PULMONARY FUNCTION TESTING: FOUNDATIONS & UPDATES

CAROLINE SISSON, MMS, PA-C

ASSISTANT PROFESSOR

Wake Forest University School of Medicine

The academic core of Atrium Health

DISCLOSURES

I have no relevant relationships with ineligible companies to disclose within the past 24 months.

OBJECTIVES

At the conclusion of this session, participants should be able to:

1. Use flow volume loop to differentiate restrictive pulmonary disease, obstructive pulmonary disease, variable extrathoracic obstruction, and fixed airway obstruction.

2. Interpret pulmonary function tests (spirometry, lung volumes, and diffusing capacity) as normal, restrictive, obstructive, or mixed.

3. Summarize 2021 European Respiratory Society/American Thoracic Society guidelines for interpreting pulmonary function testing using z-scores.

COMPONENTS OF PULMONARY FUNCTION TESTS

Spirometry	DLCO	Lung Volumes
• How much air is moving? • How fast is it moving?	• How well does air move from alveoli to capillaries?	• How much air do the lungs hold?

Can they do the test???

PFT=PULMONARY FUNCTION TESTS

Indications

Diagnosis

Monitoring

Disability/impairment evaluation

Contraindications

Increased myocardial demand

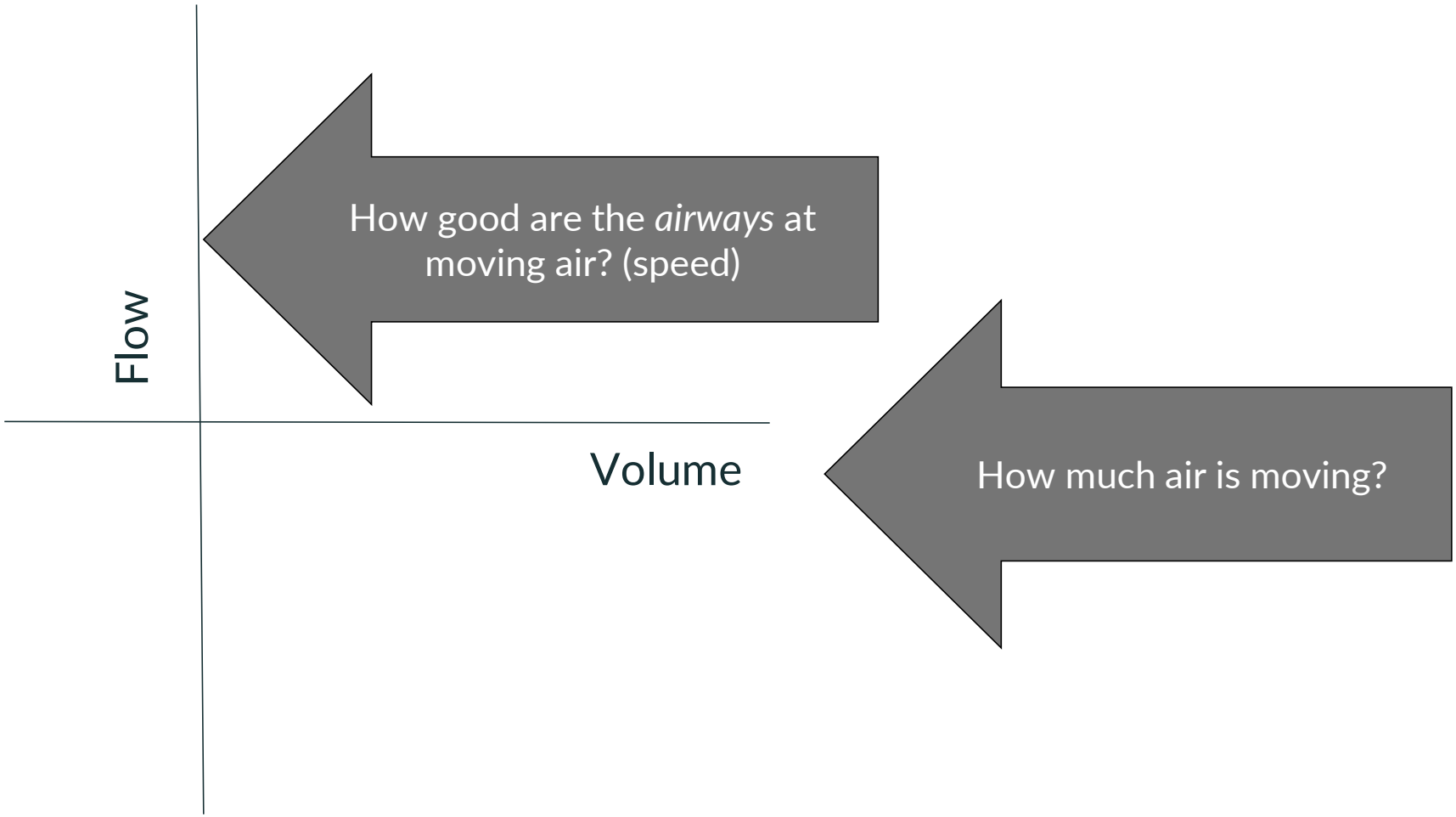
Increased pressure:

- Blood Pressure
- Intracranial
- Intraocular
- Sinus/middle ear
- Intrathoracic
- Intra-abdominal

Active infection

SPIROMETRY

LUNG VOLUMES
DIFFUSING CAPACITY


Flow
Volume
How good are the *airways* at moving air? (speed)
How much air is moving?

HOW MUCH AIR IS MOVING? VOLUME

Forced Vital Capacity

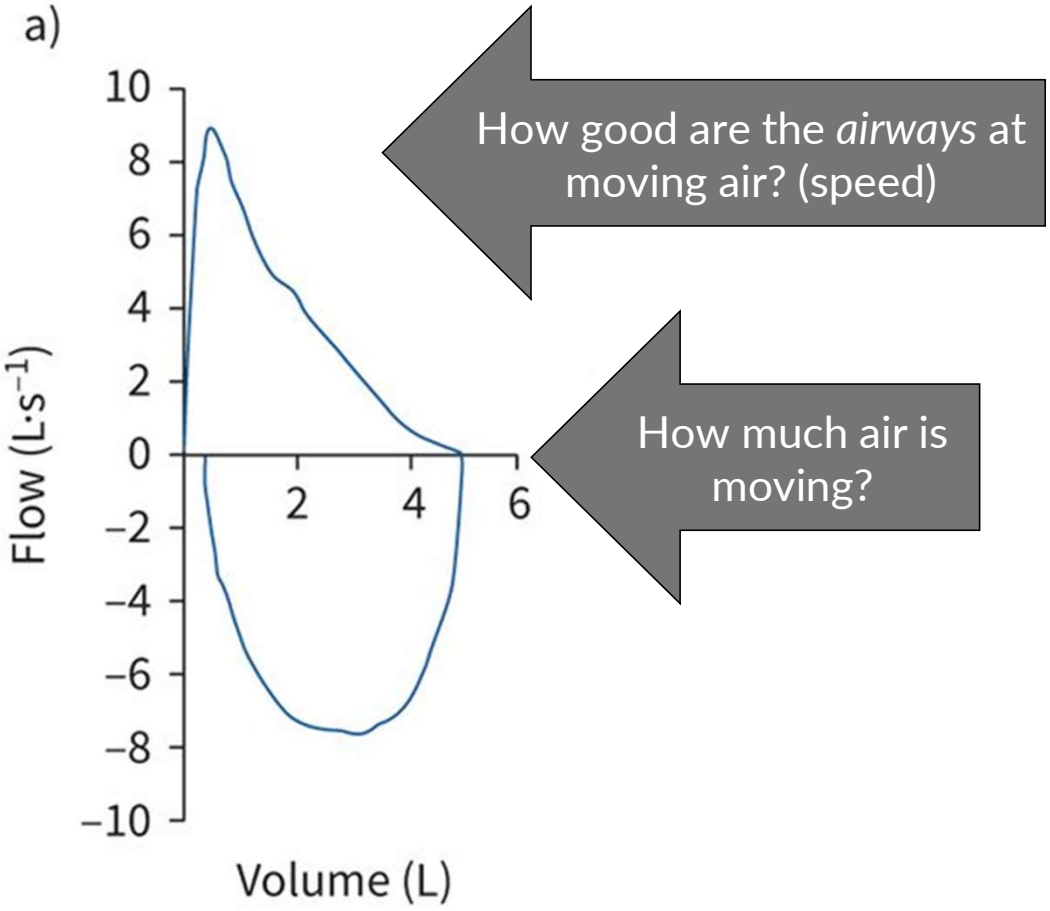
HOW FAST IS IT MOVING? FLOW

Forced Expiratory Volume in 1 second (FEV_1)

- Volume expired in first second

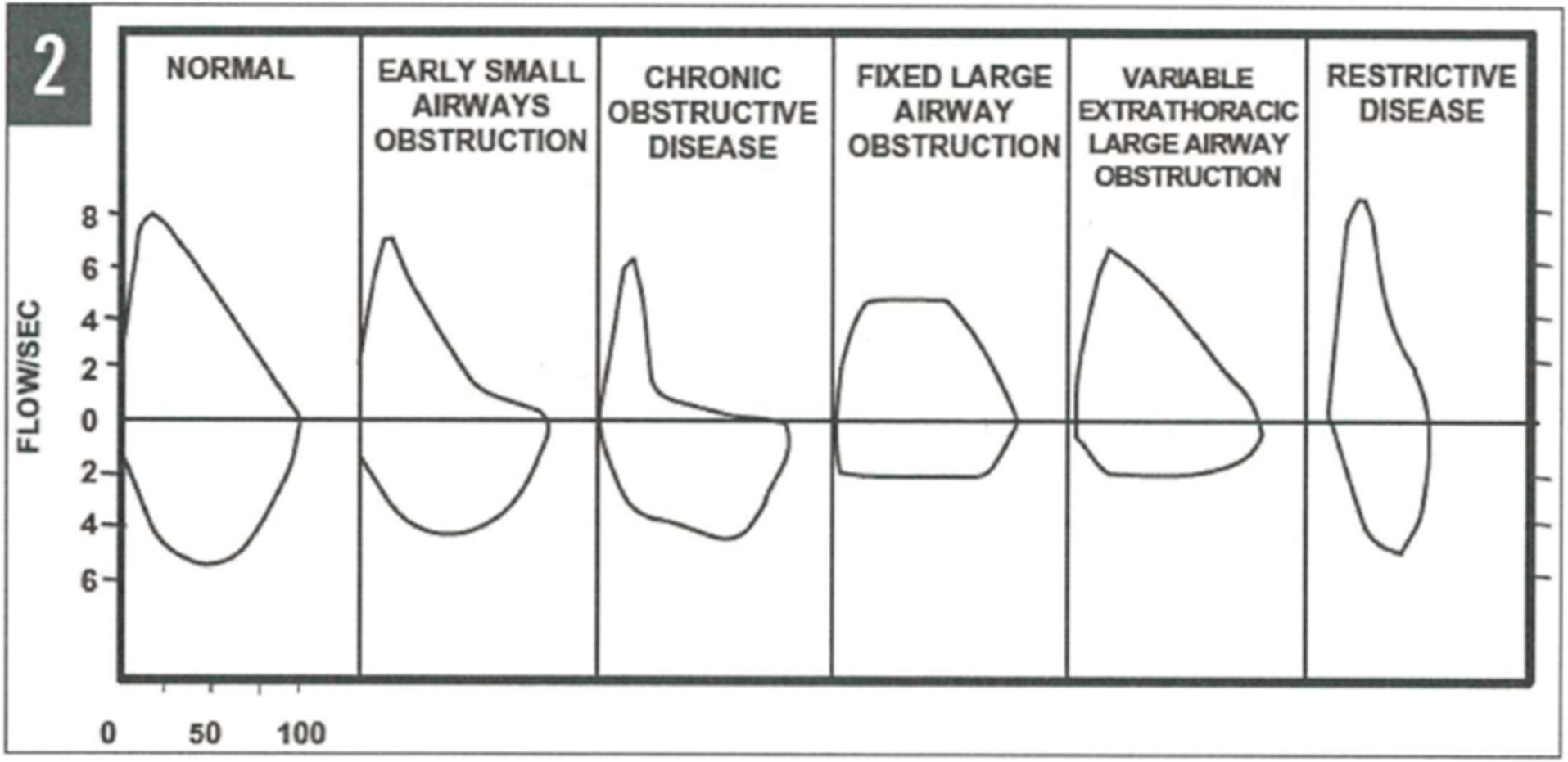
FEV_1/FVC

- Portion of FVC that is expelled in 1 second
- Reduced value indicates obstruction, a "straw" problem

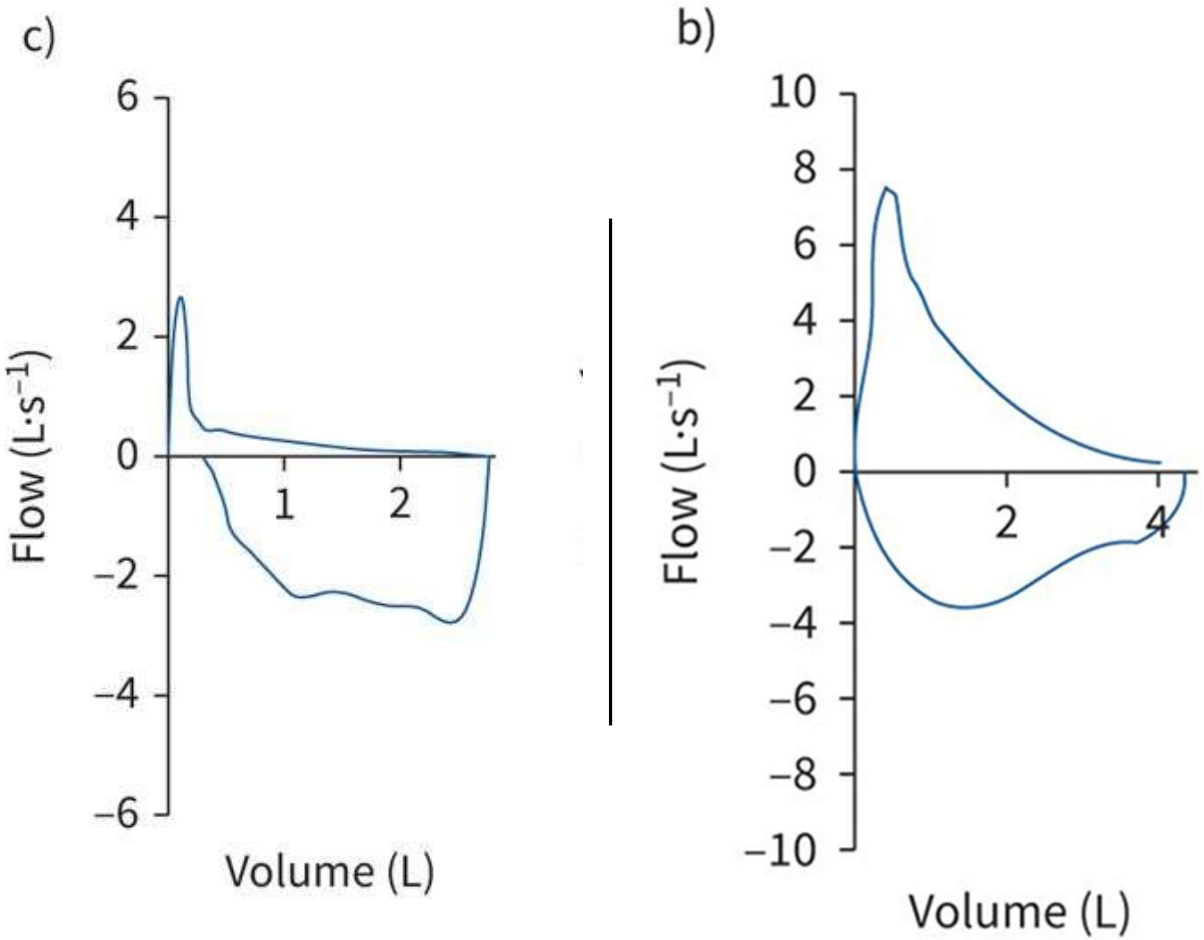

a)
10
8
6
4
2
0
−2
−4
−6
−8
−10
2
4
6
Flow (L·s⁻¹)
Volume (L)
How good are the *airways* at moving air? (speed)
How much air is moving?

CATEGORIES OF ABNORMAL FINDINGS

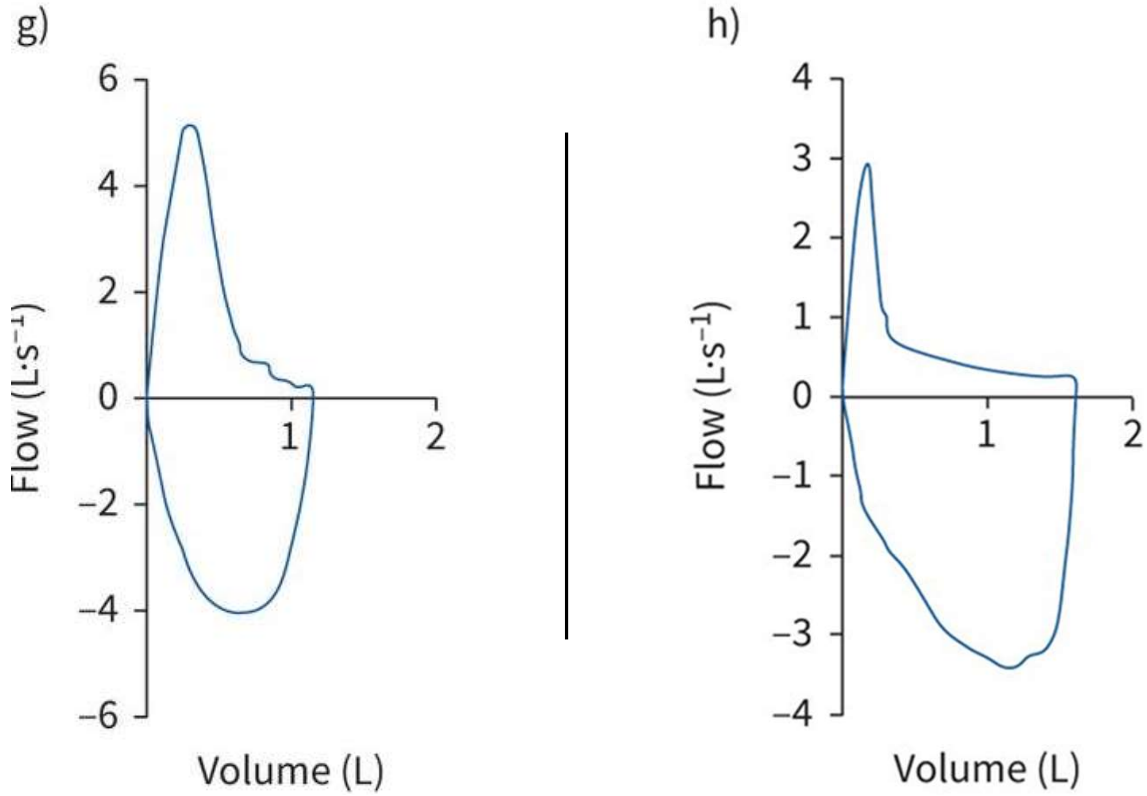
obstructive	• Narrowing of airways that results in reduction of maximal airflow in relation to maximal volume
restrictive	• Disease of lung, chest wall, pleural space, or NM that reduce *lung volumes*
combined	• Reduced lung volumes, vital capacity and airflow with airway narrowing


2
NORMAL
EARLY SMALL AIRWAYS OBSTRUCTION
CHRONIC OBSTRUCTIVE DISEASE
FIXED LARGE AIRWAY OBSTRUCTION
VARIABLE EXTRATHORACIC LARGE AIRWAY OBSTRUCTION
RESTRICTIVE DISEASE
FLOW/SEC
8
6
4
2
0
2
4
6
0
50
100

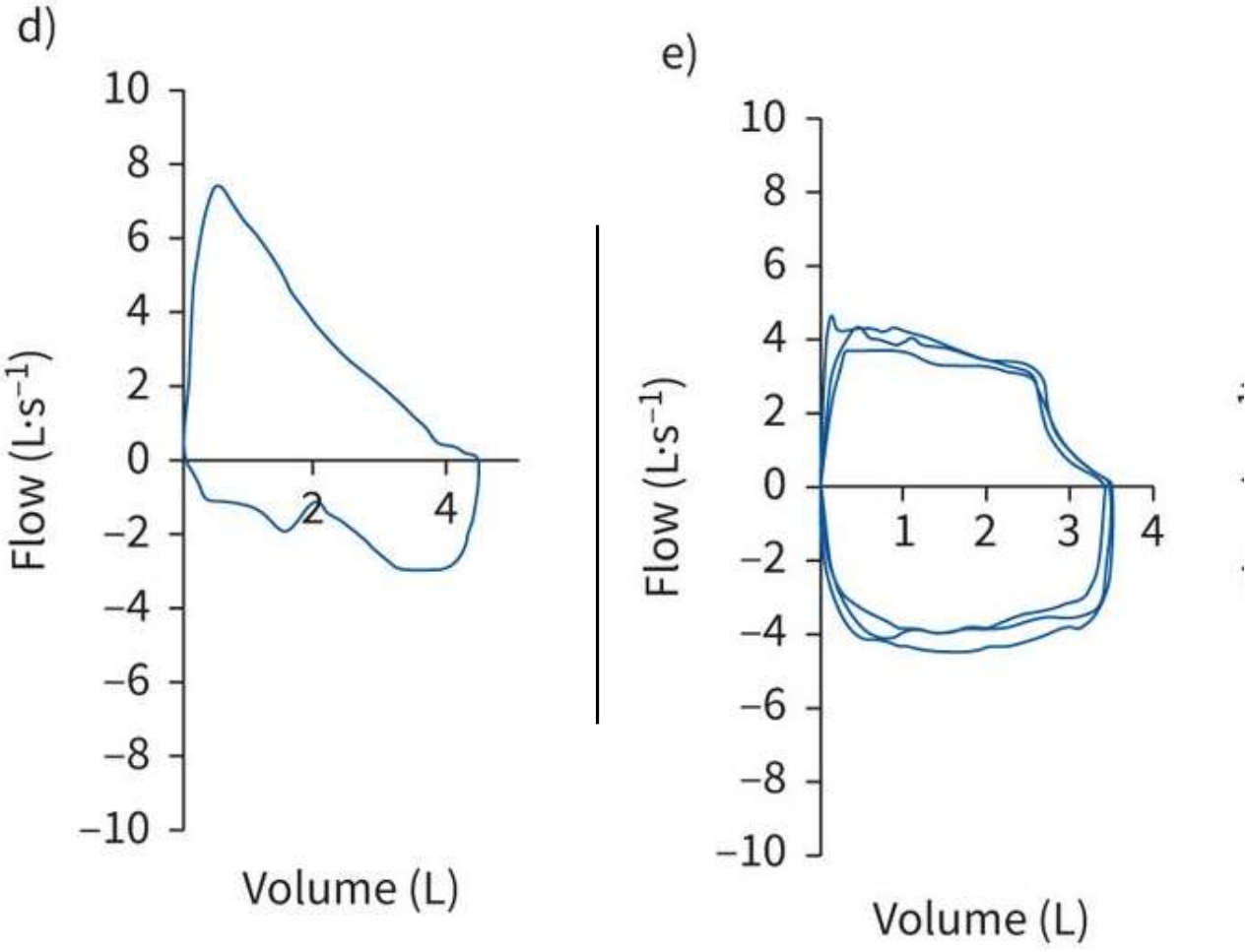
EXAMPLES


c)
6
4
2
0
−2
−4
−6
1
2
Flow (L·s⁻¹)
Volume (L)
b)
10
8
6
4
2
0
−2
−4
−6
−8
−10
2
4
Flow (L·s⁻¹)
Volume (L)

EXAMPLES


g)
6
4
2
0
−2
−4
−6
Flow (L·s⁻¹)
1
2
Volume (L)
h)
4
3
2
1
0
−1
−2
−3
−4
Flow (L·s⁻¹)
1
2
Volume (L)

EXAMPLES



WHAT IS NORMAL ANYWAY?

FVC and FEV_1

- ≥ *80% predicted*
- > LLN

FEV_1/FVC

- ≥ *70%*
- > LLN

OUT WITH THE OLD...

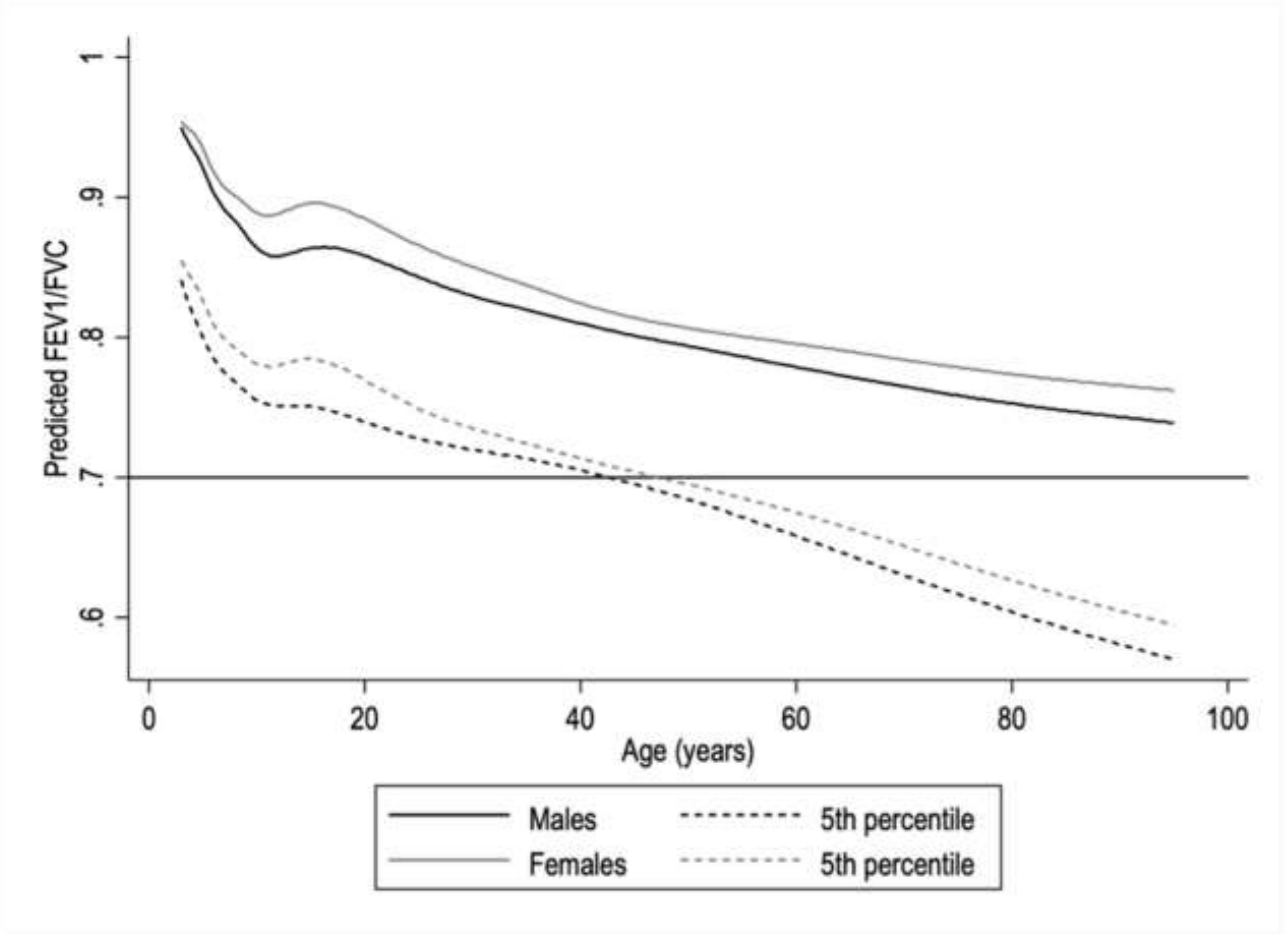
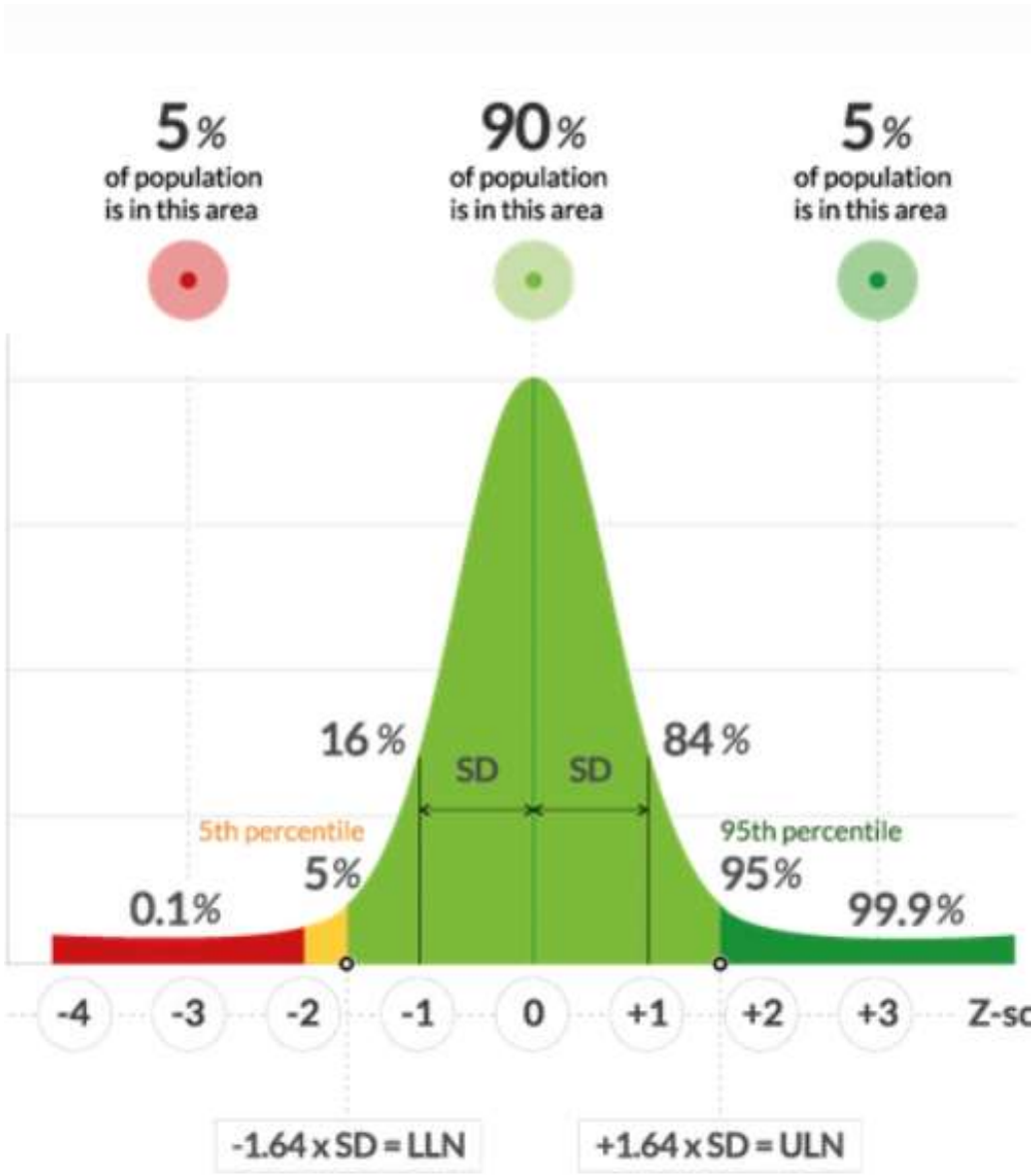


Figure 4. FEV_1/FVC predicted and limits of normal compared with the fixed cut-off of 0.7

ERS

ATS American Thoracic Society



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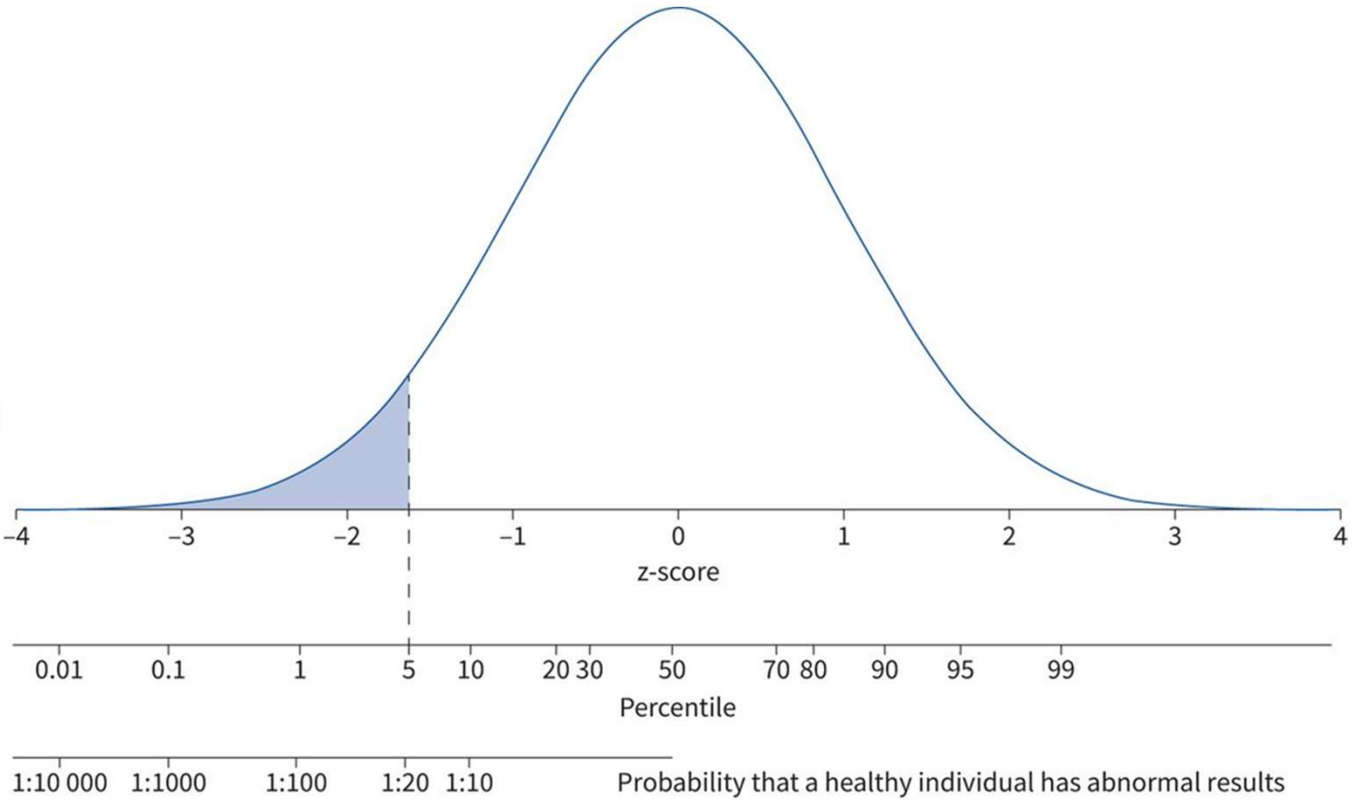
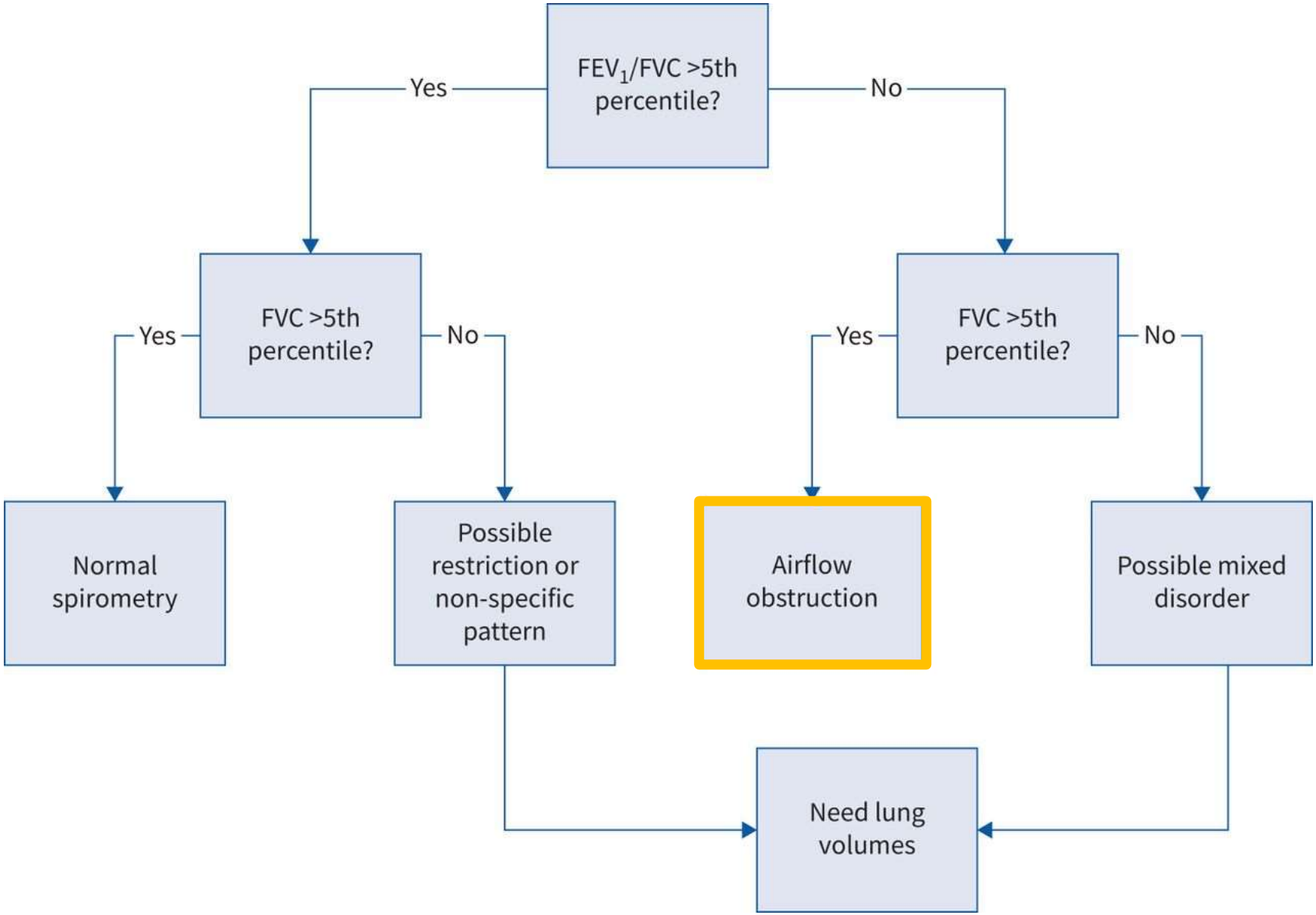


PUT IT TOGETHER

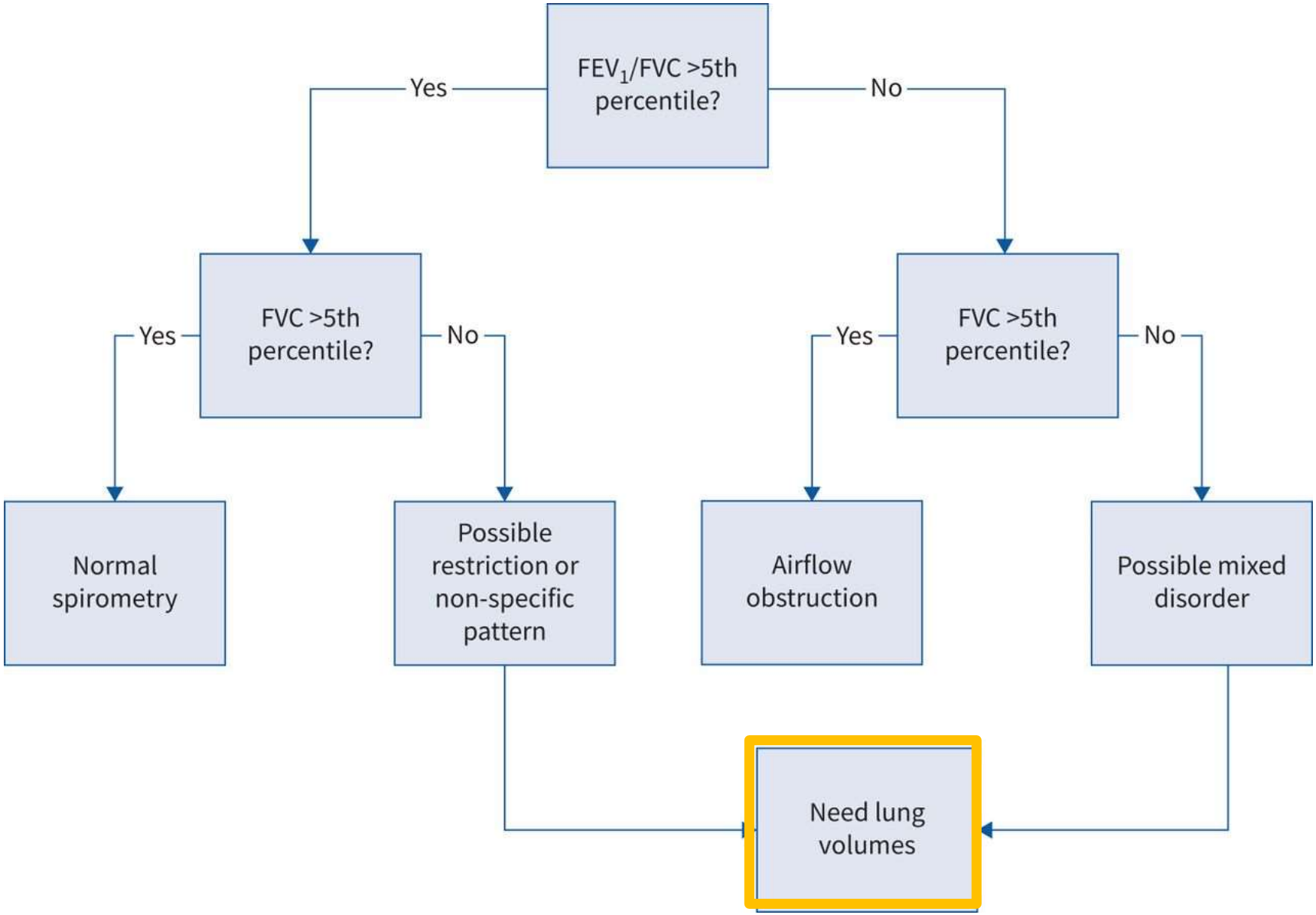
	FEV_1	**FVC**	**FEV_1/FVC Ratio**
Obstructive Disease	Normal or Decreased	Normal or Decreased	**Decreased?**
Restrictive Disease	Normal or Decreased	**Decreased**	**Normal**


FEV1/FVC >5th percentile?
Yes
No
FVC >5th percentile?
Yes
No
FVC >5th percentile?
Yes
No
Normal spirometry
Possible restriction or non-specific pattern
Airflow obstruction
Possible mixed disorder
Need lung volumes

FEV1 z-score	Impairment Severity
1.65 to -2.5	Mild
-2.5 to -4.0	Moderate
Less than -4.0	Severe

FEV1 % pred	Impairment Severity
>70%	Mild
50-70%	Moderate
35-50%	Severe
<35%	Very Severe

FEV_1 determines severity of obstruction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Yes
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Normal spirometry
Possible restriction or non-specific pattern
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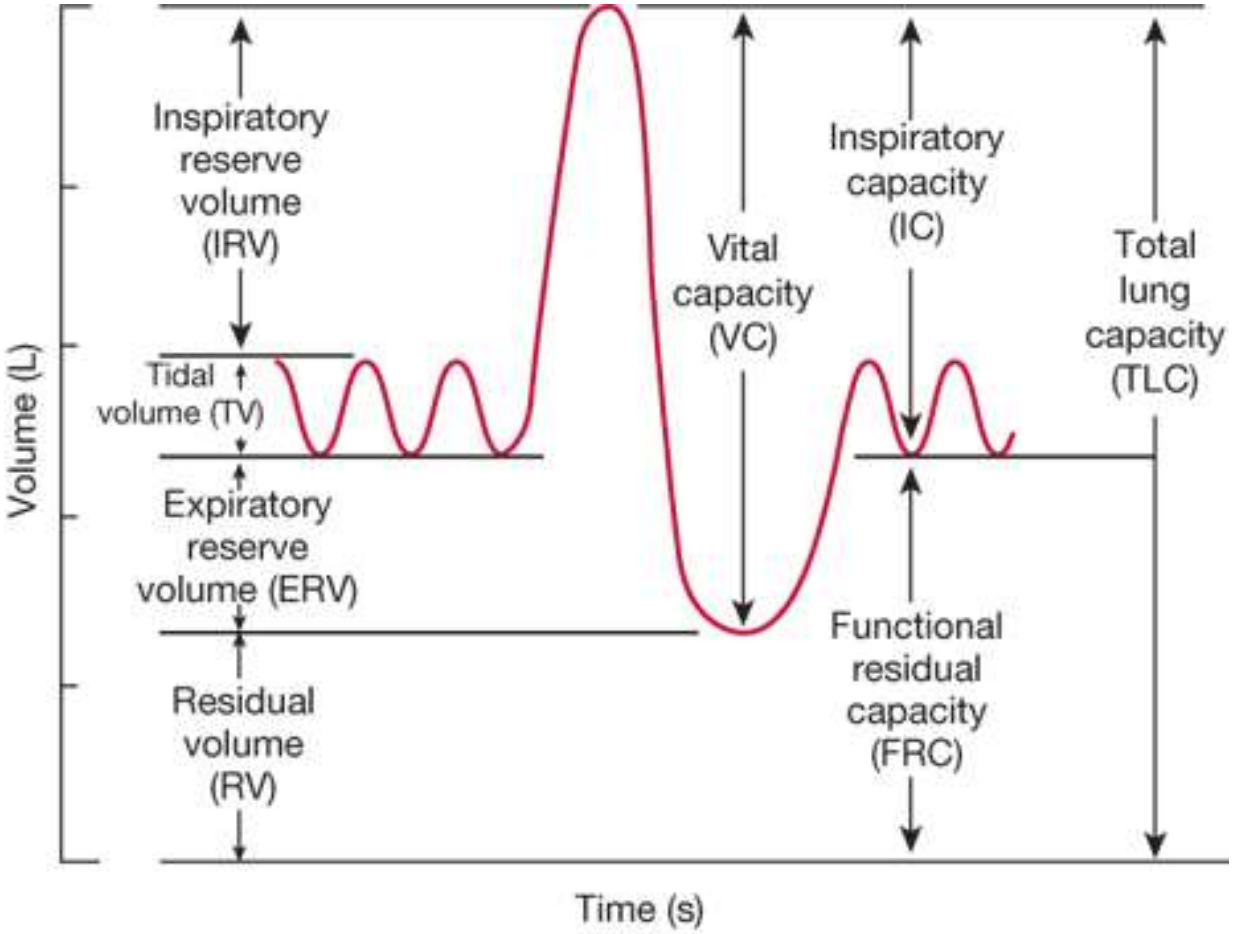
Possible mixed disorder
Need lung volumes

SPIROMETRY

LUNG VOLUMES

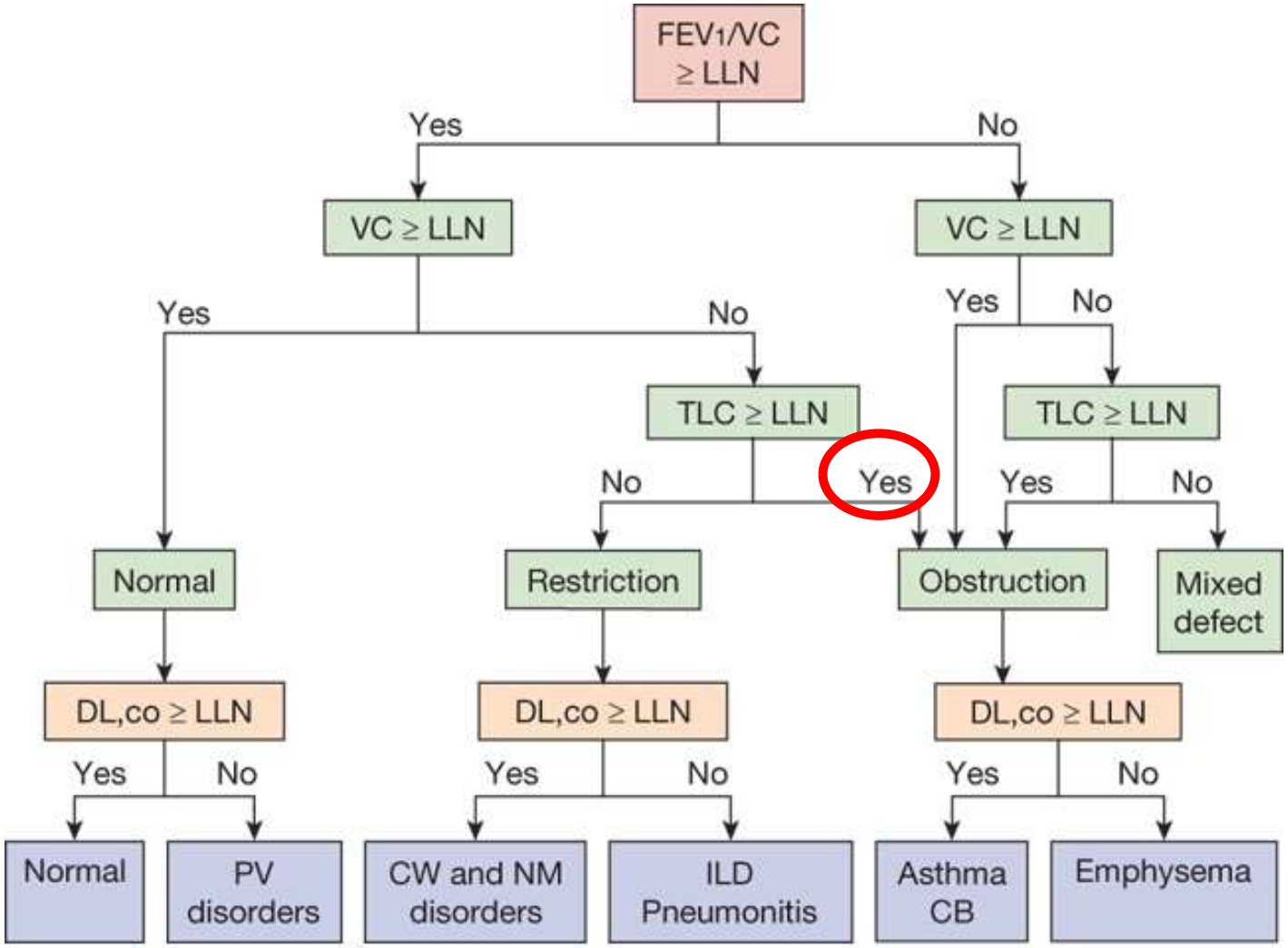
DIFFUSING CAPACITY

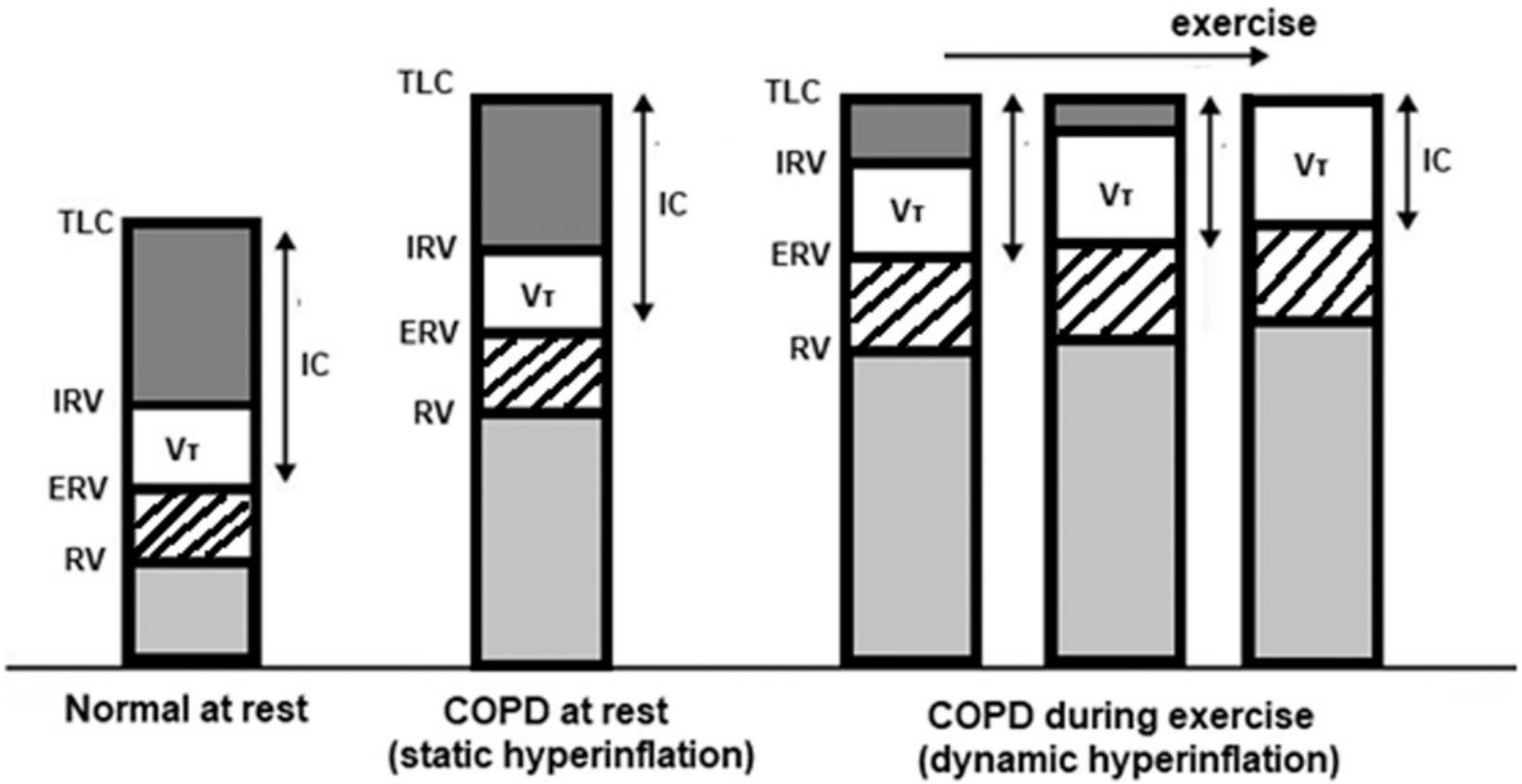
LUNG VOLUMES & CAPACITIES



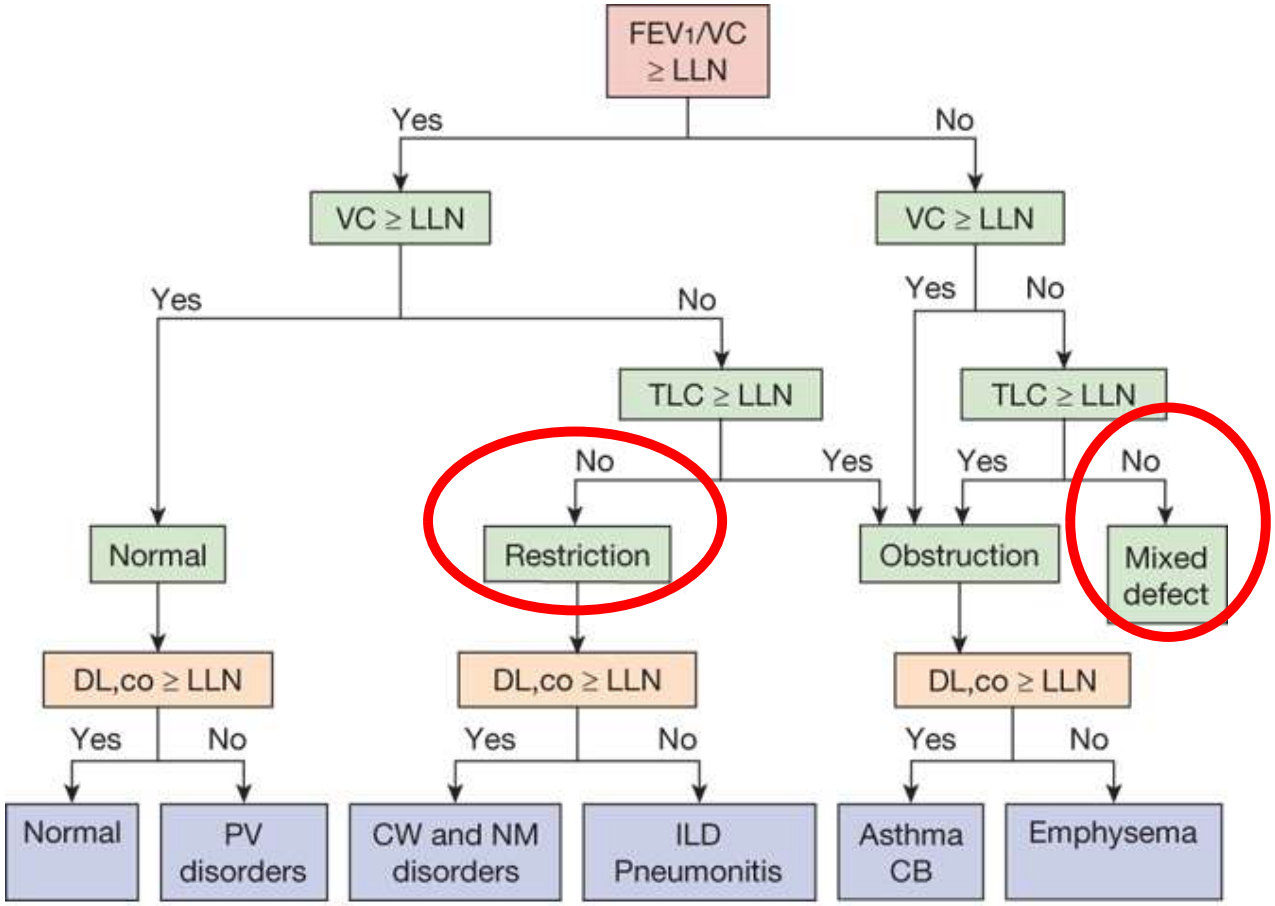
Source: M. A. Grippi, D. E. Antin-Ozerkis, C. S. Dela Cruz, R. M. Kotloff, C. N. Kotton, A. I. Pack: Fishman's Pulmonary Diseases and Disorders, 6e

OBSTRUCTION WITH "NORMAL" FEV_1/FVC




exercise
TLC
IRV
VT
ERV
RV
IC
Normal at rest
COPD at rest
(static hyperinflation)
COPD during exercise
(dynamic hyperinflation)

LUNG VOLUMES CONFIRM RESTRICTION AND/OR MIXED



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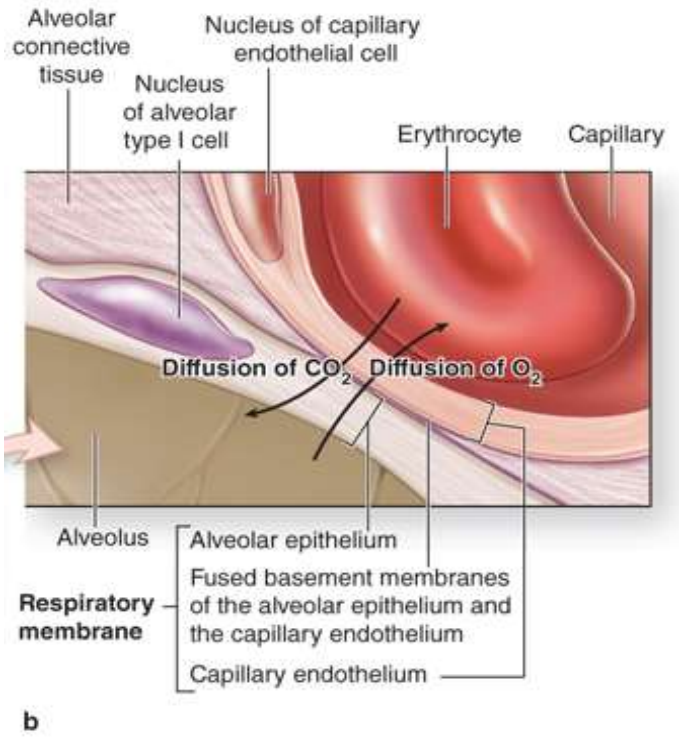
SPIROMETRY
LUNG VOLUMES

DIFFUSING CAPACITY

DLCO: HOW DO WE DO IT?



Step 1: Inspire full breath of CO (measured)

Step 2: Hold breath x 10 seconds

Step 3: Exhale Maximally (measure amount of CO)

Step 4: Measure difference in inspired and expired CO to determine how much CO crossed into the blood stream

DLCO: VARIABLES ASSESSED

Alveolar Surface Area

How much area is available to allow for diffusion?

Pulmonary Perfusion

How much blood (and Hgb) is available to take up the CO?

DLCO: PUT IT TOGETHER

Low	Normal	High
Reduced diffusion due to alveolar disease Decreased perfusion (i.e. narrowed or sclerosed arteries, thromboembolism) Anemia	Extrinsic restrictive disease	Increased pulmonary perfusion High RBC

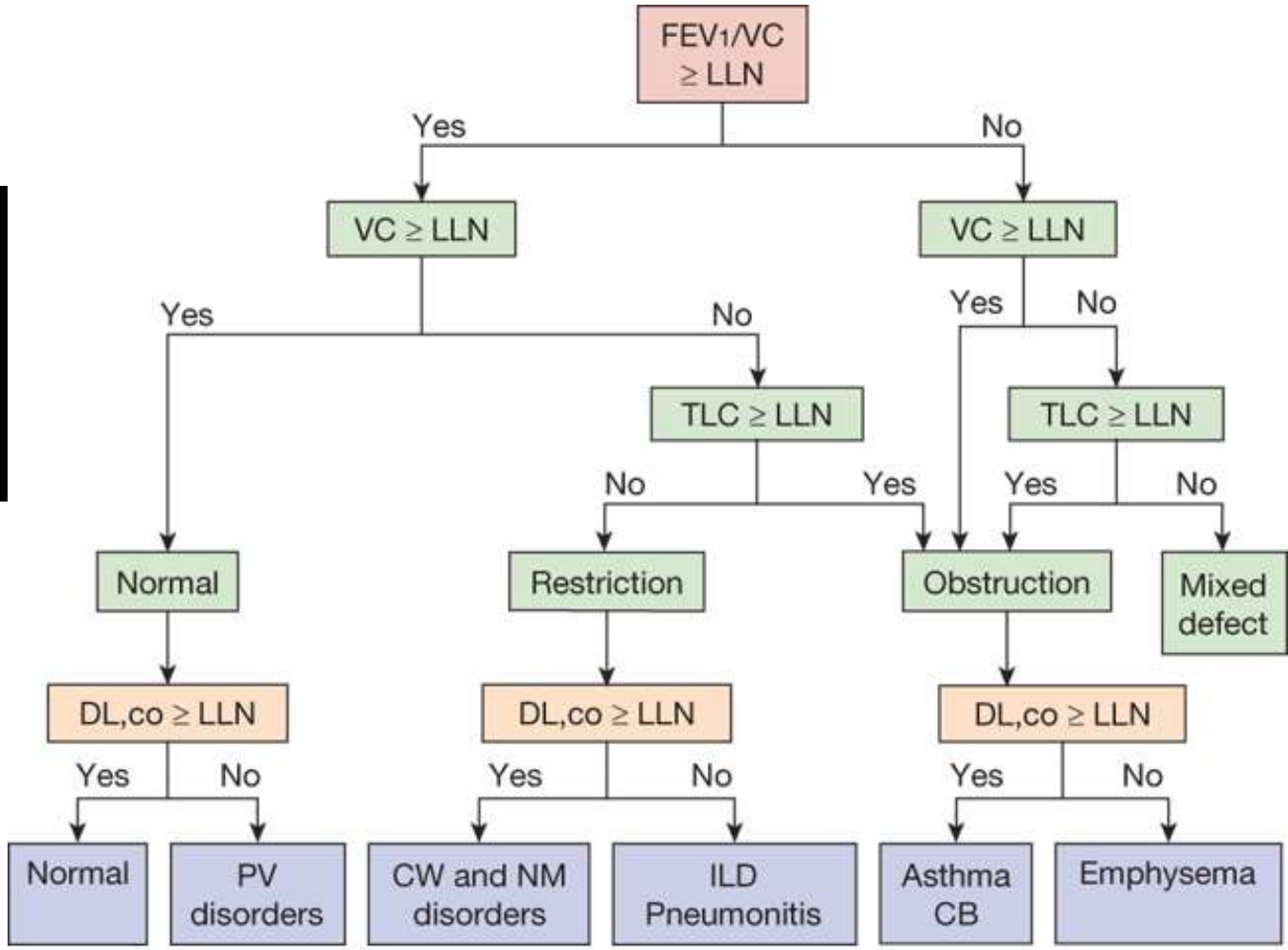
DLCO: CLINICAL APPLICATION

Asthma & Chronic Bronchitis	•Normal DLCO
Emphysema	•Low DLCO

DLCO: CLINICAL APPLICATION

Disorders of chest wall or NM disease	•Normal DLCO
Pulmonary Parenchymal Disease	•Low DLCO

DLCO CAN LOCALIZE PATHOLOGY



BRONCHODILATOR RESPONSE

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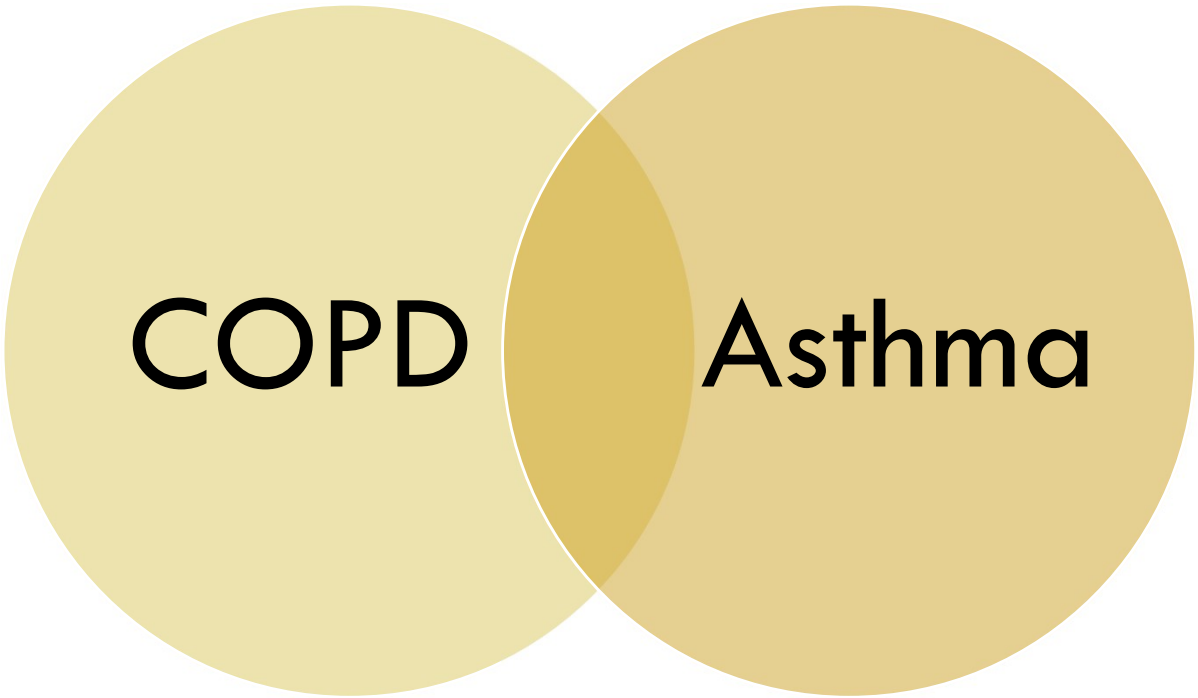

BRONCHODILATOR RESPONSE (BDR)

OLD	NEW
>200 mL AND ≥12% in FEV_1 and/or FVC	Change assessed based on individual's *predicted* value
Change assessed on absolute and relative changes from *initial* values	>10% relative to predicted value for FEV1 or FVC
Limitation: inversely proportional to baseline lung function	Advantage: avoids misinterpretation due to magnitude of baseline lung dysfunction

BRONCHODILATOR RESPONSE (BDR): AN EXAMPLE

$$\frac{\text{(Post BD value)-(Pre BD value)}}{\text{Predicted value}}$$

Pre-BD FEV1 =2.0L

Post-BD FEV1=2.4L

Predicted FEV1=3.32L

>10% relative to predicted value for FEV_1 or FVC

How should these results be interpreted?

A. Significant Response to Bronchodilator

B. No Significant Response to Bronchodilator

INDICATIONS FOR SERIAL PULMONARY FUNCTION TESTING

Track Course of Disease

Response to Treatment

SIGNIFICANT CHANGE

15% change in FVC or FEV_1

10% change in DLCO


DISCLAIMER

REFERENCES

Stanojevic S, Kaminsky DA, Miller MR, et al. ERS/ATS technical standard on interpretive strategies for routine lung function tests. Eur Respir J 2022; 60: 2101499 [DOI: 10.1183/13993003.01499-2021].

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QUESTIONS
CABELL@WAKEHEALTH.EDU