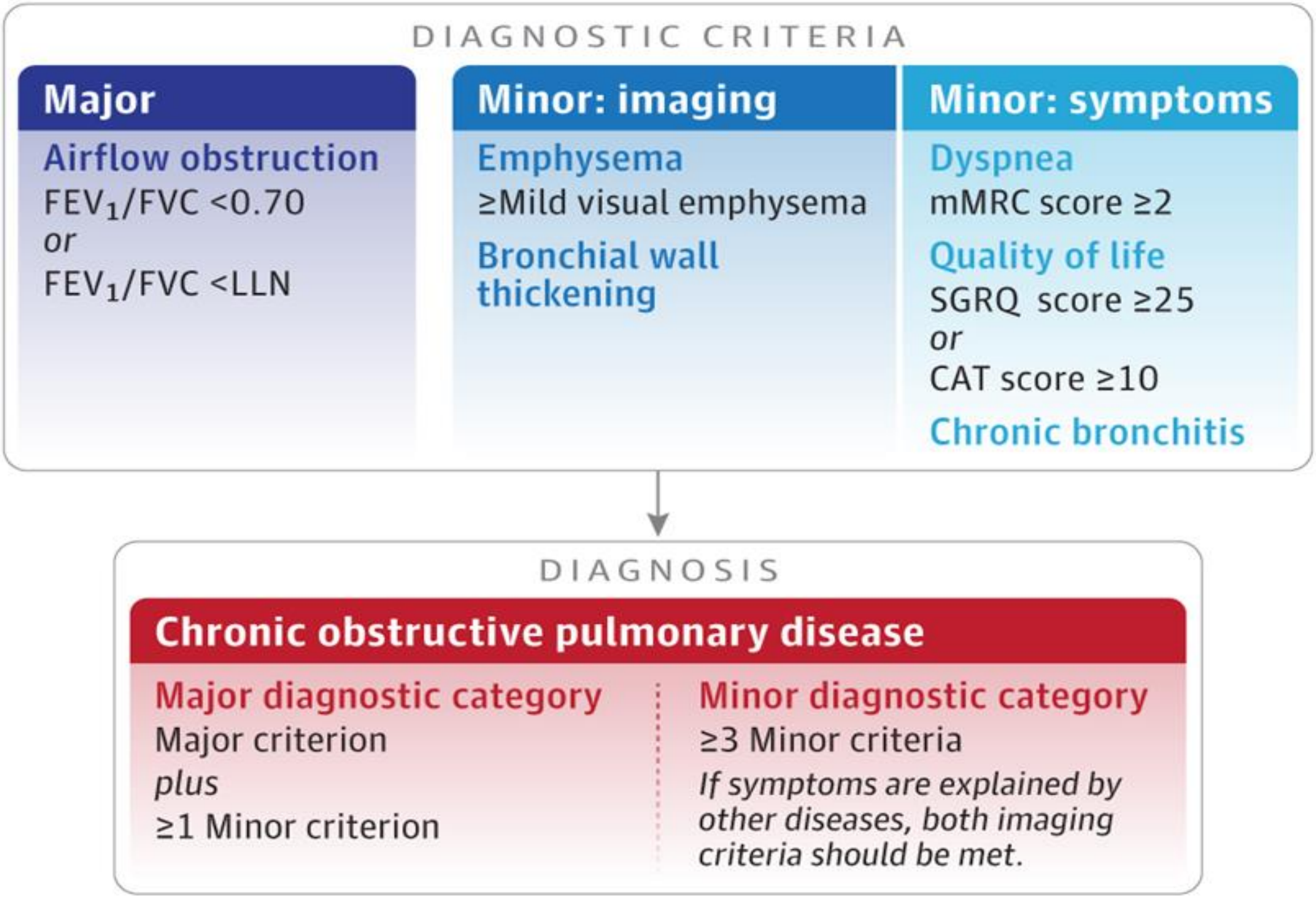
65-year-old male applying for $1 million WL

- Spirometry had been done one year previously as part of a ‘Welcome to Medicare’ exam because of past smoking
- FEV1%p was 78% and FEV1/FVC 79%.
- On careful questioning applicant denied all respiratory symptoms
- CT Thorax imaging was done looking for bronchial wall thickening and/or emphysematous change was also normal.

1. Does this applicant have COPD?

Case #4 (answers)

1. Actually not. Although spirometry would suggest this person to have COPD, a new study from the COPDGene 2025 Diagnosis Working Group and CanCOLD Investigators in JAMA May 2025 found that there is a population of individuals who may have mildly abnormal spirometry but on careful questioning have no symptoms or signs of COPD, and that also have no evidence of airway narrowing or emphysema on lung CT. This population has none of the morbidity or mortality normally seen in COPD. These latter non-spirometry indications are called minor criteria, and these authors now propose a diagnosis of COPD require spirometry showing COPD plus at least one minor criteria. They also have found that persons with 3 or more minor criteria have the significant mortality and morbidity implications of COPD despite spirometry being normal. (Ref: COPDGene 2025 Diagnosis Working Group and CanCOLD Investigators: Bhatt SP et al. JAMA. DOI: 10.1001/jama.2025.7358. PMID: 40382791)


DIAGNOSTIC CRITERIA
Major
Airflow obstruction
FEV1/FVC <0.70
or
FEV1/FVC <LLN
Minor: imaging
Emphysema
≥Mild visual emphysema
Bronchial wall thickening
Minor: symptoms
Dyspnea
mMRC score ≥2
Quality of life
SGRQ score ≥25
or
CAT score ≥10
Chronic bronchitis
DIAGNOSIS
Chronic obstructive pulmonary disease
Major diagnostic category
Major criterion
plus
≥1 Minor criterion
Minor diagnostic category
≥3 Minor criteria
If symptoms are explained by other diseases, both imaging criteria should be met.

Case #5 OSA

66-year-old male smoker applies for $2.5 million Term

- BMI = 33.4, BP = 118/78 on meds, TC/HDL = 10 on meds
- On narcotics and muscle relaxants for chronic back and shoulder pain
- ECG shows LVH (no echocardiogram available)
- Home sleep study 2 years ago showed AHI=44, oxygen saturation nadir at 79% (59 minutes at or below 89% saturation)
- Automatic titrating PAP initiated and uses PAP “almost every night for a few hours”
- Prescribed trazadone (insomnia) and Aricept (possible mild cognitive impairment)
- No follow-up with a sleep specialist

Case #5 (OSA continued)

Questions:

1. How severe is his OSA?
2. What impairments are influencing his mortality?
3. What do you want to know to complete the mortality risk assessment?

Case #5 (answers)

1. How severe is his OSA?
   - An AHI of 44 indicates severe OSA
2. What impairments are influencing his mortality?
   - Severe OSA; cardiovascular risk from HTN, possible LVH, hyperlipidemia; polypharmacy with narcotics, muscle relaxers, trazadone; possible cognitive impairment from OSA or meds or vascular disease or some combination of these?
   - The strongest mortality driver is his cardiovascular risk, and his polypharmacy and cognitive decline contribute to this mortality risk. His hypoxemia is an additive concern, and his AHI is a secondary concern.
3. What do you want to know to complete the mortality risk assessment?
   - What is his cardiovascular risk? (Needs a cardiac evaluation.) Is his PAP treatment effective? (Needs to see the sleep specialist and have a laboratory-based sleep study.) Does he have MCI? (May need a neurological evaluation, medication adjustments, better pain management.) What does his MVR show?

Case #6 OSA

34-year-old male nonsmoker applying for $1 million WL

- BMI is 36.2, BP 129/86, neck size 17.5 inches
- No diagnosis of HTN or other medical problems. On no meds.
- One year previously saw his PCP and complained of morning headaches and daytime somnolence
- Wife complained “he snores and stops breathing, then chokes” while sleeping. She also noted “difficulty remembering things”
- Home sleep study showed AHI=88 and nadir oxygen saturation = 91%
- He is now on an automatic titrating PAP device

Case #6 (OSA continued)

- He returns to his PCP 6 months later and reports feeling “a little bit better” when he uses his PAP device, but he only uses it “a couple of nights a week” because it is “uncomfortable”
- He weight remains unchanged
- A laboratory-based sleep study (polysomnography--PSG) on his PAP showed AHI=17, nadir oxygen saturation 94%, frequent PVCs and frequent periodic limb movements of sleep (PLMS) w/ arousals
- He expresses a desire to lose weight so he can sleep better and have less daytime fatigue

Case #6 OSA (continued)

Summary: 34 yo M nonsmoker with obesity, HTN, snoring, witnessed apneas, morning headaches, daytime somnolence, and worsened memory

- AHI=88 without hypoxemia on home sleep study without PAP
- Inconsistent compliance with PAP; no weight loss
- AHI=17 without hypoxemia while using PAP on PSG

Questions:

1. How severe is his OSA?
2. What impairments are influencing his mortality?
3. What do you want to know to complete the mortality risk assessment?

Case #6 (answers)

1. How severe is his OSA?
   - An AHI of 88 indicates severe OSA, even if there is no hypoxemia and even if his PAP study shows improvement.
2. What impairments are influencing his mortality?
   - Severe OSA, obesity, HTN, daytime sleepiness (risk of accidents), PVCs while sleeping.
   - The strongest mortality driver is his severe OSA with elevated AHI without hypoxemia.
3. What do you want to know to complete the mortality risk assessment?
   - How will he improve compliance with PAP? Has he been fitted with a new mask with new pressure settings? Will he exercise and lose weight? What does his MVR show?

Case #7 OSA

55 yo F never smoker applying for $5 million WL

- BMI is 30, BP is 118/84
- No medical diagnoses and not on any medications
- Three years ago, she told her gynecologist of worsening insomnia with difficulty falling asleep and staying asleep. The physician attributed to symptoms to life stressors and perimenopausal state, and prescribed hormonal therapy which she found to be unhelpful

Case #7 OSA (continued)

- One year ago, the patient self-referred to a sleep specialist, who found the patient occasionally snores. The home sleep study showed an AHI of 13 with nadir oxygen saturation of 90%
- Automatic titrating PAP was initiated, and at 3-month follow-up the patient's symptoms were mildly improved
- At 6-month follow-up, the patient stated that her adherence to PAP had diminished as the benefits of treatment were not worth the "inconvenience"
- A laboratory-based sleep study (PSG) revealed insomnia and the need for a better-fitting PAP mask and pressure titration
- The patient was also advised to seek cognitive behavioral therapy for sleep initiation insomnia (CBTi)

Case #7 OSA (continued)

One month prior to her application, she saw her gynecologist and reported substantial improvement of her symptoms, using the new PAP device at the new settings, and employing techniques learned from CBTi

Questions:

1. How severe is her OSA?
2. What impairments are influencing her mortality?
3. What do you want to know to complete the risk assessment?

Case #7 (answers)

1. How severe is her OSA?
   - An AHI of 13 indicates mild OSA
2. What impairments are influencing her mortality?
   - Mild OSA, insomnia, life stressors, overweight.
   - She has multiple common mild drivers of mortality.
3. What do you want to know to complete the mortality risk assessment?
   - What does her MVR show? Routine age/amount requirements.

Spirometry

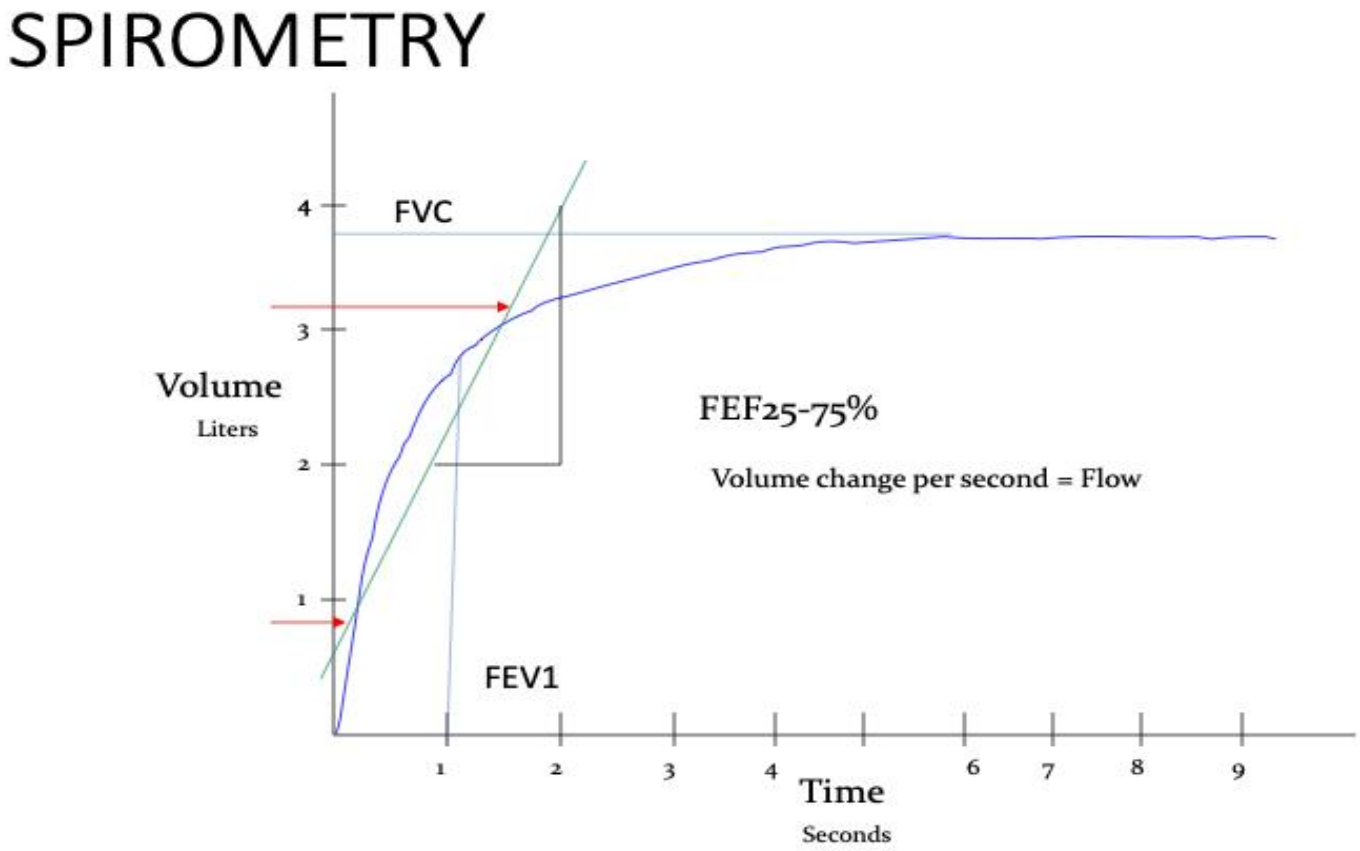
Obstruction

- FEV1 %pred reduced
- FVC %pred also reduced but to as lesser degree then FEV1%p
- **FEV1/FVC therefore reduced**
- Diagnosis is valid for obstruction, but lung volume and diffusion measurement may help define emphysema

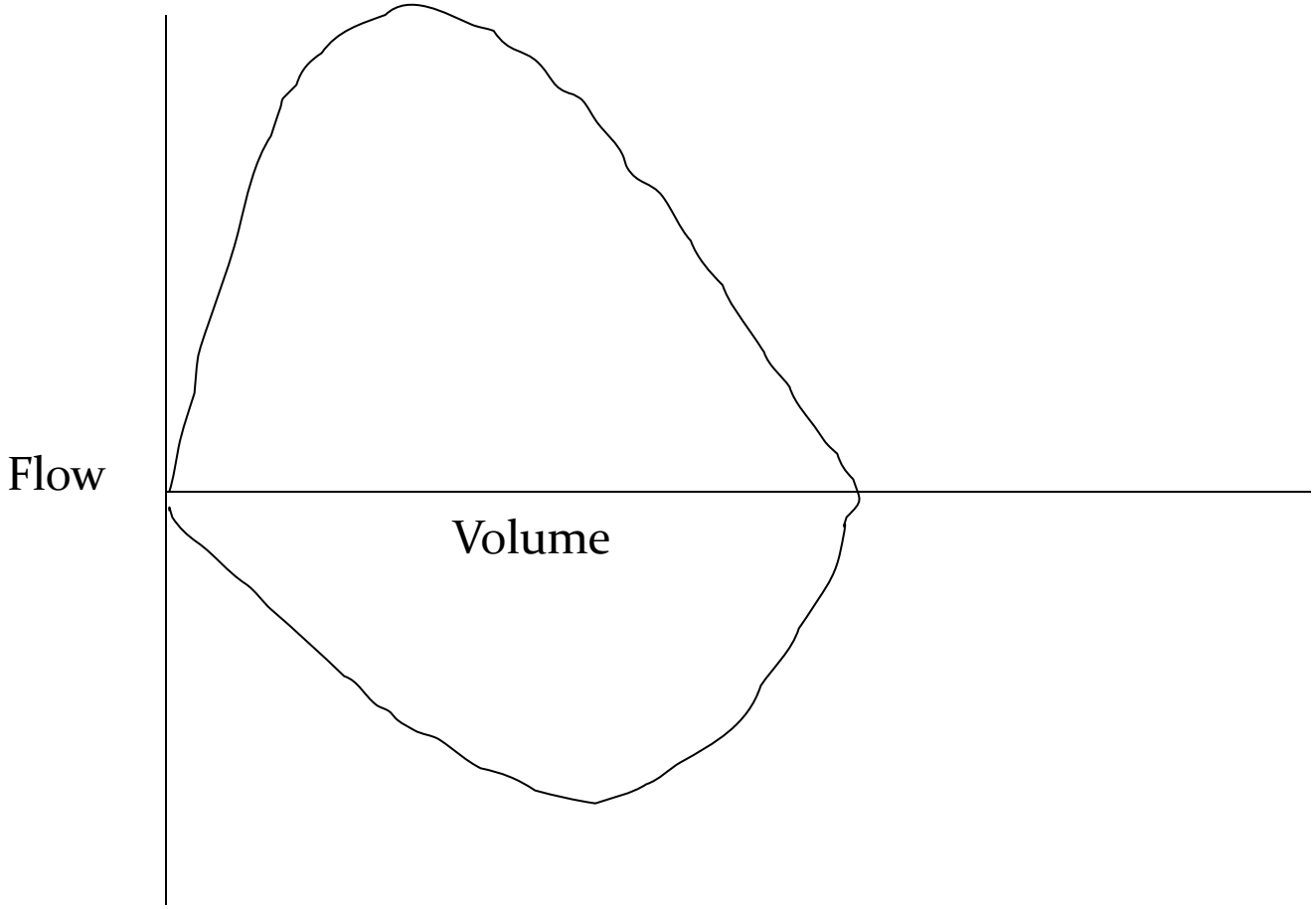
Restriction

- FEV1 %pred reduced
- FVC %pred also reduced but in proportion to the FEV1 %pred
- **FEV1/FVC therefore is normal (or increased)**
- Confirmation of restriction requires measurement of lung volumes

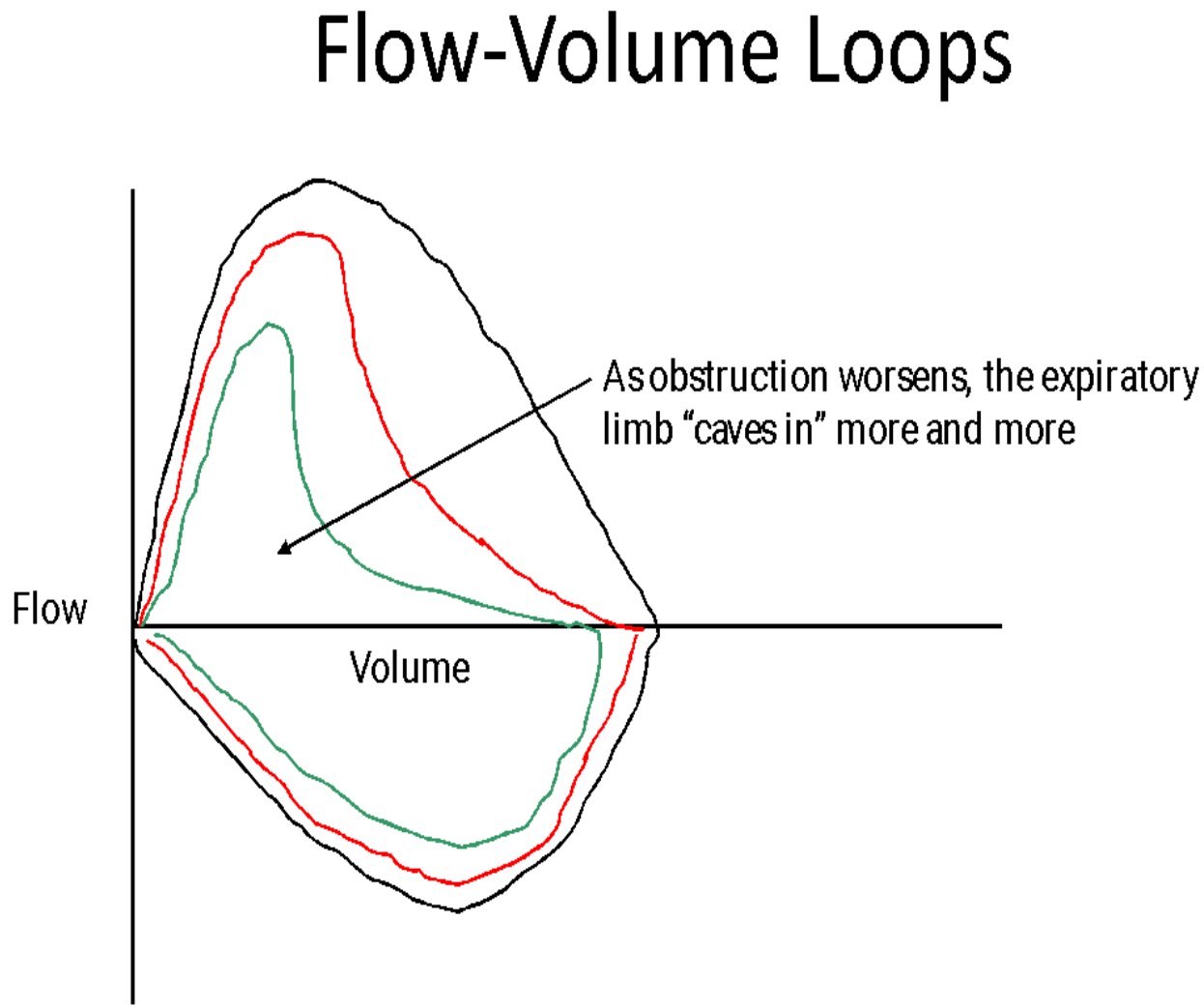
Determining the FEF 25-75%



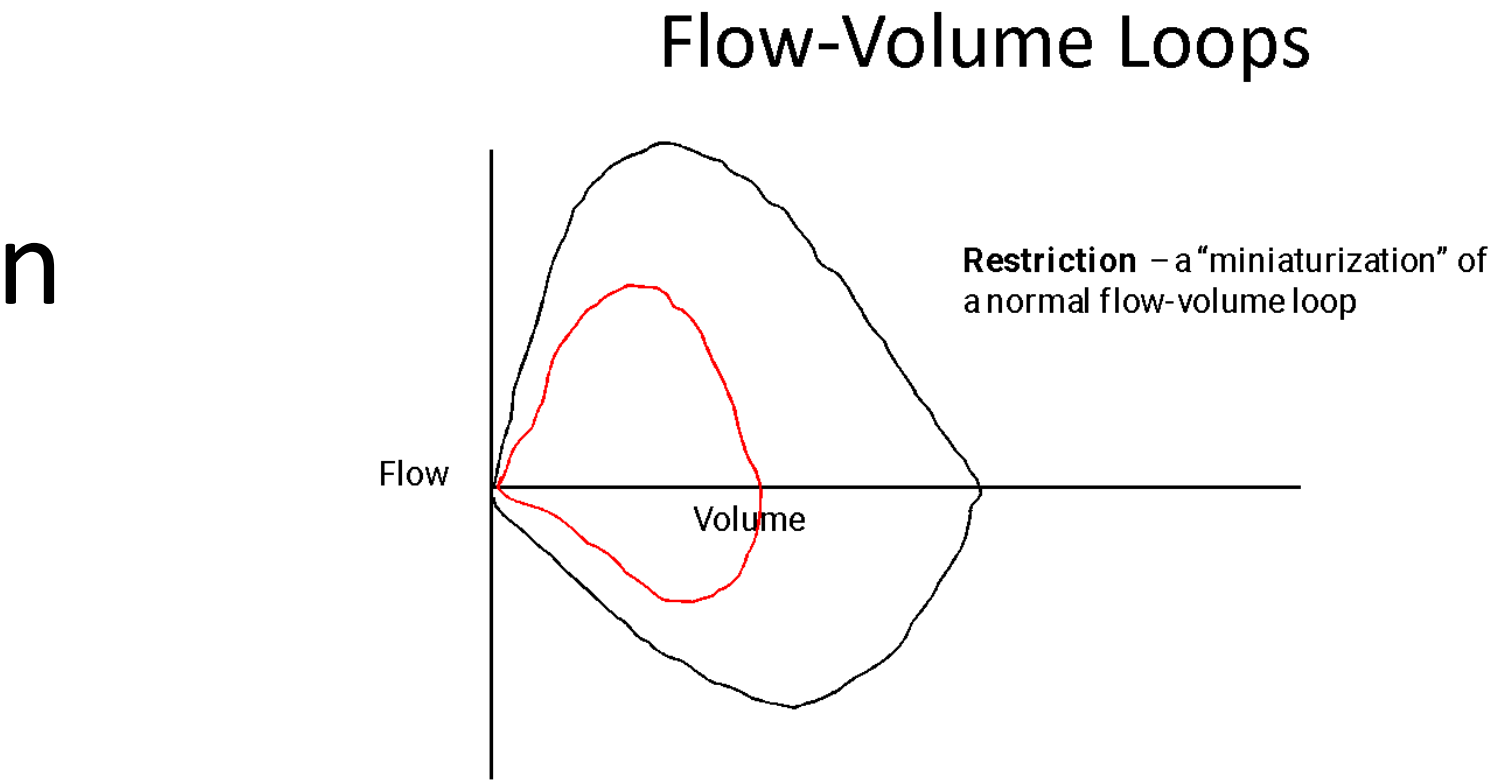
Flow-Volume Loops



Visual interpretation of severity of airway obstruction



Visual representation of restriction on FV loops



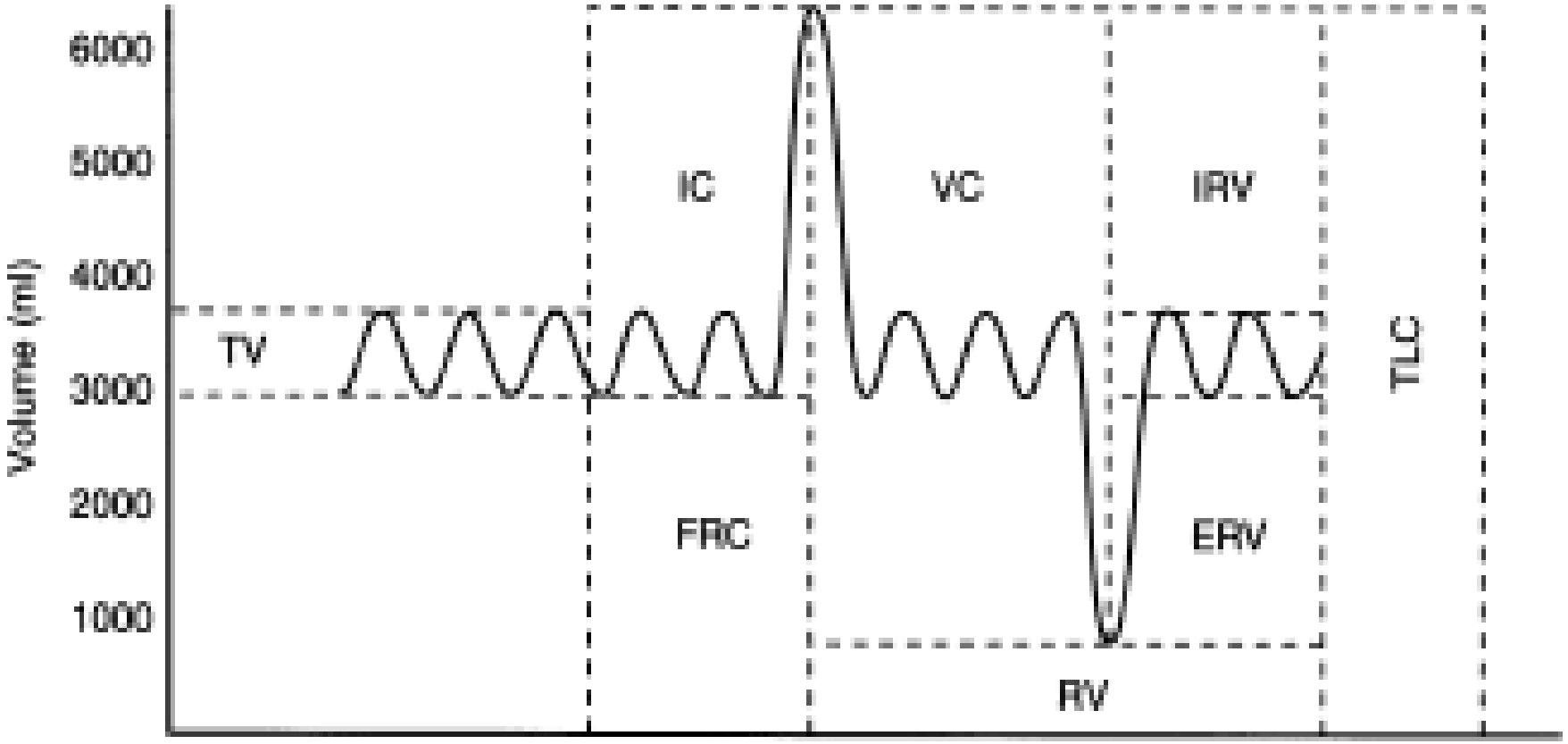
GOLD Criteria for COPD

- FEV1/FVC ratio is < 70%
  - **Defines diagnosis of COPD**

- FEV1 %predicted (FEV1%p)
  - **Defines severity of COPD**

• Mild	Stage I	FEV1%p 80%+
• Moderate	Stage II	FEV1%p 50-79%
• Severe	Stage III	FEV1%p 30-49%
• Very Severe	Stage IV	FEV1%P <30%

Measured Lung Volumes



Definitions

- **PFTs = Pulmonary Function Tests**
- **FVC = Forced Vital Capacity** (total volume of air exhaled in a forced exhalation from total inspiration to total exhalation -- ideally with the best of three efforts recorded)
- **FEV1 = Forced Expiratory Volume in one second** (total volume of air exhaled in the first second of a FVC maneuver -- ideally should be 6 seconds or more of exhalation effort with the best of three efforts recorded)
- **FEV1/FVC = ratio of FEV1 to FVC as a percentage (there are no predicted in a simple ratio)**
- **FEF25-75 = Forced Expiratory Flow in the 25th to 75th portion of flow-volume curve** (also sometimes listed as MMEF 25-75: Maximal Mid-expiratory Flow Rate)
- **TLC = Total Lung Capacity**
- **FRC = Functional Residual Capacity** (amount of air in the lung at end-of-normal tidal volume exhalation)
- **DLCO = Diffusing Capacity for Carbon Monoxide**

Diffusing Capacity (DLCO)

- Measures the ability of the lung to exchange oxygen for carbon dioxide (gas-exchange units)

- Surrogate for estimating quantity of functioning alveolar-capillary units in a lung

Diffusing Capacity of the Lung
DLCO

DLCO	FRC	Disease
DLCO decreased in Obstruction	Increased FRC	Emphysema
DLCO decreased in Restriction	Decreased FRC	Interstitial Lung Disease
DLCO decreased without Obstruction or Restriction	Normal FRC	Pulmonary Vascular Disease*
DLCO increased	Normal FRC	Left-to-Right shunt Pulmonary hemorrhage
		*Pulmonary Vascular Disease includes Occult Pulmonary

OSA – Apnea-Hypopnea Index (AHI) Severity

AHI Frequency	Severity of OSA
0 to 4.9 events/hr	Normal (No OSA)
5 to 14.9 events/hr	Mild
15 to 29.9 events/hr	Moderate
30 or more events/hr	Severe

Does AHI Predict Mortality?

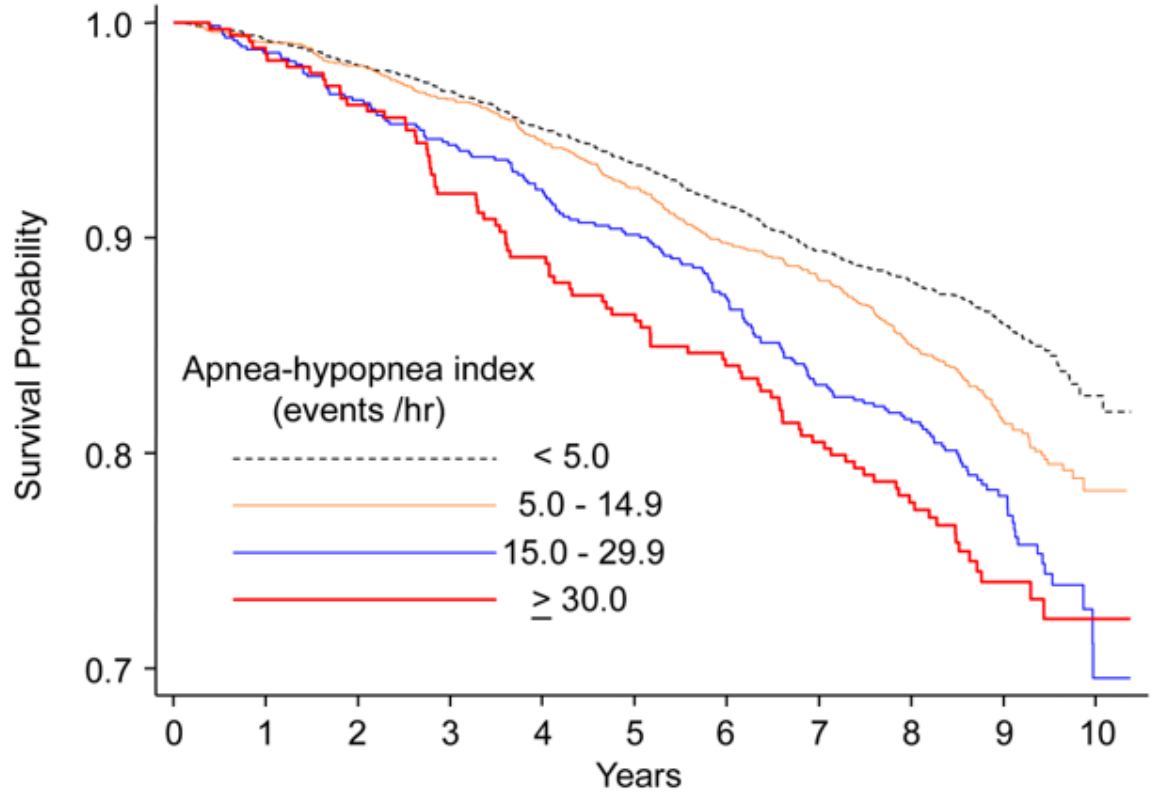
- 6441 men + women, 40+ years
- 8.2-year follow-up (average)
- 1,047 deaths – All cause (especially CAD)

OSA Severity	Hazard Ratio
Mild	0.93
Moderate	1.17
Severe	1.46

WORSE = MEN < 70 YEARS OLD WITH DECREASED OXYGEN SATURATIONS (HR=2.0)
Punjabi, *PLoS Med* 2009

Does AHI predict mortality?

Punjabi NM, Caffo BS, Goodwin JL, Gottlieb DJ, Newman AB, O'Connor GT, et al. (2009) Sleep-Disordered Breathing and Mortality: A Prospective Cohort Study. PLoS Med 6(8): e1000132. https://doi.org/10.1371/journal.pmed.1000132



At risk:	6294	6205	6110	6001	5868	5732	5566	5411	4756	2357	300
Deaths:	0	59	143	241	359	478	616	757	875	989	1046

Does PAP save lives?

Sample	HR
RCTs	0.87 (0.65-1.16)
NRCTs	0.60 (0.52-0.70)
All Studies Combined	0.63 (0.56-0.72)

Benjafield, AV. *Lancet Respir Med* 2025; 13:403

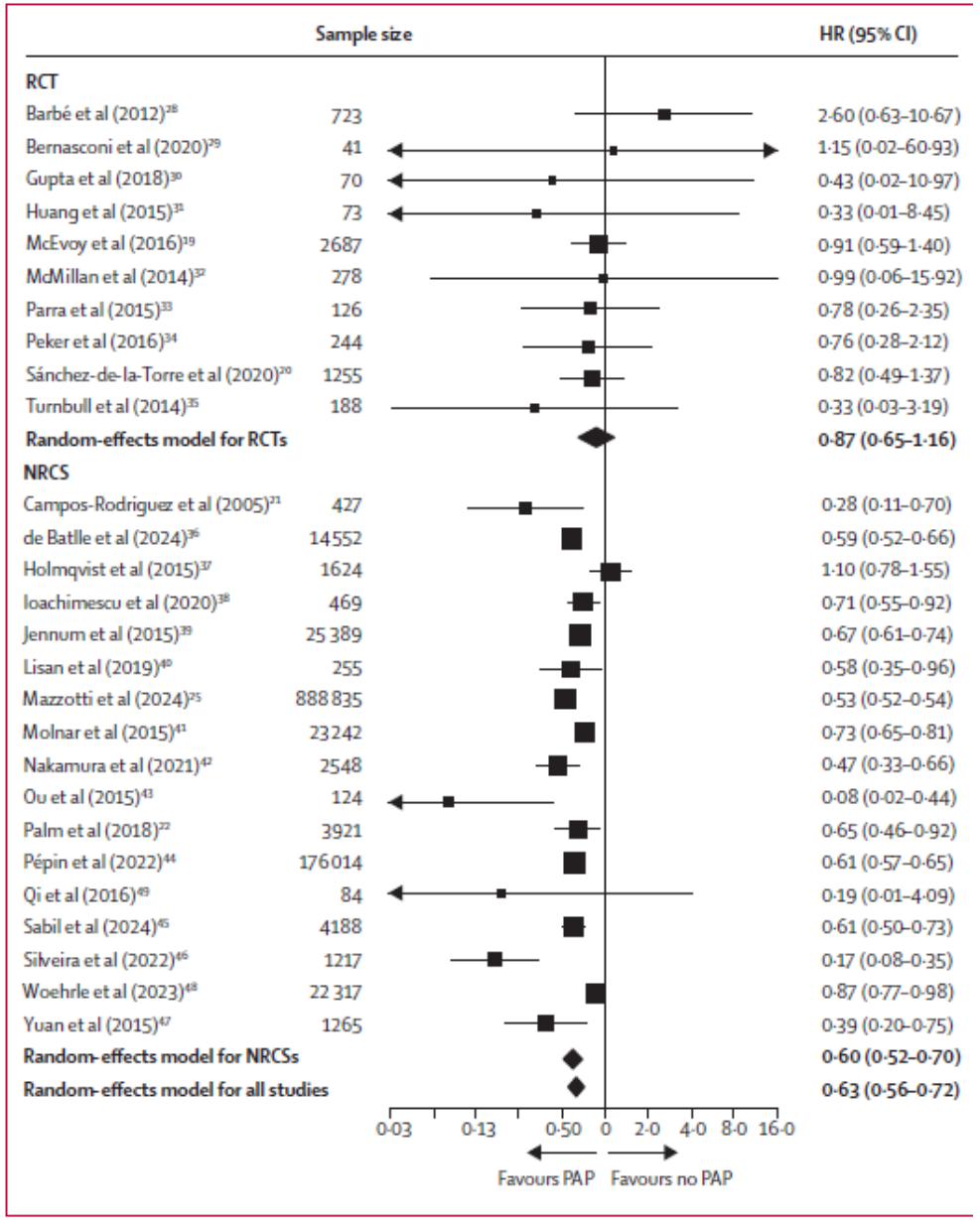


Figure 2: **Forest plot showing the risk of all-cause death in the PAP *vs* no PAP therapy groups**
Black squares indicate the point estimate and horizontal bars indicate 95% CI. Black diamonds indicate the effect estimate in study groups and overall. HR=hazard ratio. NRCS=non-randomised controlled study. PAP=positive airway pressure. RCT=randomised controlled trial.

PAP reduces CV mortality

Sample	HR
RCTs	0.87 (0.53-1.41)
NRCTs	0.35 (0.21-0.58)
All Studies Combined	0.45 (0.29-0.72)

Benjafield, AV. *Lancet Respir Med* 2025; 13:403

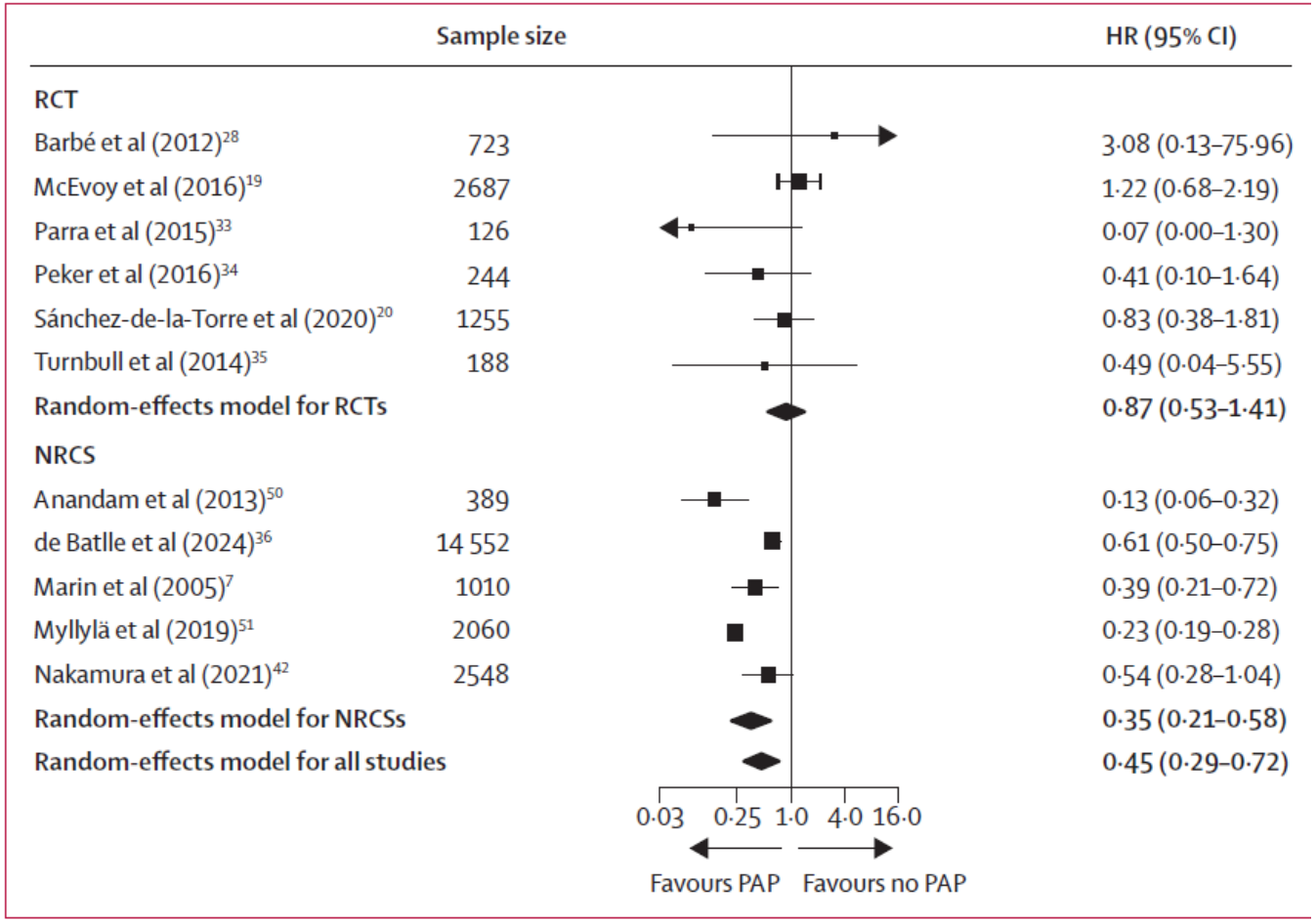


Figure 3: **Forest plot showing the risk of cardiovascular death in the PAP *vs* no PAP therapy groups**
Black squares indicate the point estimate and horizontal bars indicate 95% CI. Black diamonds indicate the effect estimate in study groups and overall. HR=hazard ratio. NRCS=non-randomised controlled study. PAP=positive airway pressure. RCT=randomised controlled trial.

MCEVORY NEJM 2016

2717 adults (45-75 years old)

All cause mortality

3.7 years of follow up

Adherence 3.3 hours per night (average)

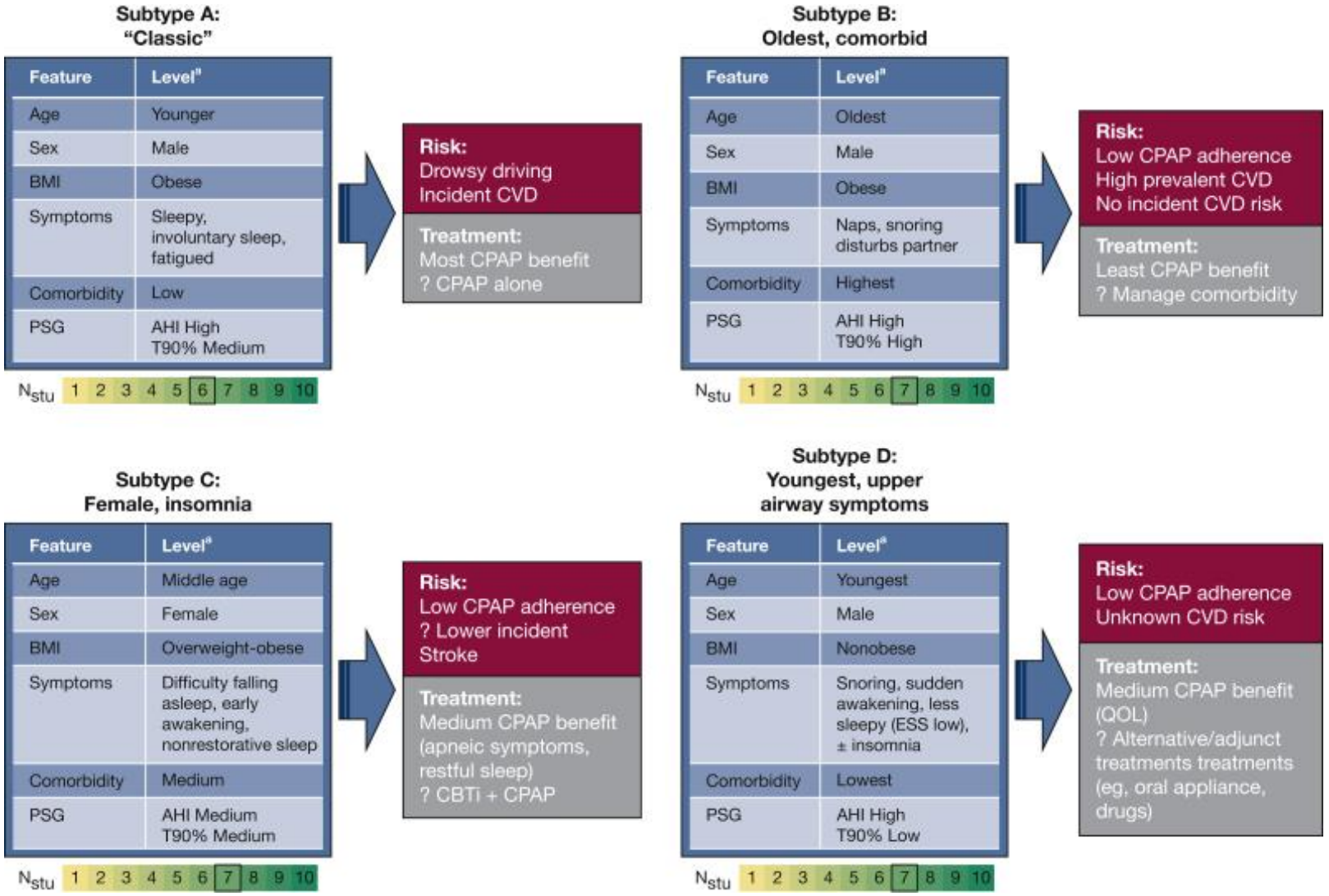
CPAP did NOT change mortality or CVD events

CPAP did improve BP control, Quality of Life, especially decreased snoring and decreased daytime somnolence

McEvoy. *N Engl J Med* 2016;375(10):919-931.

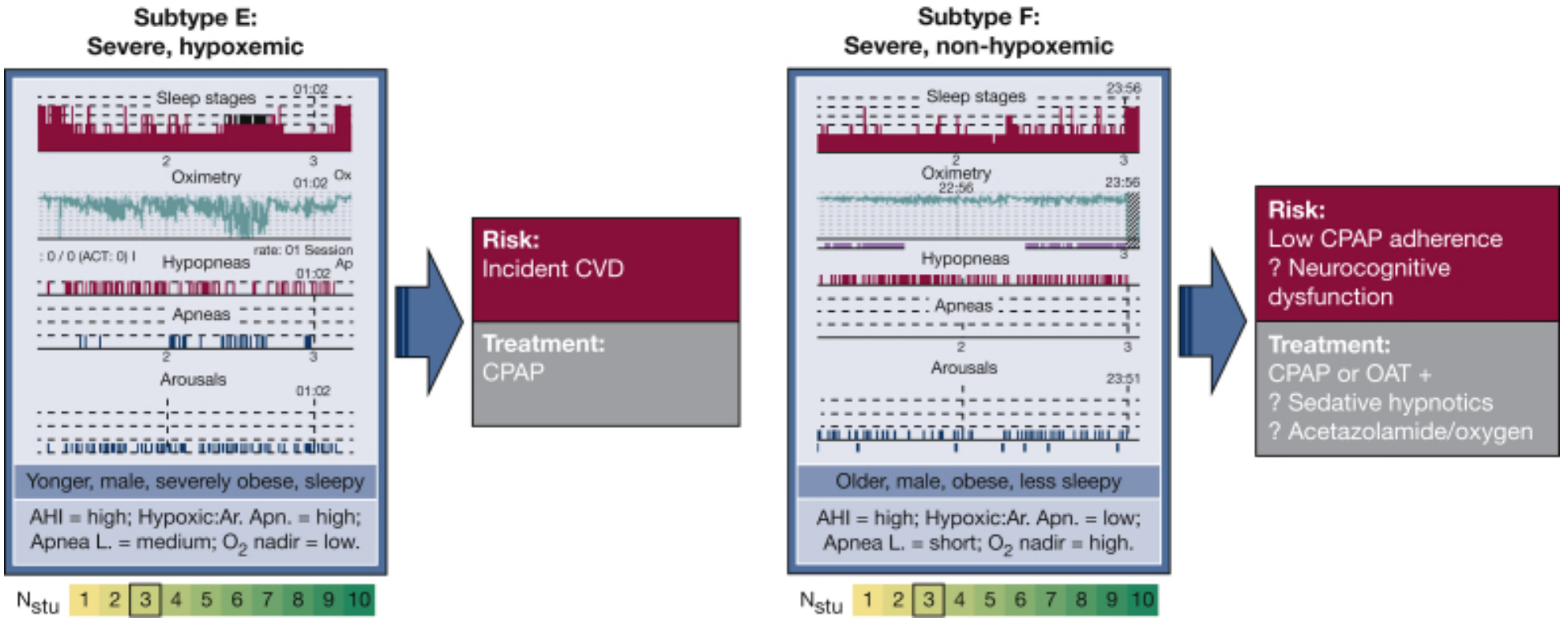
OSA Phenotypes 1/2

From Zinchuk and Yaggi in [Chest. 2020 Feb; 157(2): 403–420]



OSA Phenotypes 2/2

From Zinchuk and Yaggi in Chest. 2020 Feb; 157(2): 403–420.



OSA TAKE-AWAYS

- OSA is associated with increased atrial fibrillation, hypertension, CVA, CAD, and Heart Failure
- PAP has a potentially beneficial effect on all-cause and cardiovascular mortality
- PAP helps HTN, QoL, snoring, daytime somnolence
- Think beyond AHI! OSA mortality is also driven by
  - Hypoxemia
  - CAD, arrythmias, heart failure, CVA
  - DM
  - Accidents

OSA Reading

- Benjafield, AV, et al. Positive airway pressure therapy and all-cause and cardiovascular mortality in people with obstructive sleep apnoea: a systemic review and meta-analysis of randomized controlled trials and confounder-adjusted, non-randomized controlled studies. Lancet Respir Med 2025;13:403-413.
- Richie, RC. Assessing the Pathophysiology, Morbidity, and Mortality of Obstructive Sleep Apnea *J Insur Med* 2024;51:143-162.
- UpToDate. Excellent articles on OSA and treatment-emergent sleep apnea. Subscription required.