What’s New in PFTs in 2026?

David A. Kaminsky, MD
Pulmonary and Critical Care Medicine
University of Vermont Medical Center/Larner College of Medicine
Burlington, Vermont USA

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Disclosures:

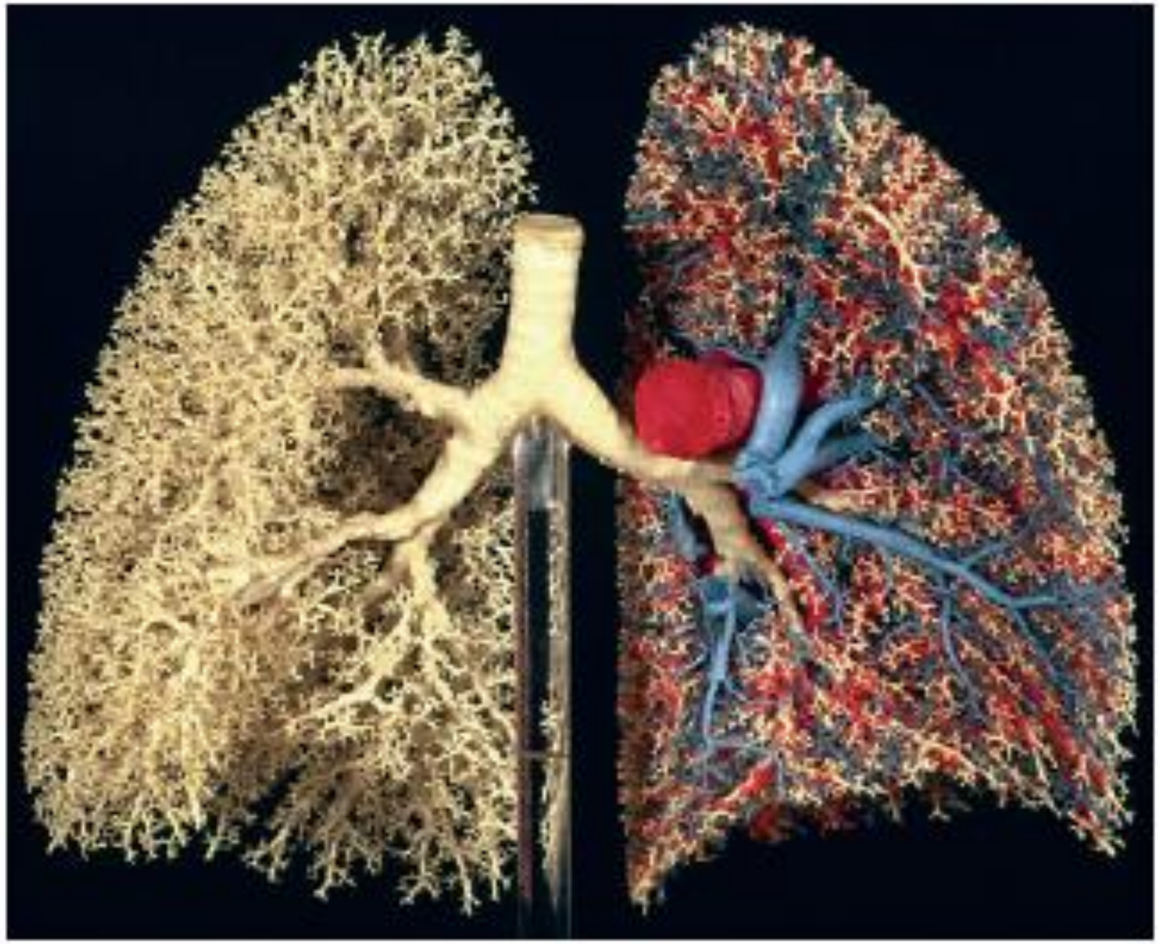
1. Speaker: MGC Diagnostics, Inc.
2. Contributor: UptoDate, Inc.; Elsevier, Inc.

What's New in PFTs in 2026?

Objectives:

1. Review key points of 2022 ERS/ATS interpretation standards
2. Appreciate why we should adopt race-neutral reference values
3. Recognize physiologic patterns of disease

The Complexities of the Human Lung



What makes a good lung?

The morphometric basis of lung function

Ewald R. Weibel

Institute of Anatomy, University of Bern, Bern, Switzerland

SWISS MED WKLY 2009;139(27–28):375–386 · www.smw.ch

- Large surface area for gas exchange (130 m^2)
- Very thin air-blood interface (1μm)
- Mechanical stability

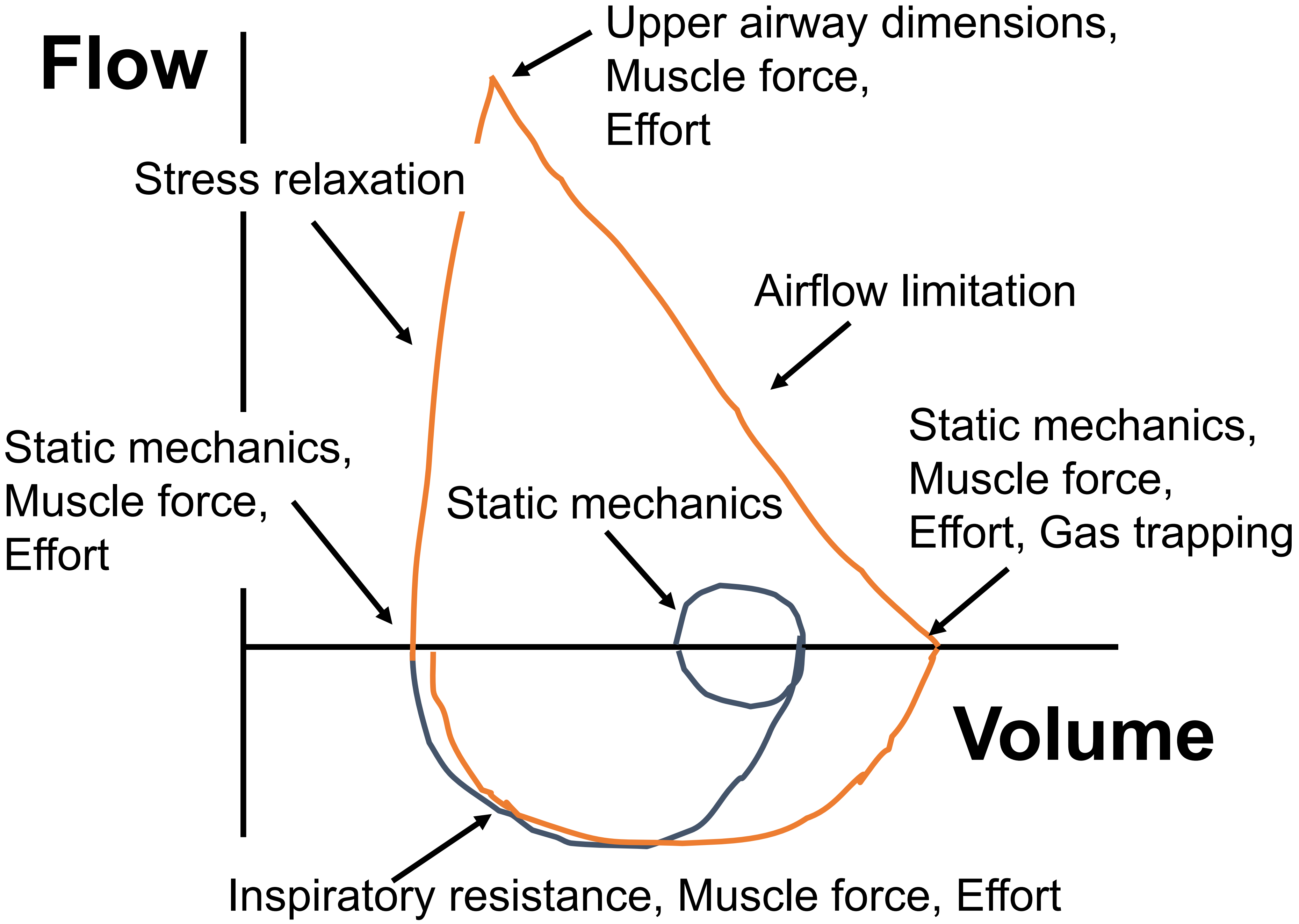
Challenges:

- Fitting surface area into chest cavity (5 L)
- Stabilizing huge surface area with little tissue
- Matching ventilation and perfusion

The Flow-Volume Loop

"The MEFV curve … is an overall expression of the lung's mechanical behavior…but (it) reflects a very complex system and a series of mechanical events that is very poorly understood".

Hyatt and Black, Am Rev Respir Dis, 1973


Flow
Upper airway dimensions,
Muscle force,
Effort
Stress relaxation
Airflow limitation
Static mechanics,
Muscle force,
Effort
Static mechanics
Static mechanics,
Muscle force,
Effort, Gas trapping
Volume
Inspiratory resistance, Muscle force, Effort

Historical Perspective

The American Journal of Medicine

VOLUME 45 SEPTEMBER 1968 NUMBER 3

Editorial

A Quantitative Definition of Obstructive Lung Disease

K. P. POIRIER, M.D.
Country Club Medical Center
2322 Butano Drive
Sacramento, California 95825

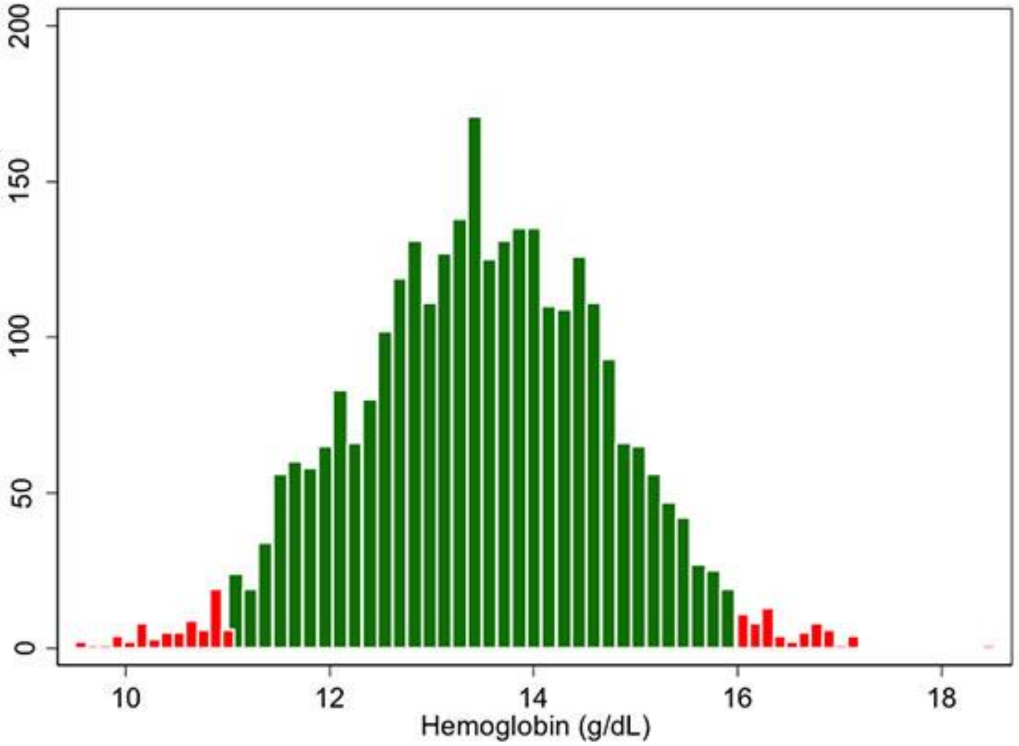
"… the general tendency in pulmonary function testing at the clinical level is toward cautiously noncommittal overinterpretation expressed in language replete with modifiers…"

What is a Normal Value?

	Ref Range & Units
WBC	4.00 - 12.40 K/cmm
RBC	3.86 - 5.04 M/cmm
Hemoglobin	11.6 - 15.2 gm/dL
HCT	34.9 - 44.4 %
MCV	81 - 98 fl
MCH	26.7 - 33.3 pg
MCHC	32.1 - 35.9 gm/dL
RDW-CV	<14.7 %
RDW-SD	<50.4 fl
PLT	141 - 377 K/cmm
MPV	9.5 - 12.7 fl

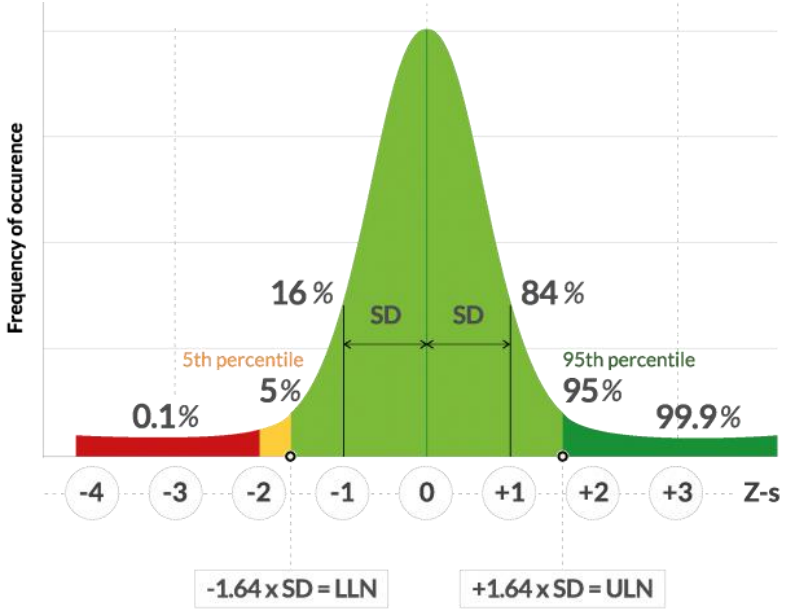
	Ref Range & Units
Sodium	136 - 145 mmol/L
Potassium	3.5 - 5.0 mmol/L
Chloride	96 - 110 mmol/L
CO2 Total	22 - 32 mmol/L
Glucose	70 - 100 mg/dL
BUN	10 - 26 mg/dL
Creatinine	0.52 - 1.04 mg/dL
eGFR	>60 mL/min/1.73m2
Total Protein	6.3 - 8.2 g/dL
Albumin	3.4 - 4.9 g/dL
Alkaline Phosphatase	38 - 126 U/L
AST	15 - 46 U/L
ALT	<35 U/L
Bilirubin, Total	<1.4 mg/dL
Calcium	8.5 - 10.5 mg/dL
Albumin/Globulin Ratio	1.0 - 2.5
Anion Gap	8 - 16

What is a Normal Value?



- Usually determined from a large number of observations derived from a reference population of "healthy" individuals.
- The normal range commonly chosen as 95% of this distribution, setting cut-offs at the bottom and top 2.5% of the population.
- This means people in the "tails" will be labeled as abnormal when they are actually healthy.

Normal Lung Function:
> LLN (5th percentile, z-score = -1.64)



LLN = lower limit of normal
ULN = upper limit of normal

In spirometry, we are only concerned about low values, not high values, so the LLN is set at the 5th percentile.

	Pre-BD			
	Actual	LLN	Z Score	% Pred
---- SPIROMETRY ----				
FVC (L)	4.67	3.13	1.67	120
FEV1 (L)	3.50	2.71	0.28	103
FEV1/FVC (%)	74.96	78.10	-2.17	85
FEF 25-75% (L/sec)	2.85	2.61	-1.34	72
PEF (L/min)	450.6			
TestGrade(ATS)	AA			

Lung Function Reference Values

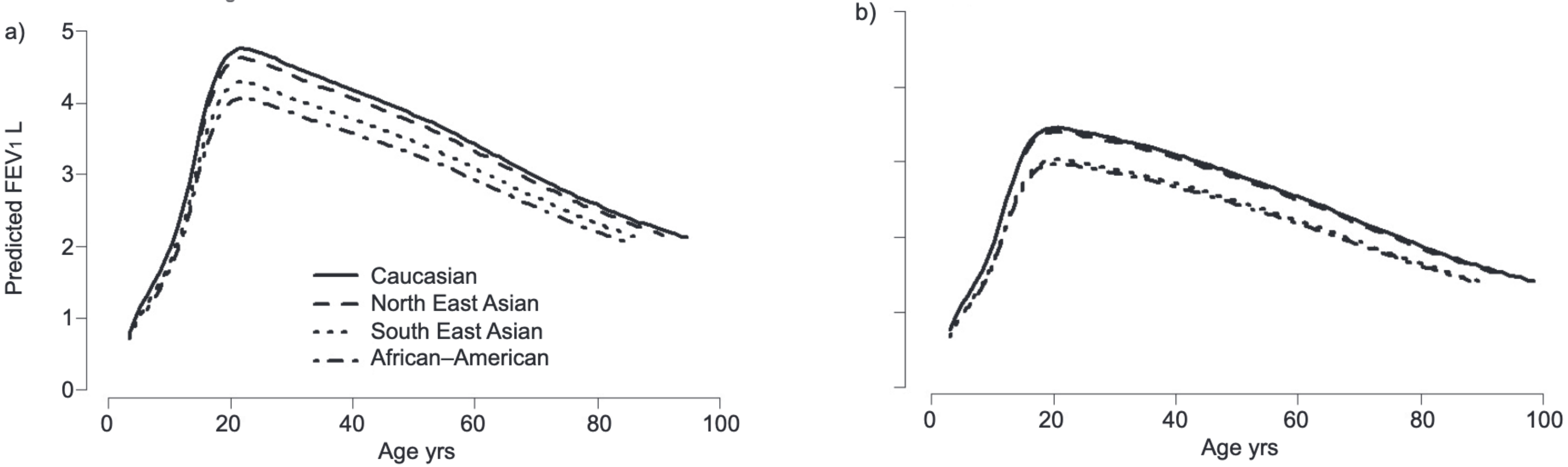
ERS TASK FORCE

Multi-ethnic reference values for spirometry for the 3–95-yr age range: the global lung function 2012 equations

Eur Respir J 2012; 40: 1324–1343
DOI: 10.1183/09031936.00080312

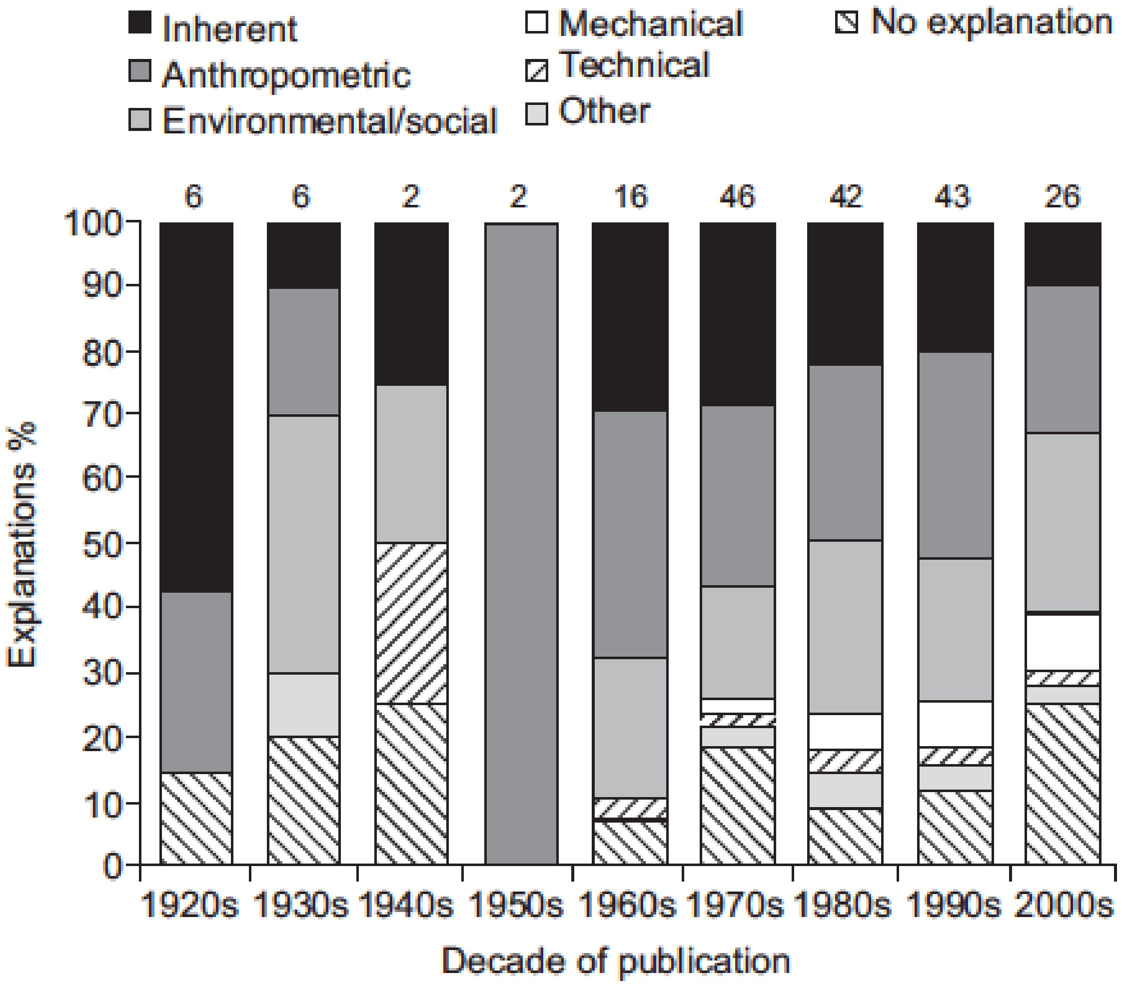
Global Lung Function Initiative

Philip H. Quanjer, Sanja Stanojevic, Tim J. Cole, Xaver Baur, Graham L. Hall, Bruce H. Culver, Paul L. Enright, John L. Hankinson, Mary S.M. Ip, Jinping Zheng, Janet Stocks and the ERS Global Lung Function Initiative



- Lung size varies with ***Age, Sex and Height***
- Lung size varies with self-identified racial or ethnic backgrounds

Most of Lung Function Literature Fails to Take into Account non-Anthropomorphic Factors



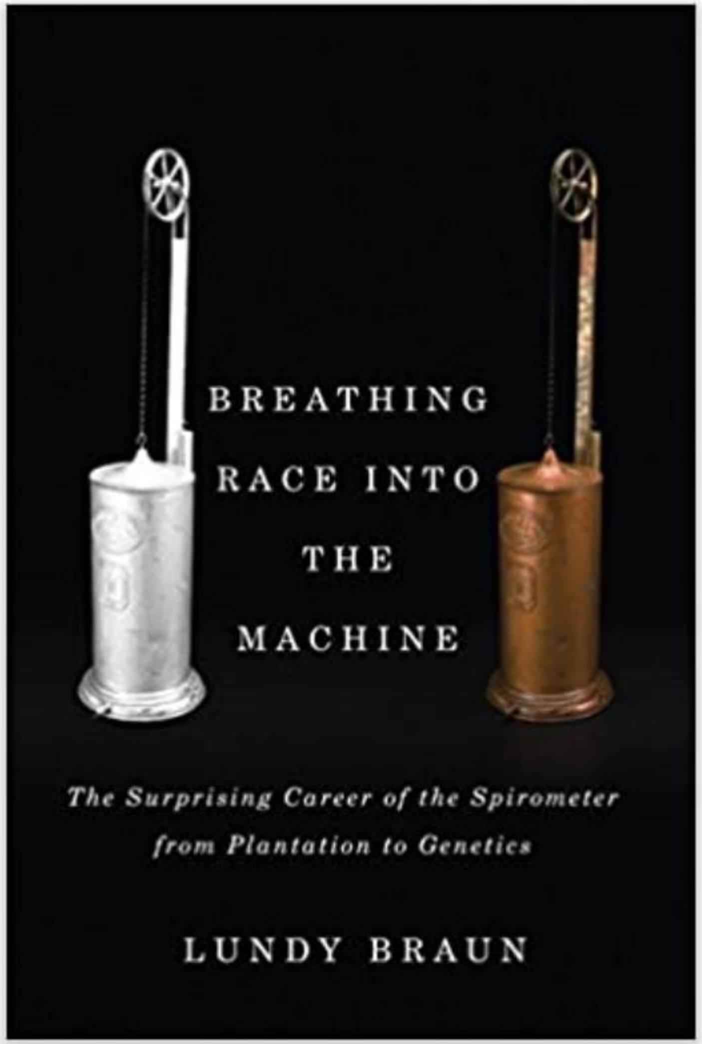
- Literature review of 226 articles 1922-2008
- Variable definition of “race”, “ethnicity”
- 84% reported “other racial/ethnic groups” have lower lung function than “white”

•***94% failed to examine socioeconomic status***

- 22% cited inherent/anthropometric factors
- 23% cited environmental/social factors

Braun, Eur Respir J 2013

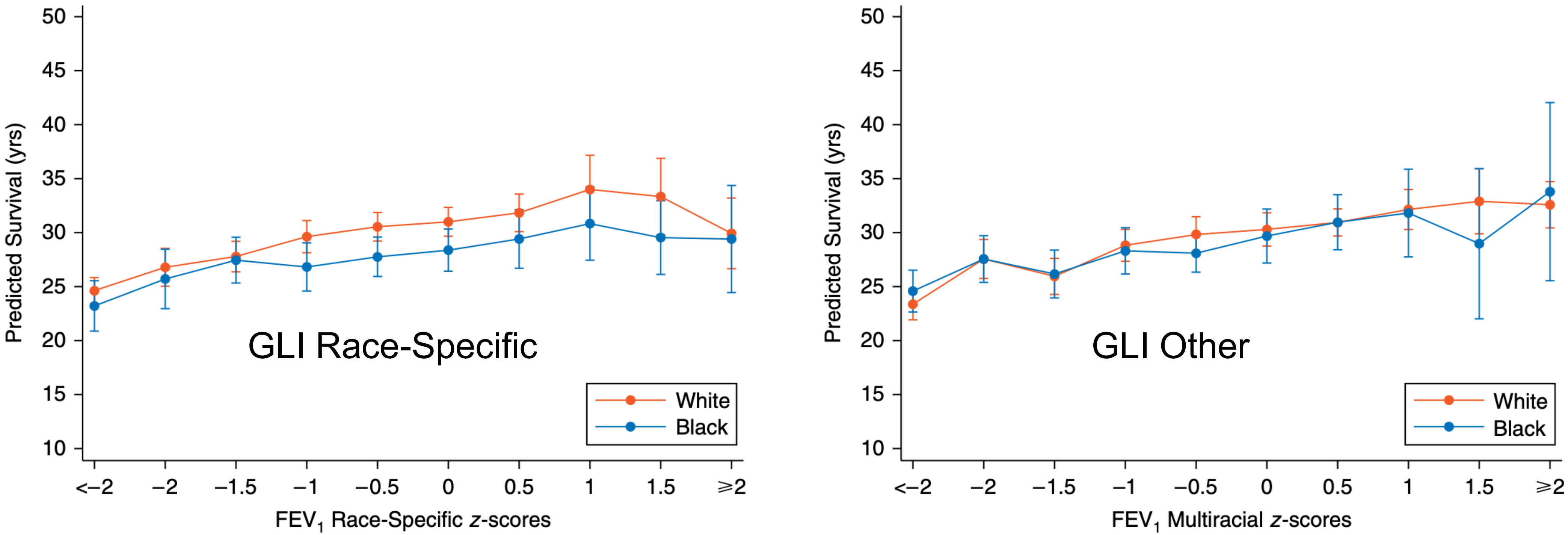
Influence of Race and Ethnicity on Lung Function



Today most commercially available spirometers, used around the world to diagnose and monitor respiratory illness, have a "race correction" built into the software, which controls for the assumption that blacks have less lung capacity than whites. In her 2014 book, "Breathing Race Into the Machine: The Surprising Career of the Spirometer from Plantation to Genetics," Lundy Braun, a Brown University professor of medical science and Africana studies, notes that "race correction" is still taught to medical students and described in textbooks as scientific fact and standard practice.

Race-Specific Equations Lead to Overestimation of Mortality in African-Americans

Applying GLI-race specific or GLI-Other to NHANES III Population



For a given age, sex, height and absolute FVC, mortality is similar between Black and White individuals. But if use race-specific equations, mortality now seems higher in Black individuals for a given % predicted value (which corresponds to a lower absolute value in Black than in White individuals).

McCormack et al., AJRCCM 2021

Illustrating the Issue of Race and Lung Function Interpretation

DP was a 22-year-old, healthy, non-smoking male college graduate who was born in India and was pursuing his education in the US.

Using NHANES III (Caucasian)

	Measured	LLN	Predicted	%Predicted
FVC(L)	4.22	5.21	5.49	77
FEV1(L)	3.63	4.26	4.51	80
FEV1/FVC	0.86	0.80	0.84	

Using Fulambarker, 2010 (Indian)

	Measured	LLN	Predicted	%Predicted
FVC(L)	4.22	4.06	4.28	99
FEV1(L)	3.63	3.32	3.52	103
FEV1/FVC	0.86	0.75	0.86	

Using GLI-Global (race neutral)

	Measured	LLN	Predicted	%Predicted
FVC(L)	4.22	3.83	4.88	86
FEV1(L)	3.63	3.31	4.21	86
FEV1/FVC	0.86	0.75	0.86	

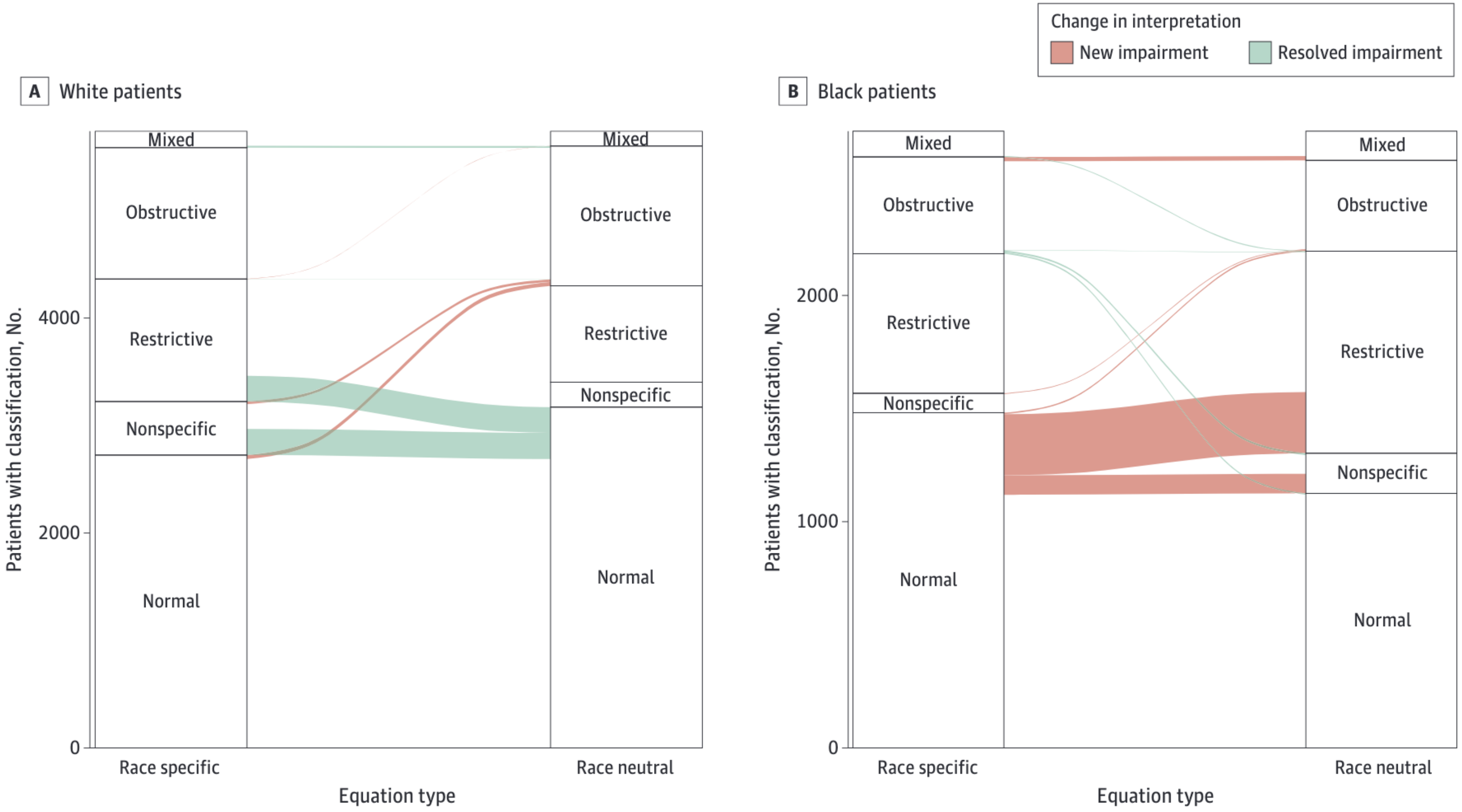
What do we tell him?

↓

Normal lung function

Effects of Changing to Race-Neutral Reference Equations on Identification of Disease and on Disease Severity

Prevalence of restriction in White patients decreased from 23 to 18%

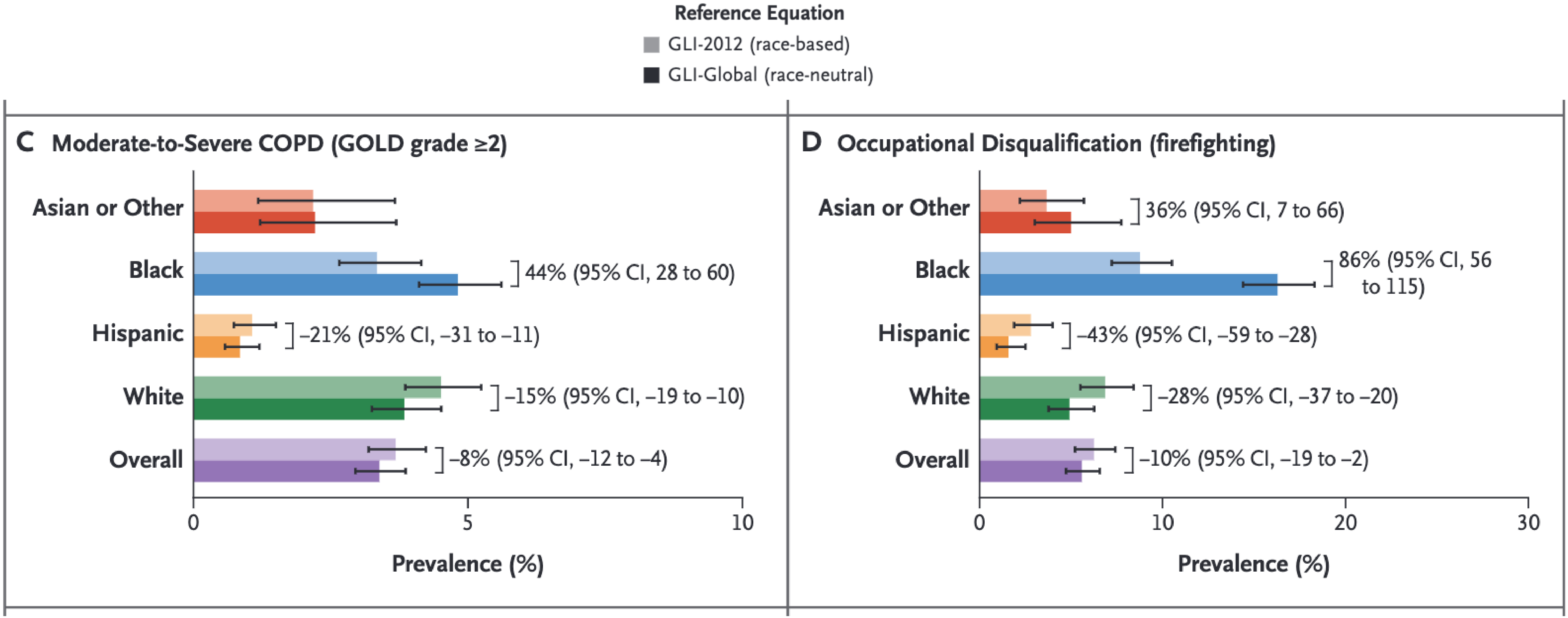


Prevalence of restriction in Black patients increased from 27 to 37%

N = 2700 Black and 5700 White patients
University of Pennsylvania

Moffett, JAMA Network Open 2023

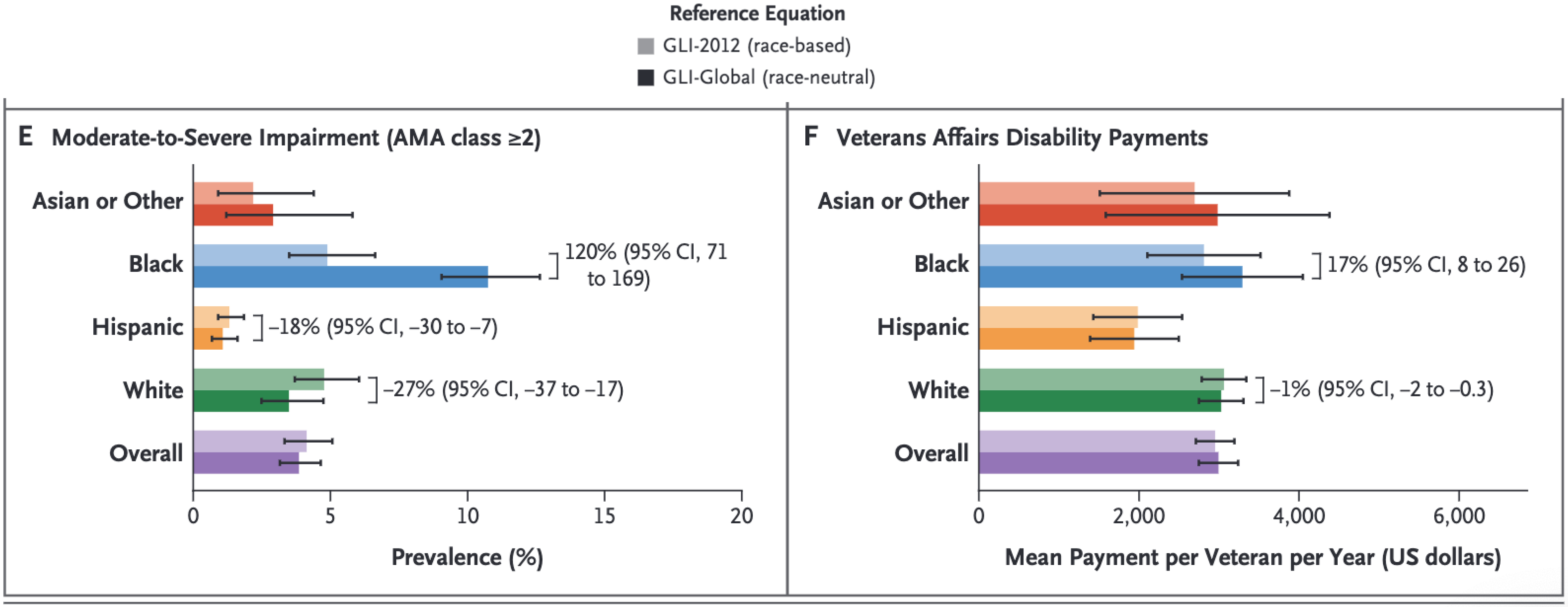
Effects of Changing to Race-Neutral Reference Equations on Identification of Disease and on Outcomes



Projecting data from ~370K people in US, UK when changing from GLI 2012 to GLI Global, onto US population age 6-79 yrs

N Engl J Med 2024;390:2083-97.
DOI: 10.1056/NEJMsa2311809

Effects of Changing to Race-Neutral Reference Equations on Identification of Disease and Outcomes



Projecting data from ~370K people in US, UK when changing from GLI 2012 to GLI Global, onto US population age 6-79 yrs

N Engl J Med 2024;390:2083-97.
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How Should We Proceed?

Move From:

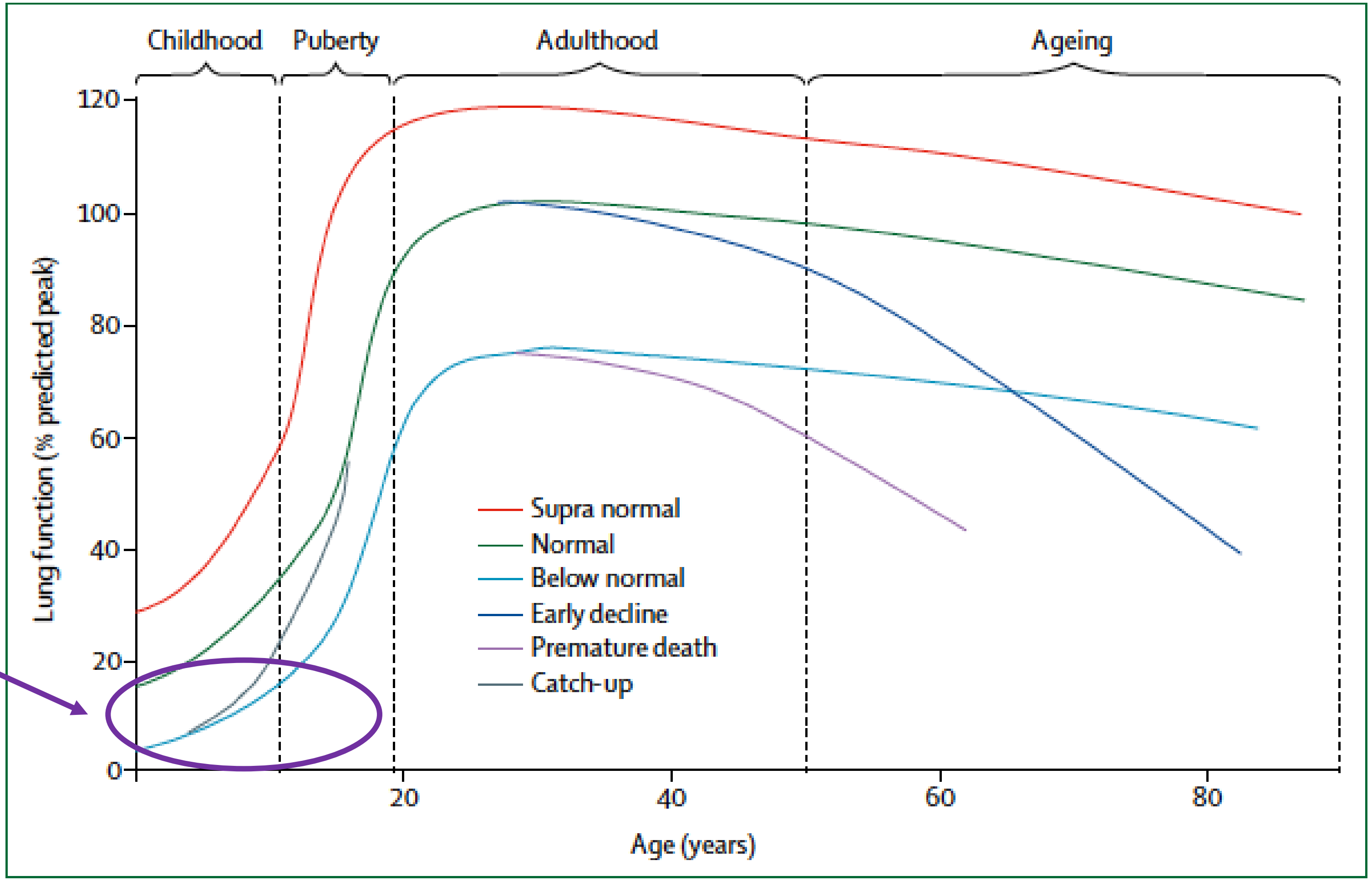
Race-based medicine approach: using race-specific equations assumes that race explains differences in lung function.

To:

Race-conscious medicine approach: using race-neutral equations that attempt to define normal lung health among all humans. Any differences found from normal causes us to consider multiple factors associated with "race" that may be modifiable to improve lung health.

Early Origins of Adult Respiratory Disease

Modifying risk factors early is key to being able to influence and optimize early lung growth



Different Trajectories of Lung Health Dependent on Early Life Factors

Agusti and Faner, Lancet 2019

EUROPEAN RESPIRATORY journal
FLAGSHIP SCIENTIFIC JOURNAL OF ERS

ERS/ATS technical standard on interpretive strategies for routine lung function tests

Sanja Stanojevic, David A. Kaminsky, Martin Miller, Bruce Thompson, Andrea Aliverti, Igor Barjaktarevic, Brendan G. Cooper, Bruce Culver, Eric Derom, Graham L. Hall, Teal S. Hallstrand, Joerg D. Leuppi, Neil MacIntyre, Meredith McCormack, Margaret Rosenfeld, Erik R. Swenson

Eur Respir J. 2021 Dec 23:2101499. doi: 10.1183/13993003.01499-2021.

ERS/ATS technical standard on interpretive strategies for routine lung function tests

2005ATS/ERS Statement	2021 ATS/ERS Technical Standard
General comments: • Using PFT interpretation to aid in clinical diagnosis and decision making	General comments: • More emphasis on using PFTs to classify physiology, not make a clinical diagnosis • Emphasis on uncertainty of interpretation, especially near LLN
Reference Equations • Use of race/ethnic specific equations preferred over using adjustment factors • Spirometry: In USA: NHANES 3 recommended In Europe: no specific equations recommended • Lung Volumes and DLCO: In USA and Europe: no specific equations recommended	Reference Equations: • Recommendation to use GLI reference equations for spirometry, lung volumes and D_LCO • More emphasis on incomplete understanding of role of race/ethnicity on lung function • Clarify that biological sex, not gender be used to interpret lung function

ERS/ATS technical standard on interpretive strategies for routine lung function tests

2005 ATS/ERS Statement	2021 ATS/ERS Technical Standard
<u>Defining Normal Range</u> • General use of LLN = 5th percentile • Use of fixed ratio $FEV_1/FVC < 0.7$ not recommended • Use of 80% predicted to define normal not recommended	<u>Defining Normal Range</u> • General use of LLN = 5th percentile and ULN = 95th percentile • Use of fixed ratio $FEV_1/FVC < 0.7$ not recommended • Use of 80% predicted to define normal not recommended
<u>Bronchodilator Response</u> • >12% and 200 ml in FEV_1 or FVC from baseline • 4 doses of 100 mcg salbutamol; wait 15 minutes	<u>Bronchodilator Response</u> • >10% of predicted value in FEV_1 or FVC • Choice of protocol for administering bronchodilator not specified

ERS/ATS technical standard on interpretive strategies for routine lung function tests

2005 ATS/ERS Statement	2021 ATS/ERS Technical Standard
Severity of Lung Function Impairment • Using FEV_1 (includes obstruction or restriction): o Mild = FEV_1 > 70% predicted o Mod = 60-69% predicted o Mod-Severe = 50-59% predicted o Severe = 35-49% predicted o Very severe = < 35% predicted • D_LCO: o Mild = >60% predicted and < LLN o Mod = 40-60% predicted o Severe = < 40% predicted	Severity of Lung Function Impairment • For all measures use z-score: o Mild = -1.65 to -2.5 o Mod = -2.51 to -4.0 o Severe = > -4

ERS/ATS technical standard on interpretive strategies for routine lung function tests

2005 ATS/ERS Statement	2021 ATS/ERS Technical Standard
Classification of Physiological Impairments • Airflow obstruction: $FEV_1/FVC < 5^{th}$ percentile, using largest VC; lung volumes to detect hyperinflation or air trapping; elevated airway resistance; central/upper airway obstruction • Restriction: o TLC < 5^{th} percentile and normal FEV_1/VC o Mixed = FEV_1/VC and TLC < 5^{th} percentile • Gas Transfer Impairment: o D_LCO, KCO < 5^{th} percentile o Importance of adjustments for Hb, COHb	Classification of Physiological Impairments • Airflow obstruction: $FEV_1/FVC < 5^{th}$ percentile, using FVC; lung volumes to detect hyperinflation or air trapping; dysanapsis; non-specific pattern and PRISm; central/upper airway obstruction • Restriction: o TLC < 5^{th} percentile o Simple vs. complex restriction o Hyperinflation o Mixed • Gas Transfer Impairment o $D_LCO < 5^{th}$ percentile o Using VA, KCO to classify low D_LCO

Change is Hard…

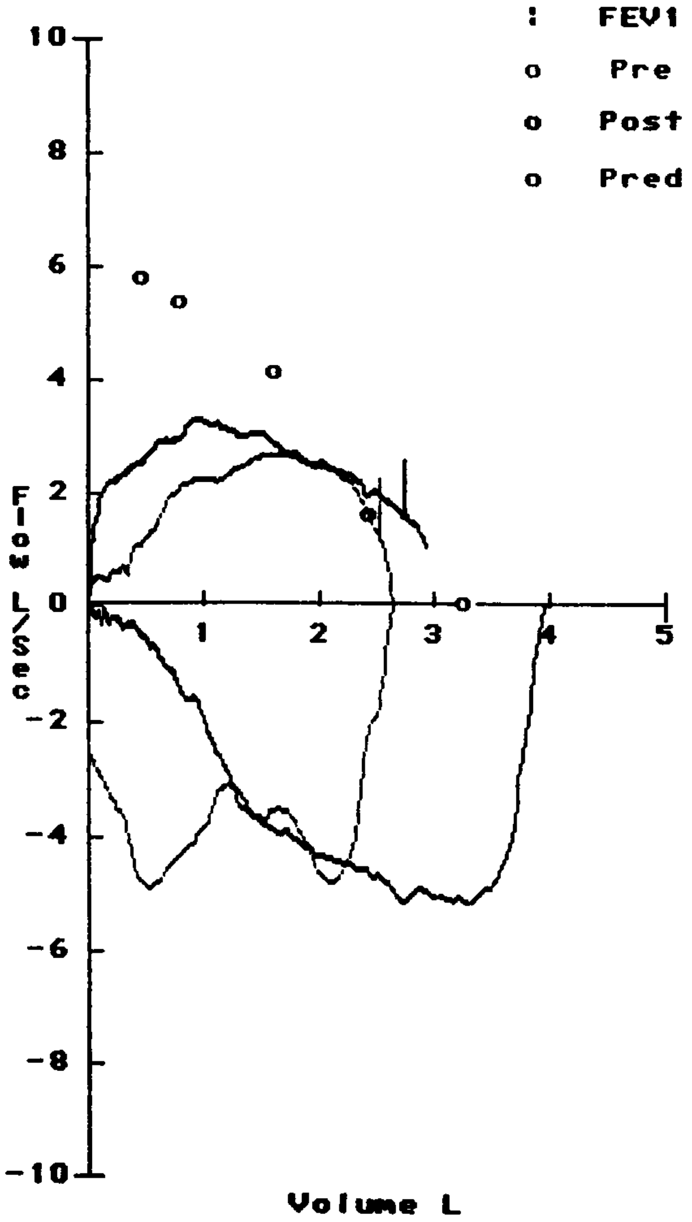
"I want you to find a bold and innovative way to do everything exactly the same way it's been done for 25 years."

Spirometry Quality Grading Criteria

Table 10. Grading System for FEV_1 and FVC (Graded Separately)

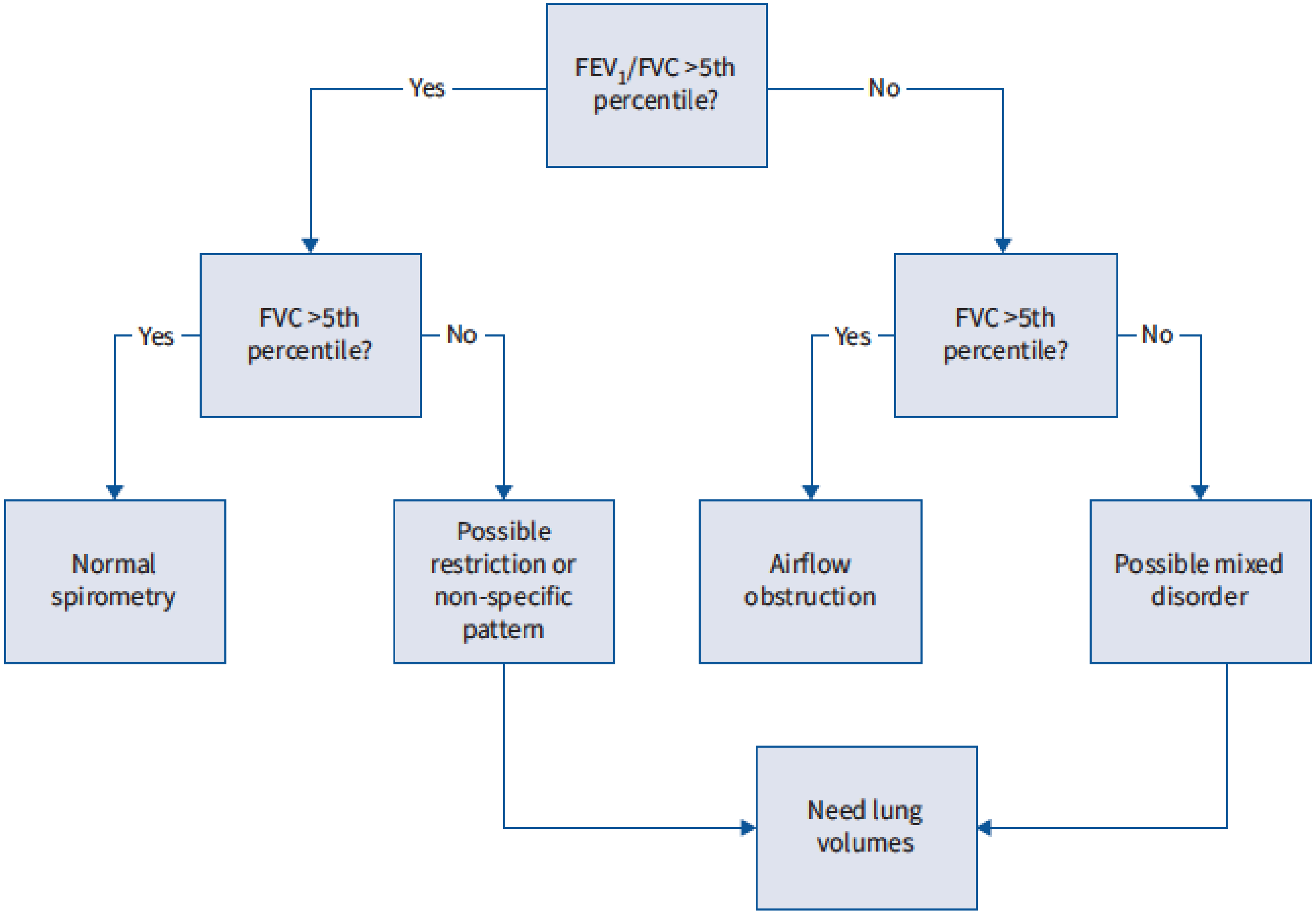
Grade	Number of Measurements	Repeatability: Age >6 yr	Repeatability: Age ≤6 yr*
A	≥3 acceptable	Within 0.150 L	Within 0.100 L*
B	2 acceptable	Within 0.150 L	Within 0.100 L*
C	≥2 acceptable	Within 0.200 L	Within 0.150 L*
D	≥2 acceptable	Within 0.250 L	Within 0.200 L*
E	≥2 acceptable	>0.250 L	>0.200 L*
	OR 1 acceptable	N/A	N/A
U	0 acceptable AND ≥1 usable	N/A	N/A
F	0 acceptable and 0 usable	N/A	N/A

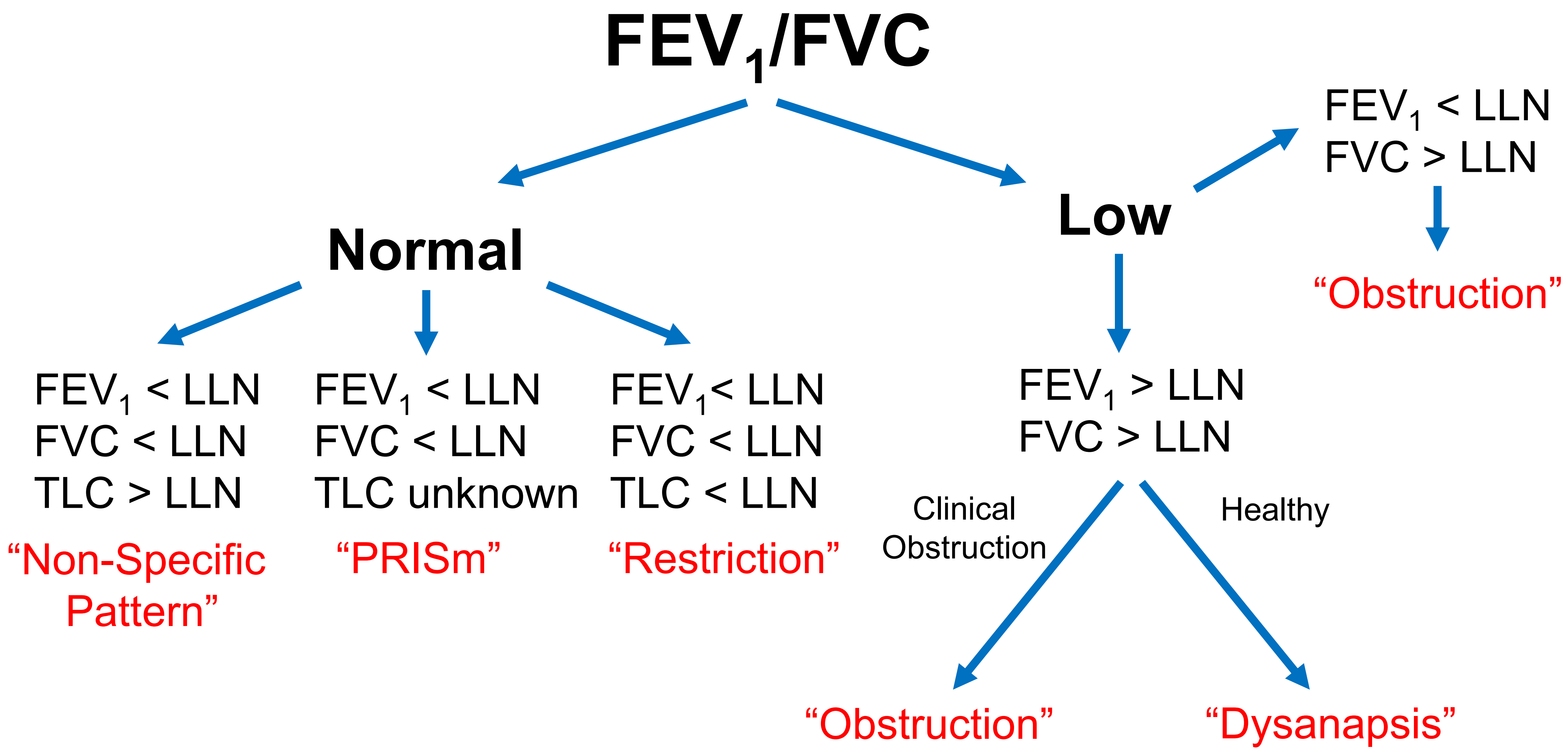
Graham, *AJRCCM 2019*



Oops!!

ERS-ATS Spirometry Interpretation Algorithm




FEV1/FVC
Normal
Low
FEV1 < LLN
FVC > LLN
"Obstruction"
FEV1 < LLN
FVC < LLN
TLC > LLN
"Non-Specific Pattern"
FEV1 < LLN
FVC < LLN
TLC unknown
"PRISm"
FEV1< LLN
FVC < LLN
TLC < LLN
"Restriction"
FEV1 > LLN
FVC > LLN
Clinical Obstruction
Healthy
"Obstruction"
"Dysanapsis"

Non-Specific Pattern: Low FEV_1, Low FVC, Normal TLC

Table 3—*Summary of Patient Diagnosis**

Diagnostic Categories	Men (n = 62)	Women (n = 38)	Combined (n = 100)
1. AHR without obesity	11 (18)	10 (26)	21 (21)
2. AHR with obesity	16 (26)	15 (40)	31 (31)
3. Chronic lung disease	13 (21)	3 (8)	16 (16)
4. Obesity	7 (11)	0 (0)	7 (7)
5. Other	15 (24)	10 (26)	25 (25)

*Data are presented as No. (%). Categories 1, 2, and 3 are designated as group A (airway). Categories 4 and 5 are designated as group B (nonairway).

N= 9.6% of > 80,000 tests at Mayo Clinic

- 68% with airway disease
- 32% with restricted expansion of lung/thorax

Hyatt, Chest 2009

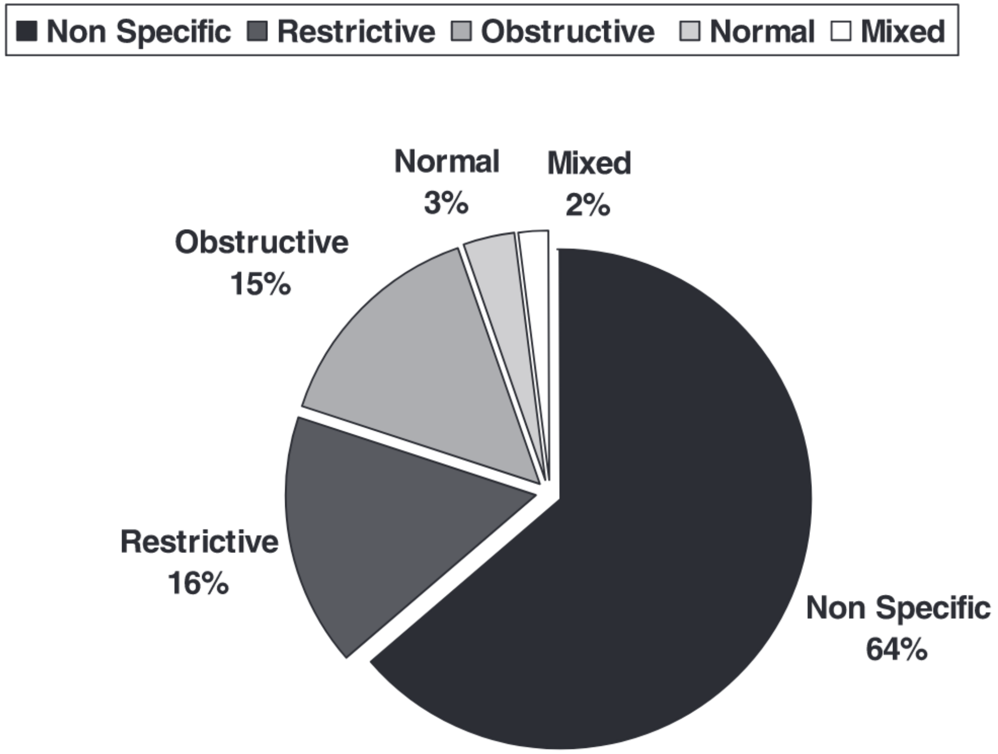
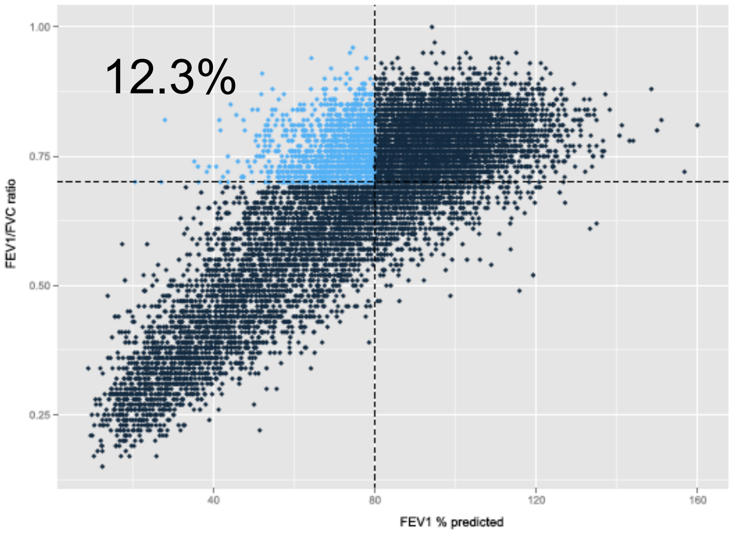


FIGURE 1. Pulmonary function pattern at last follow-up (N = 1,284).

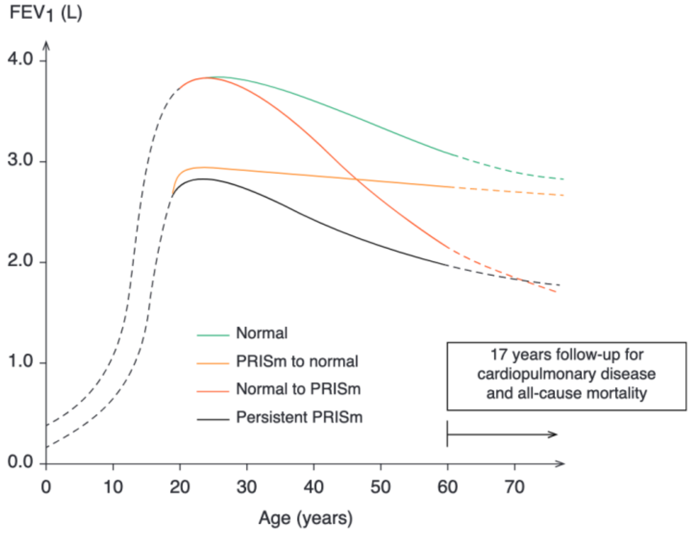
N= 1284 people with NSP over median 3 years

Iyer, Chest 2011

PRISm:Preserved Ratio (FEV_1/FVC) Impaired Spirometry (low FEV_1)

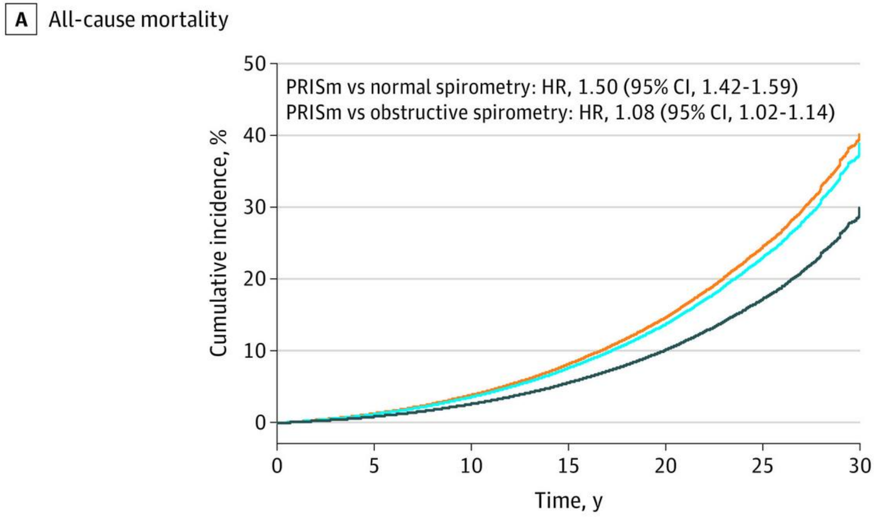


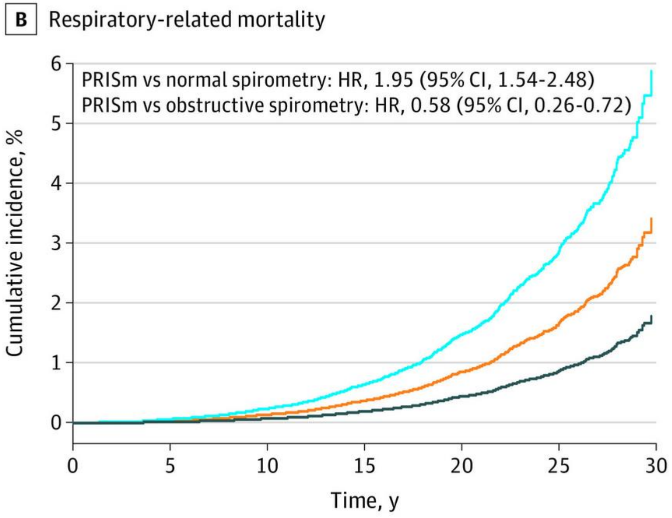
Wan, Respir Res 2014

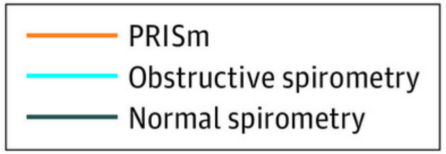


Marott, AJRCCM 2021

- Proposed to replace GOLD – “unclassified” signifying low FEV_1 with normal FEV_1/FVC
- Similar to “restriction” or “non-specific” pattern but both require TLC
- Prevalence= 17-24%
- Associated with:
  - Transitions over time Increased respiratory symptoms
  - Increased diagnosis of asthma, COPD
  - Increased cardiopulmonary mortality





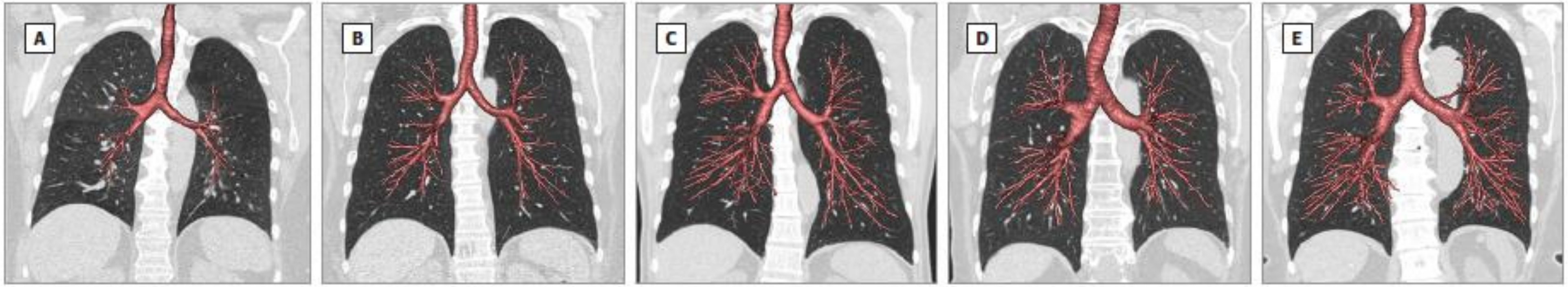


Wan, JAMA 2021

Dysanapsis: Airways Small Relative to Lung Volume

- Normal FEV_1 and FVC with low FEV_1/FVC
- Dysanapsis ratio = $FEF_{25\text{-}75}$/FVC
- Dysanapsis by CT: airway lumen diameter / cube root of lung volume

Figure. Representative CT Images Depicting the Spectrum of Dysanapsis Quantified as the Airway to Lung Ratio Among Older Adults Free of Standard COPD Risk Factors

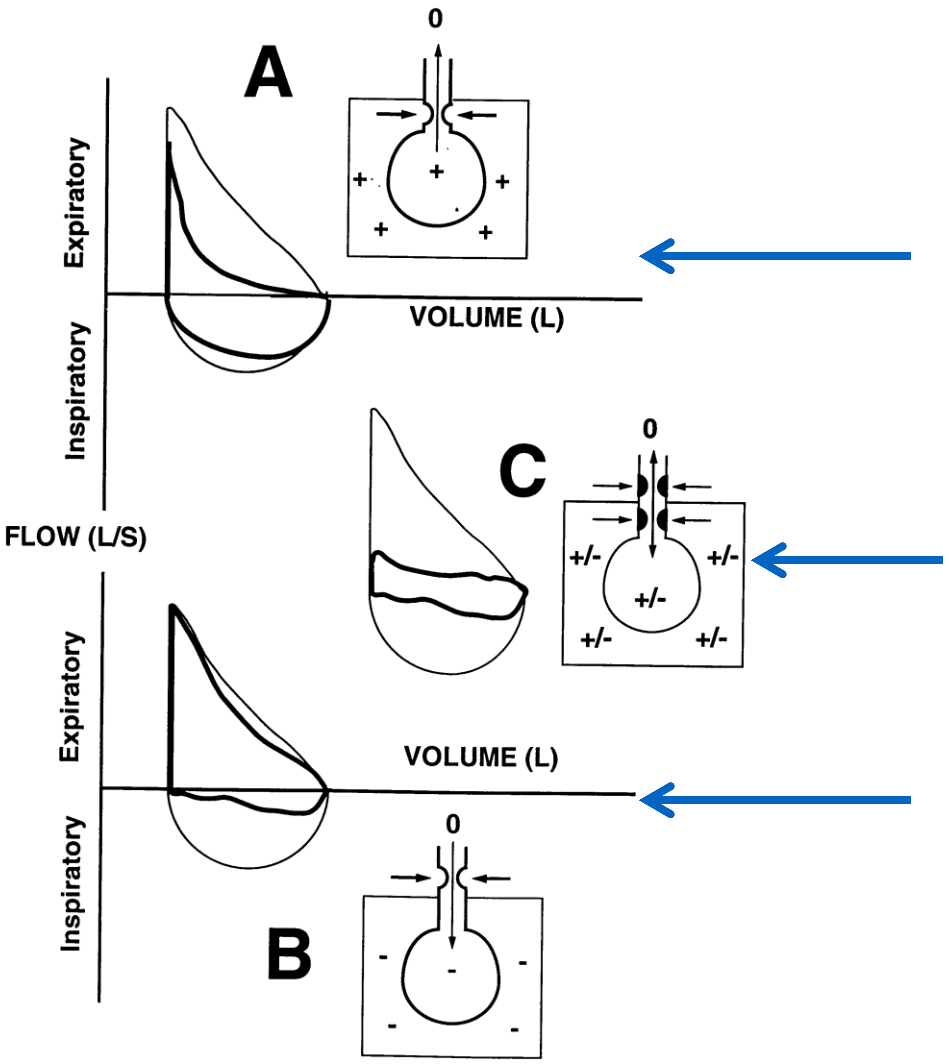


Smith, JAMA 2020

Dysanapsis associated with:
- COPD (Smith, JAMA 2020)
- Bronchodilator responsiveness (Vameghestahbanati, AJRCCM 2021)
- Obesity in children (Forno, AJRCCM 2017)
- Severe asthma in children with obesity (Forno, AJRCCM 2017)

Possibly a normal physiologic variant?

Anatomic Localization of Flow Limitation



Variable Intrathoracic Obstruction

Fixed Obstruction

Variable Extrathoracic Obstruction

Flow-Volume Loop Configurations in Different Physiological Conditions

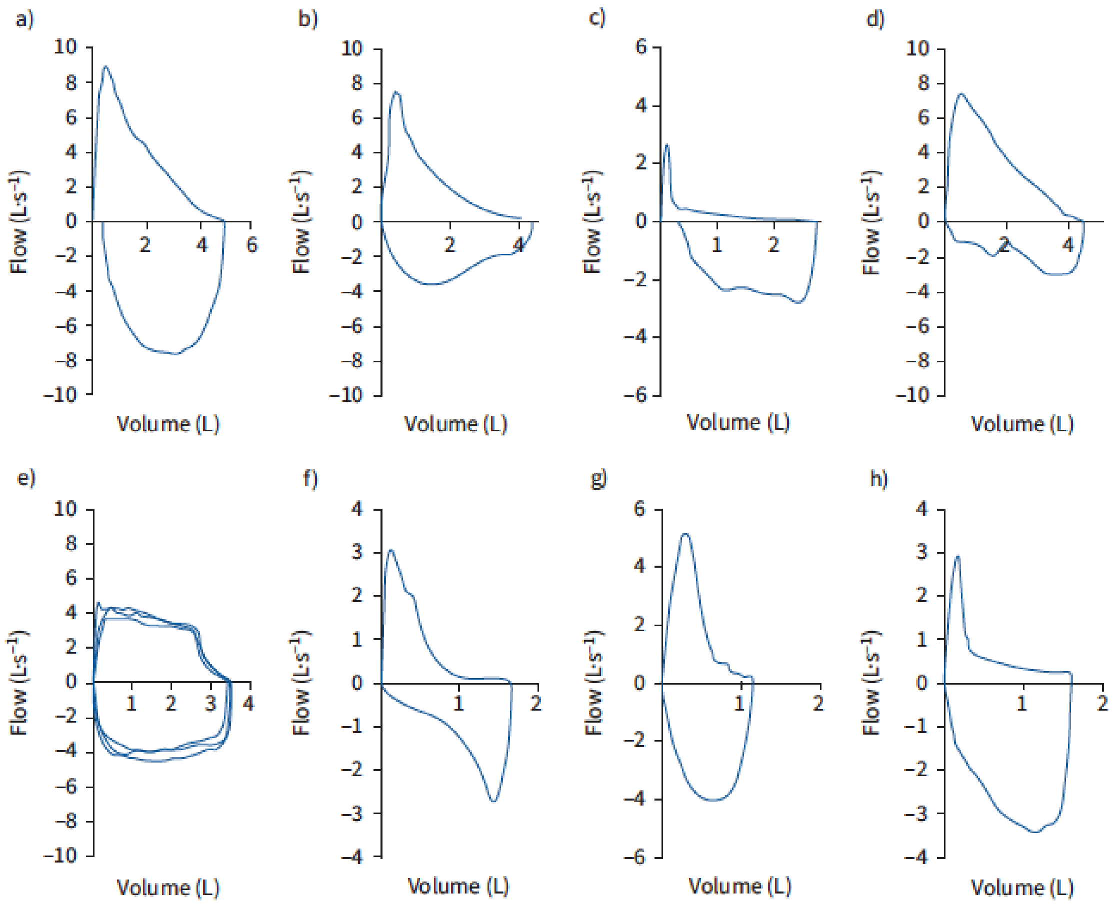
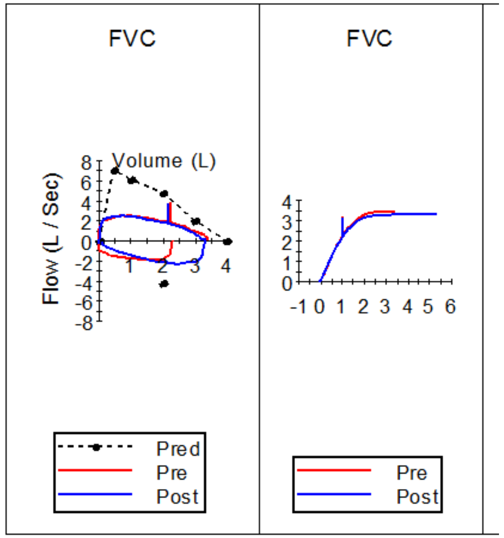
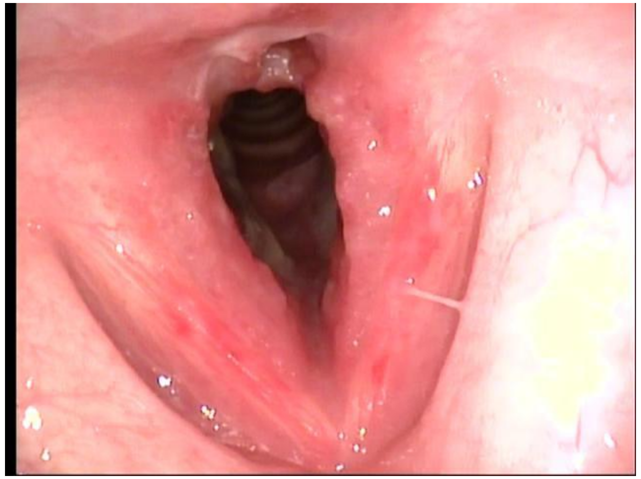


FIGURE 9 Examples of typical flow–volume loop configurations for a) normal, b) mild–moderate obstruction, c) severe obstruction, d) variable extrathoracic obstruction, e) fixed large/central airway obstruction, f) unilateral mainstem bronchial obstruction [179], g) restriction and h) mixed disorder.

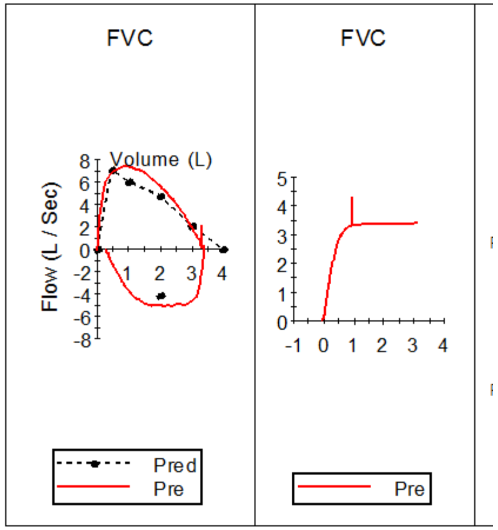
22 year-old woman, shortness of breath with exertion: Is this asthma?

	Pre-BD			
	Actual	LLN	Z Score	% Pred
---- SPIROMETRY ----				
FVC (L)	3.42	3.22	-1.21	86
FEV1 (L)	2.22	2.82	-3.27	64
FEV1/FVC (%)	64.92	76.18	-3.54	75
FEF 25-75% (L/sec)	1.98	2.48	-2.30	52
PEF (L/min)	154.6			
TestGrade(ATS)				





	Pre-BD			
	Actual	LLN	Z Score	% Pred
---- SPIROMETRY ----				
FVC (L)	3.39	3.22	-1.27	85
FEV1 (L)	3.32	2.81	-0.28	97
FEV1/FVC (%)	97.86	76.18	1.99	113
FEF 25-75% (L/sec)	5.68	2.48	2.45	150
PEF (L/min)	448.6			
TestGrade(ATS)				



Fixed obstruction: Granulomatous polyangiitis: involving larynx

Defining Bronchodilator Response

Bronchodilator Responsiveness = change in FEV1 or FVC

Old criteria was 12% change relative to start value + 200 ml:

- 12% favored those with lower FEV_1 start value
- 200ml favored males

Change in FEV_1 of:

> 8% predicted: anchors to a survival advantage over non-responsive [1]

> 10% predicted: upper limit of normal BDR in healthy population [2]

> 4% predicted: separates patients who were peer reviewed as improved [3]

1. Ward H, et al. Chest. 2015; 148 (4): 877–86.
2. Tan WC et al. Thorax 2012.
3. Redelmeier DA, et al. Chest. 1996; 109: 1163–8.

Defining Bronchodilator Response

- Expressed as the percent change relative to the individual's predicted value
- A change >10% of the predicted value indicates a positive response
- Reporting changes as the increase relative to predicted value minimizes sex and height bias in assessing bronchodilator response

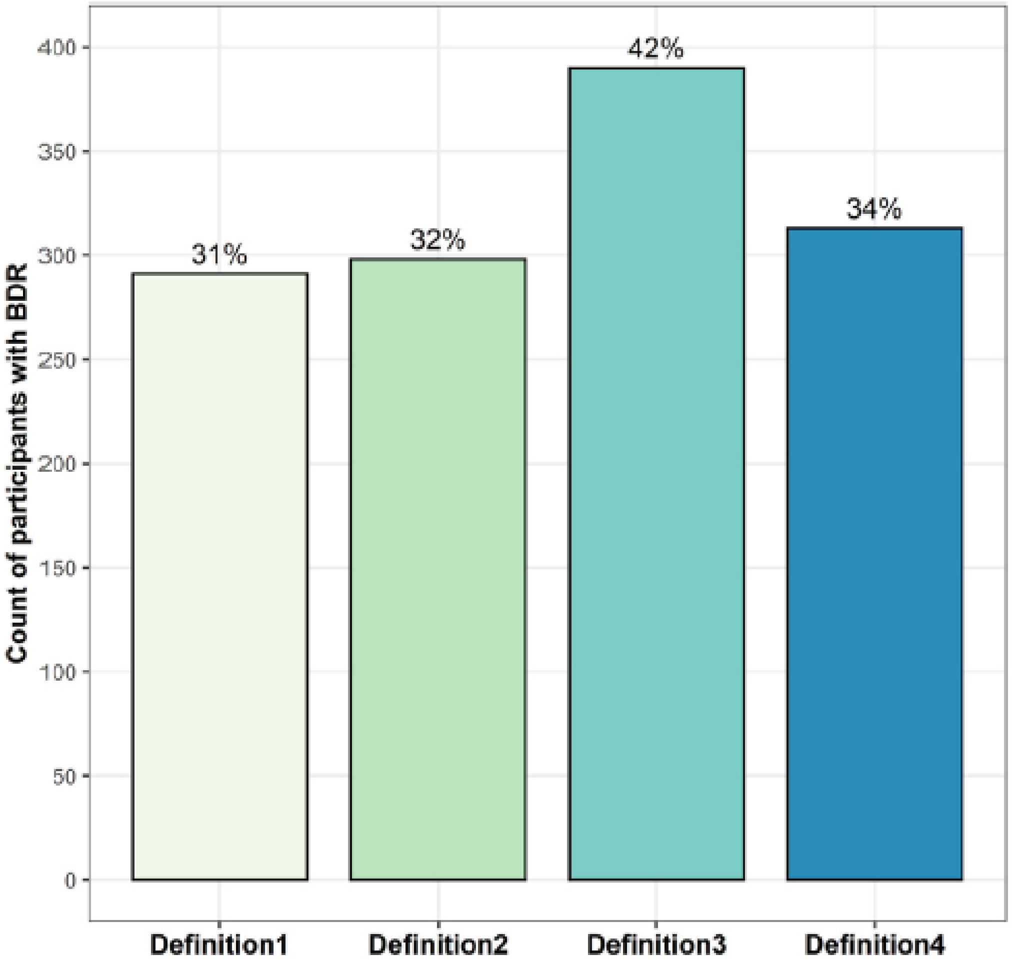
$$\frac{(\text{Post}-\text{bronchodilator value (l)} - \text{Pre}-\text{bronchodilator value (l)}) * 100}{\text{Predicted value (l)}}$$

- Simply look at the predicted value: if the absolute change is more than 10% of this value, then the bronchodilator response is significant

Performance of Bronchodilator Responsiveness in Participants with Poorly Controlled Asthma

Good agreement among BDR definitions

Kaminsky, Resp Med 2023

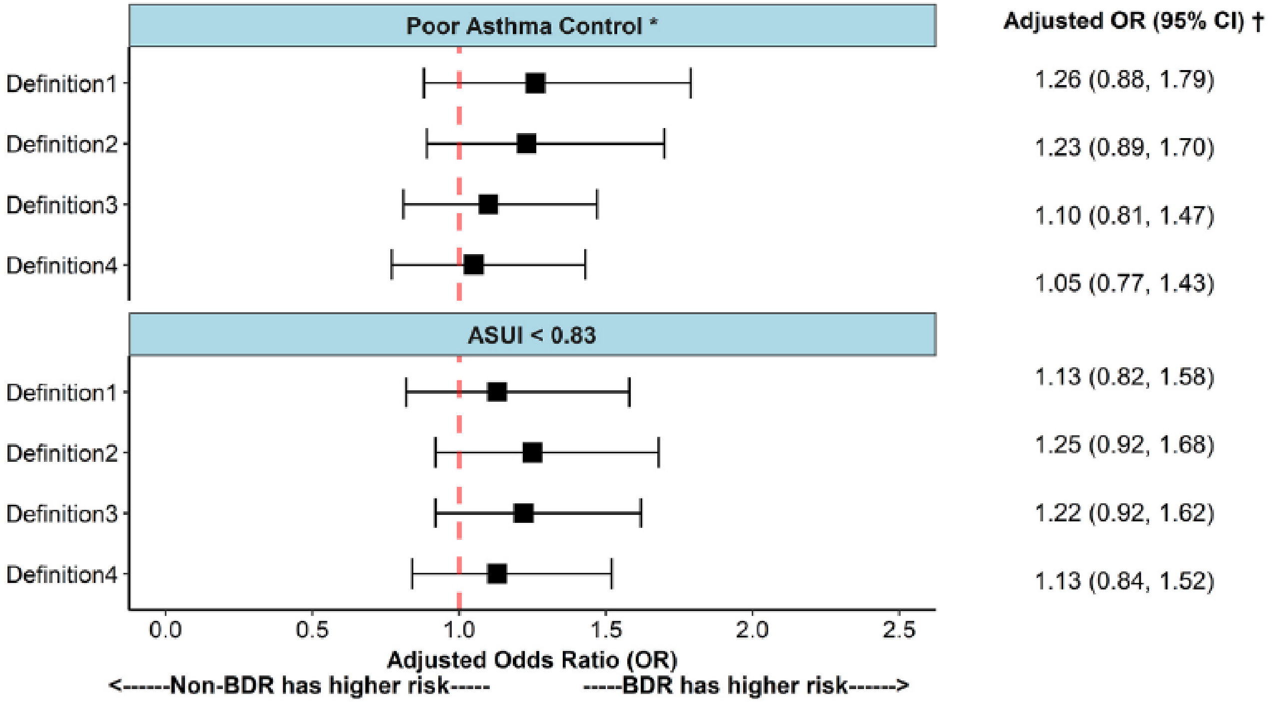


ATS/ERS 2005

ATS/ERS 2022

Δ FEV1 >8% pred

Δ FEV1z or FVCz > 0.78, 0.64

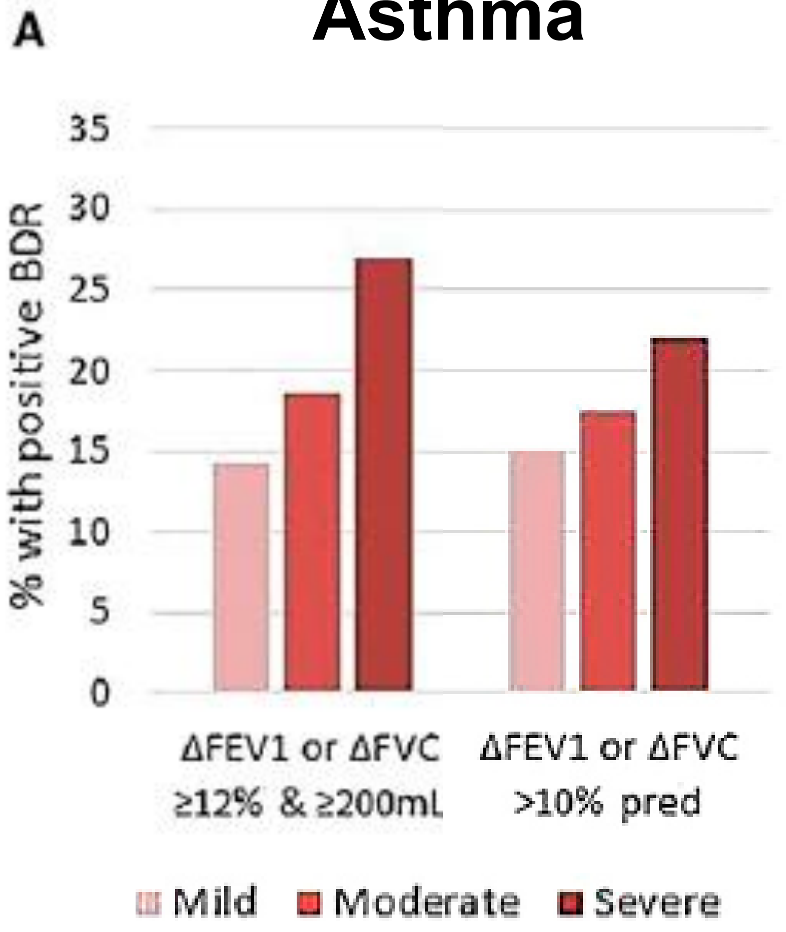


N= 931 poorly controlled asthmatics

BDR did not associate with asthma symptoms or control

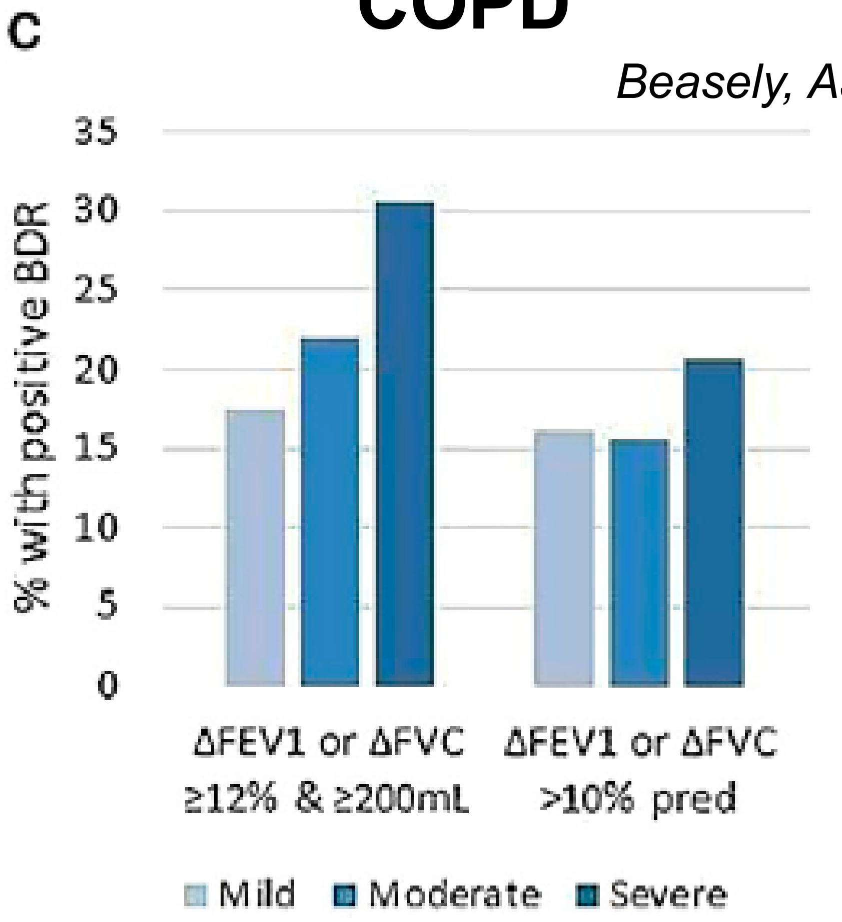
Associations of BDR with Asthma and COPD Outcomes

Asthma



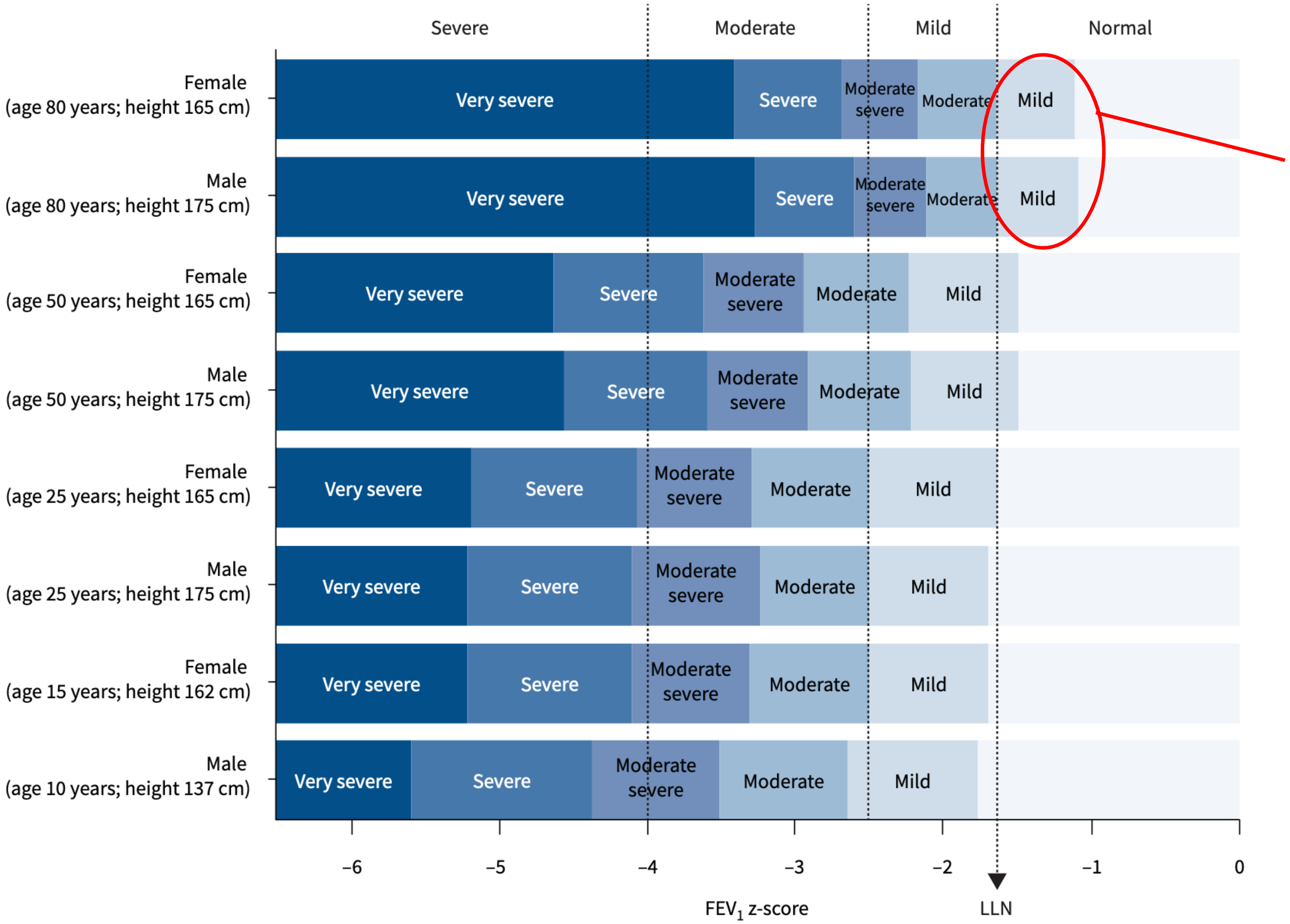
COPD

Beasely, AJRCCM 2024



- N= 6788 patients, > 12 yr old, with asthma and/or COPD, in 18 countries ("NOVELTY")
- ***BDR did not differentiate Asthma from COPD but did associate with severity of disease***

Severity of Ventilatory Impairments Defined by Spirometry

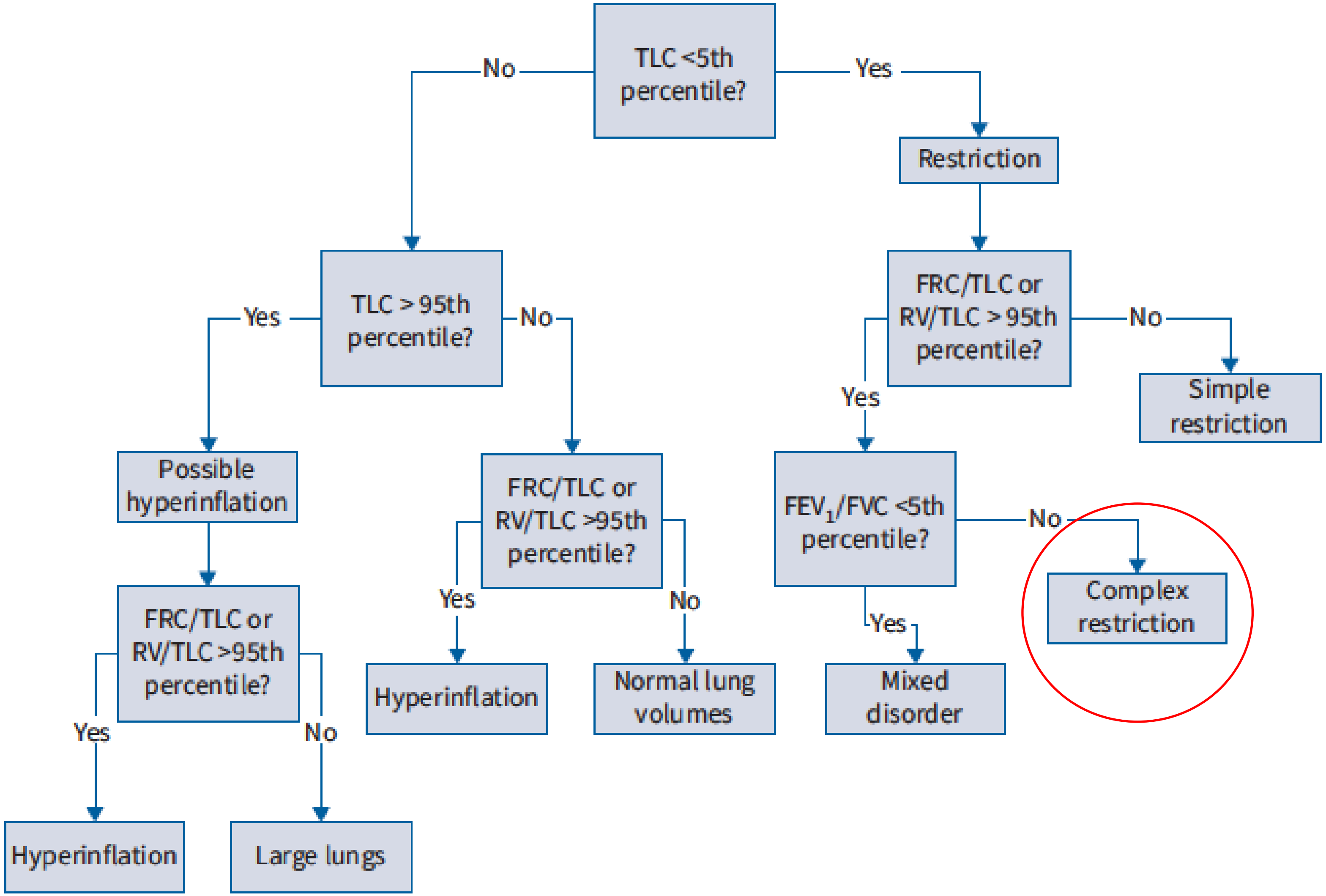


- If FEV1 > LLN and FEV/FVC < LLN, this is still "obstruction" and should be graded as "Mild"

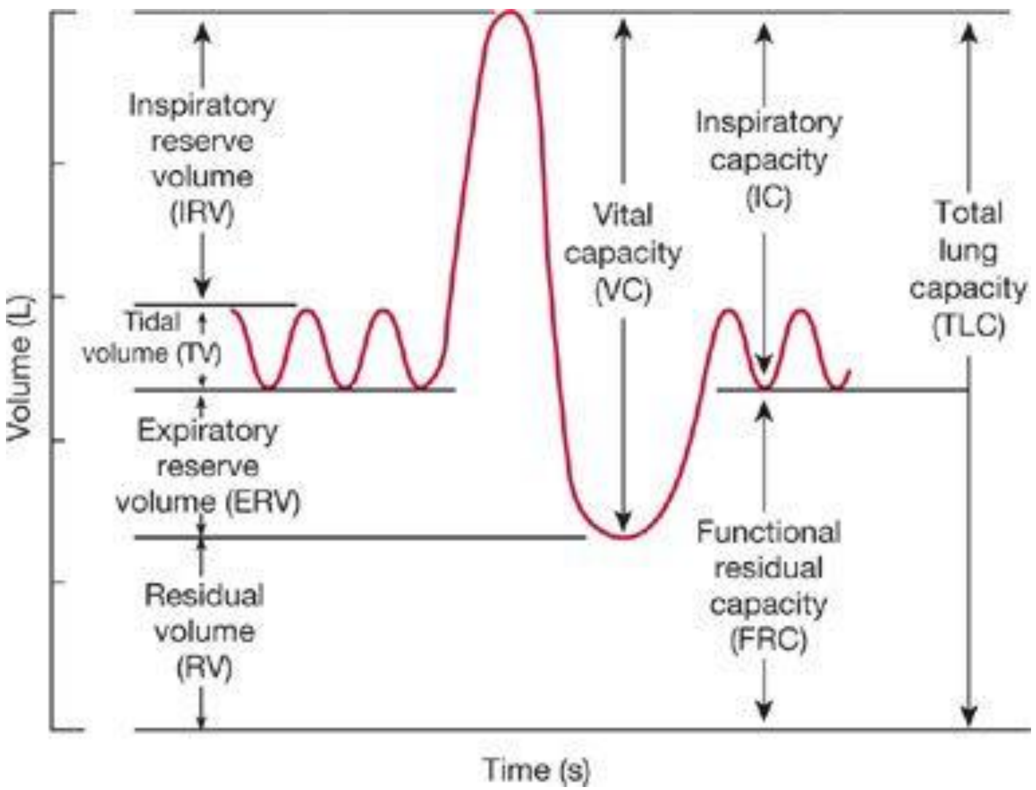
- This may represent "dysanapsis" related to risk of obstructive disease, but also may be normal in someone who just has a large FVC

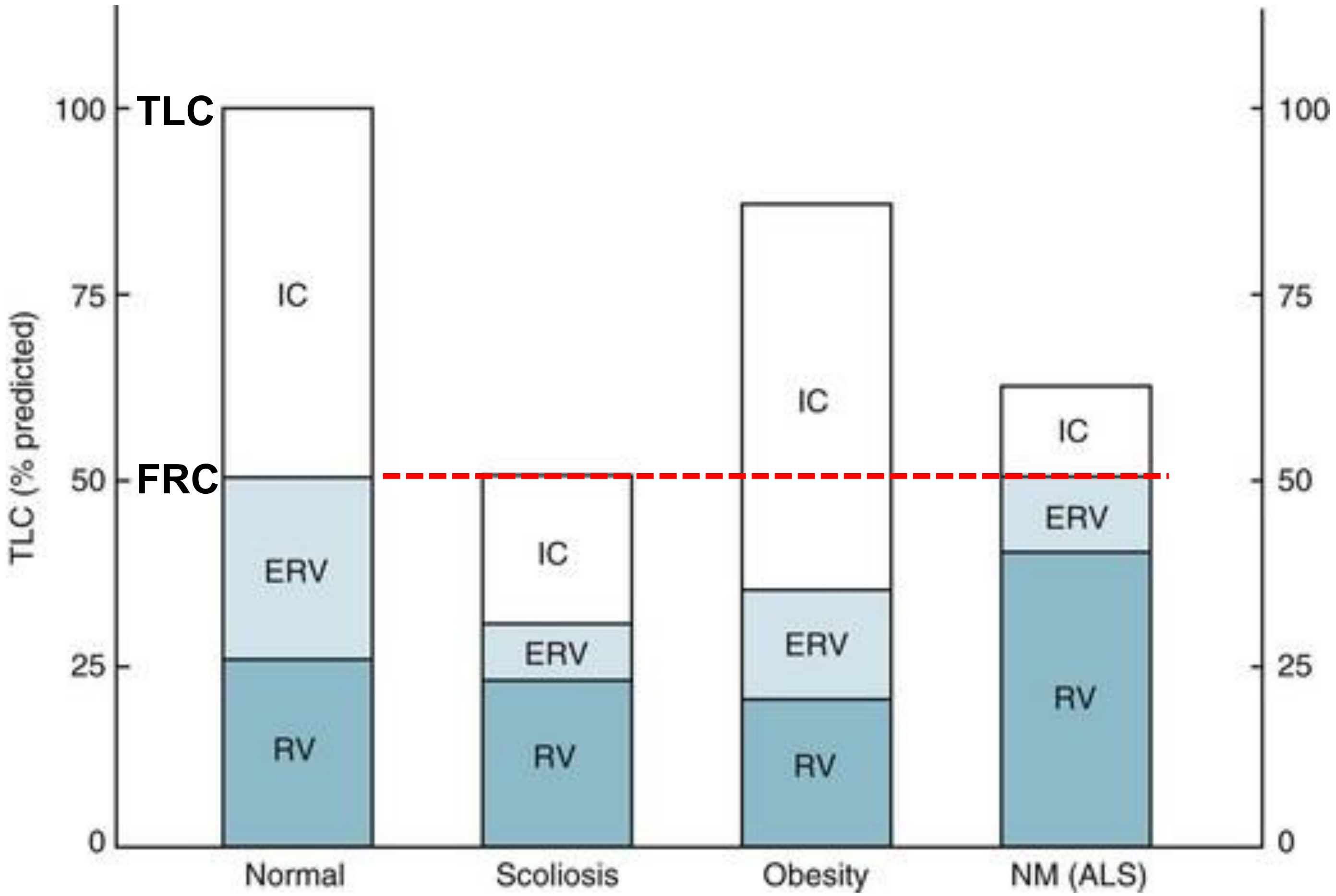
- Other methods of grading obstruction have been proposed; e.g. STAR system based on FEV1/FVC in COPDGene cohort

ERS-ATS Lung Volume Interpretation Algorithm

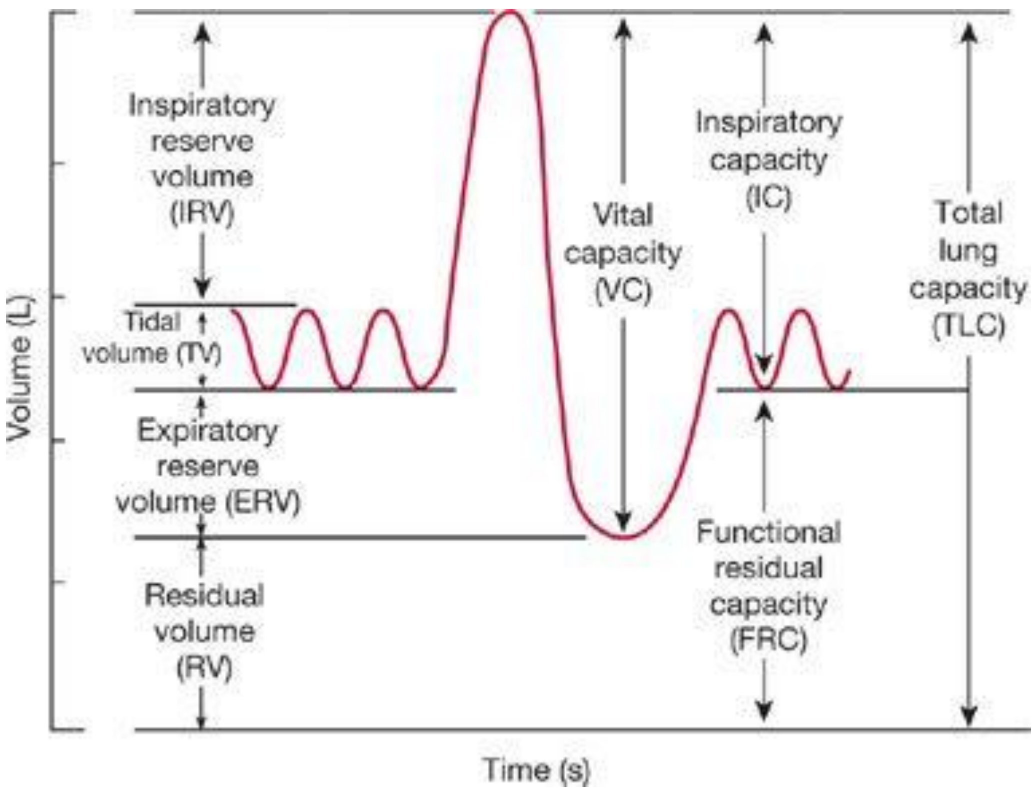


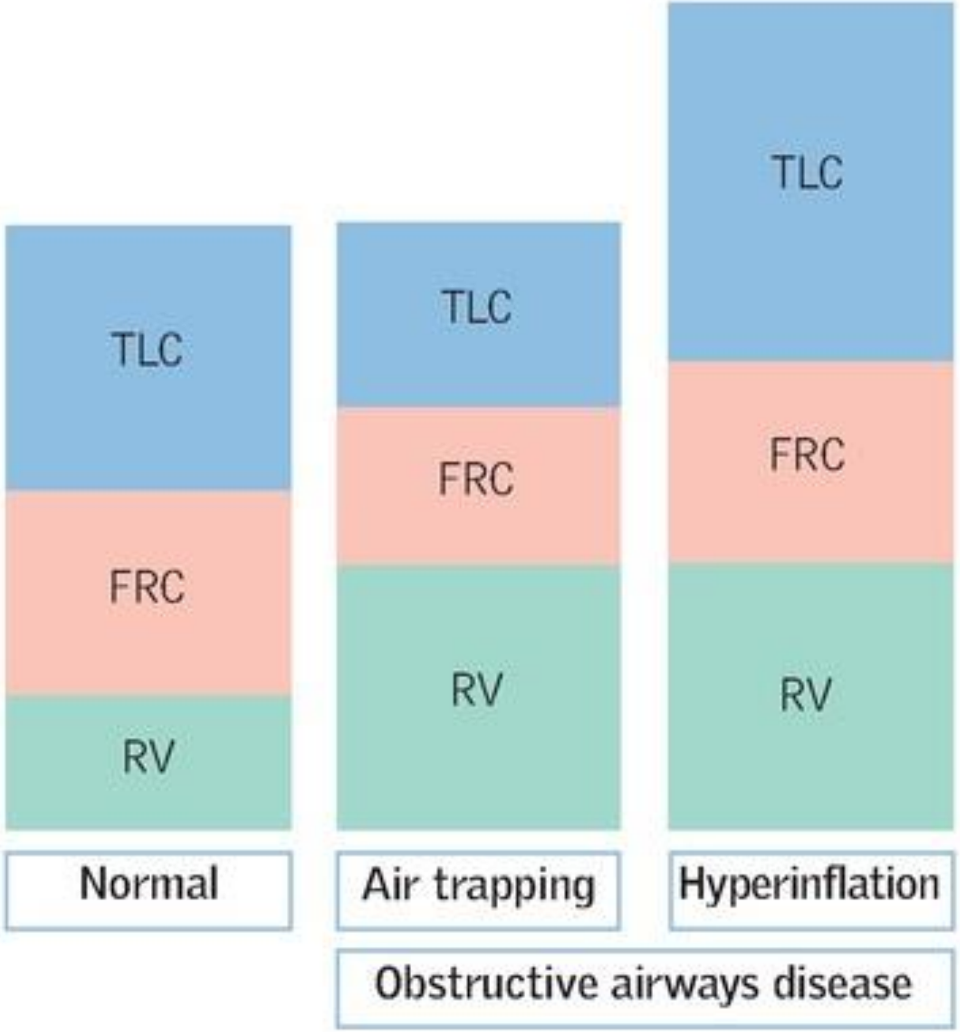
Measure Lung Volumes to Confirm Restriction



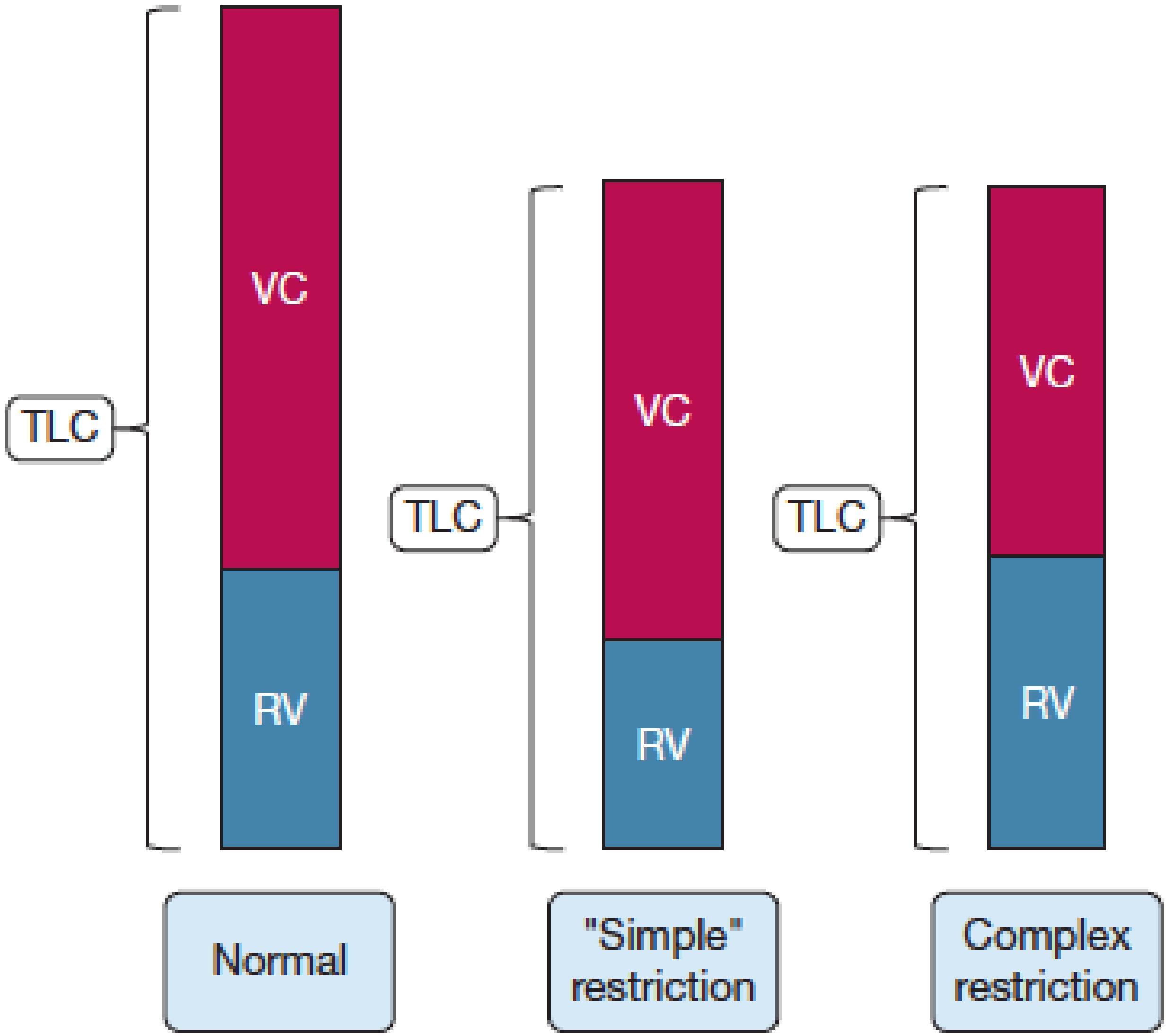


Measure Lung Volumes to Evaluate Obstruction





"Complex Restriction"



- Neuromuscular disease
- Chest wall restriction (including obesity)
- Occult air trapping (high RV/TLC, mosaic attenuation on chest CT)

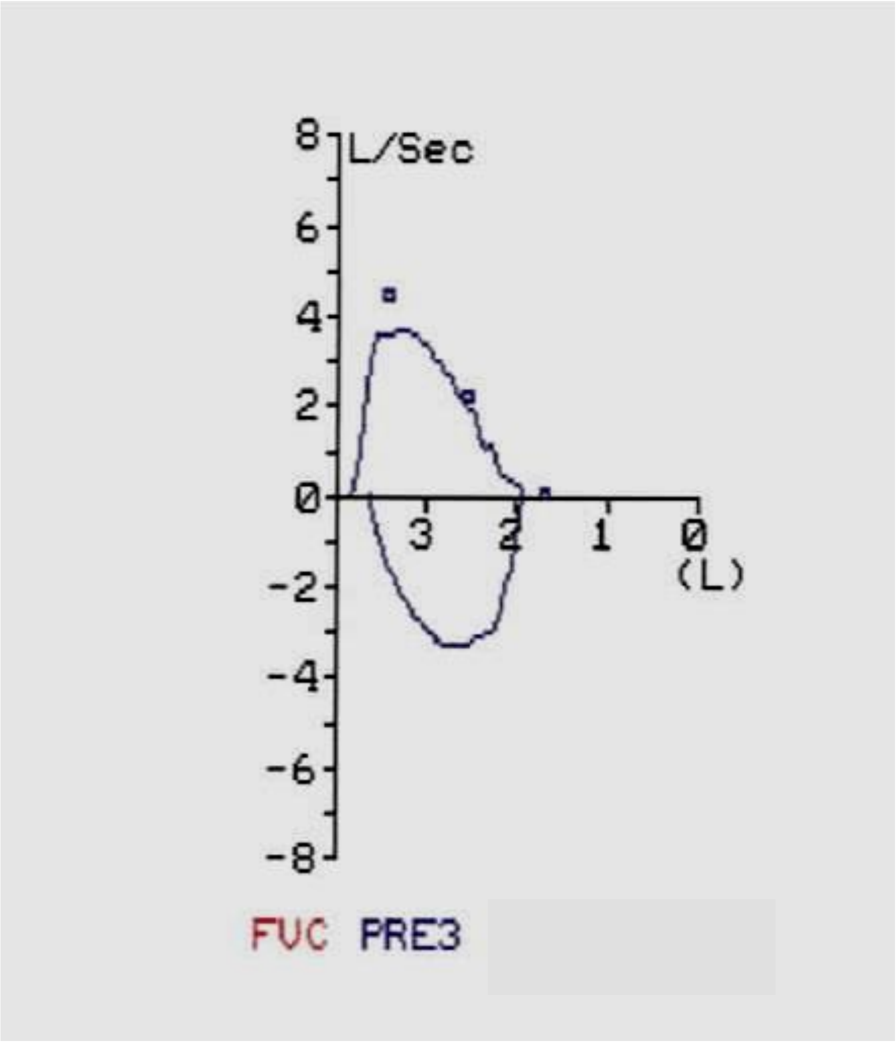
Clay, Chest 2017

Complex Restriction: Muscle Weakness

FVC = 1.90 L (55%)
FEV1 = 1.72 L (65%)
FEV1/FVC = 91% (119%)

TLC = 3.55 L (69%)
FRC = 2.27 L (82%)
RV = 1.95 L (114%)

MIP = -33 cm H2O (> -50)
MEP = + 31 cm H2O(> 80)



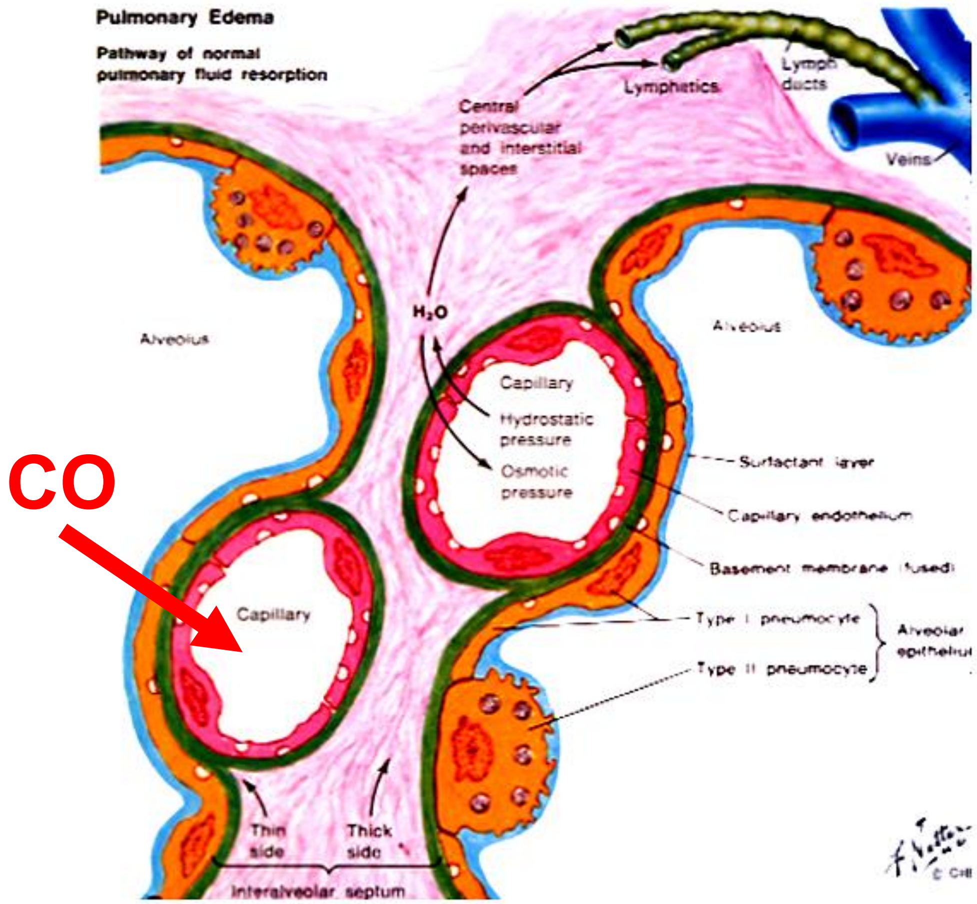
45 year old woman, history of SLE

Diffusing Capacity

CO uptake dependent on:

- Kco (CO concentration change over time)
  - Vc: capillary blood (including Hb)
  - Dm: alveolar-capillary membrane properties, surface area
- VA: total volume of gas in lungs

$D_LCO = Kco \times VA$



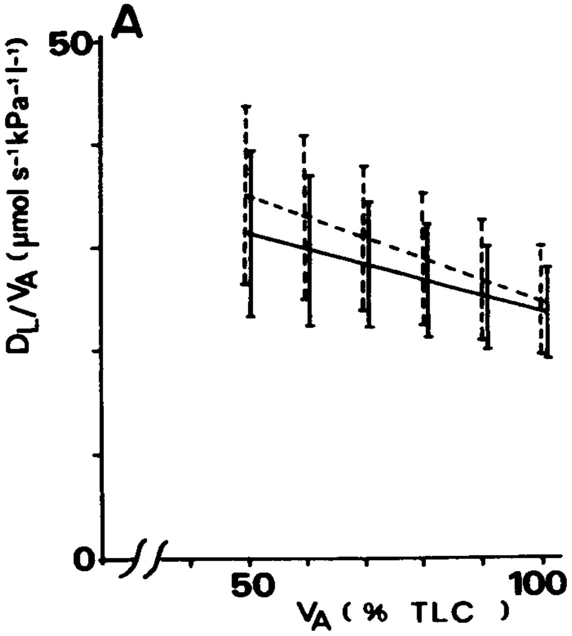
Note: $Kco = D_LCO/VA$ (*it is **not** a correction for lung volume*)

D_LCO and Lung Volume

D_LCO/VA appears to be a “correction” of D_LCO for VA, but it is not:

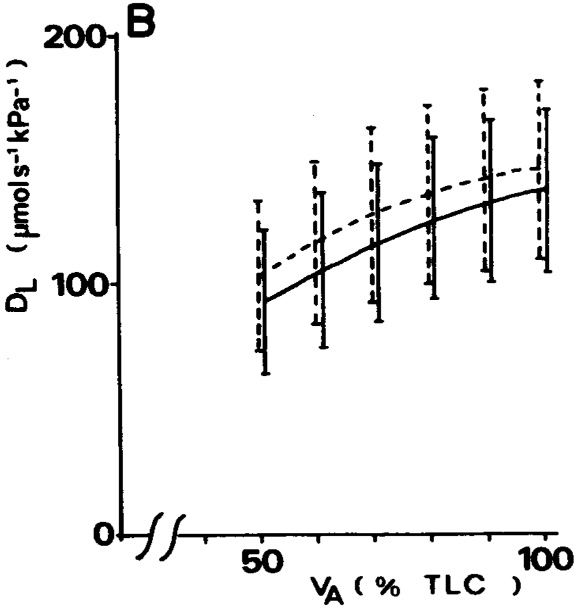
– D_LCO and D_LCO/VA vary with lung volume (VA)

– D_LCO/VA increases when VA is reduced due to an increase in surface area to volume ratio as alveoli become smaller.



↑ in surface area to volume ratio as VA ↓

Stam, JAP 1991



overall DLCO increases with increased alveolar volume

Low D_LCO: Relative Changes in VA and Kco

- If D_LCO reduced less than VA, suggests incomplete lung expansion (poor effort, chest wall restriction, weakness) or lung resection
  - (Kco > ULN = high Kco)

- If D_LCO reduced more than VA, suggests diffuse loss of alveolar tissue (emphysema, ILD) or vascular disease (pulmonary hypertension)
  - (Kco < LLN = low Kco)

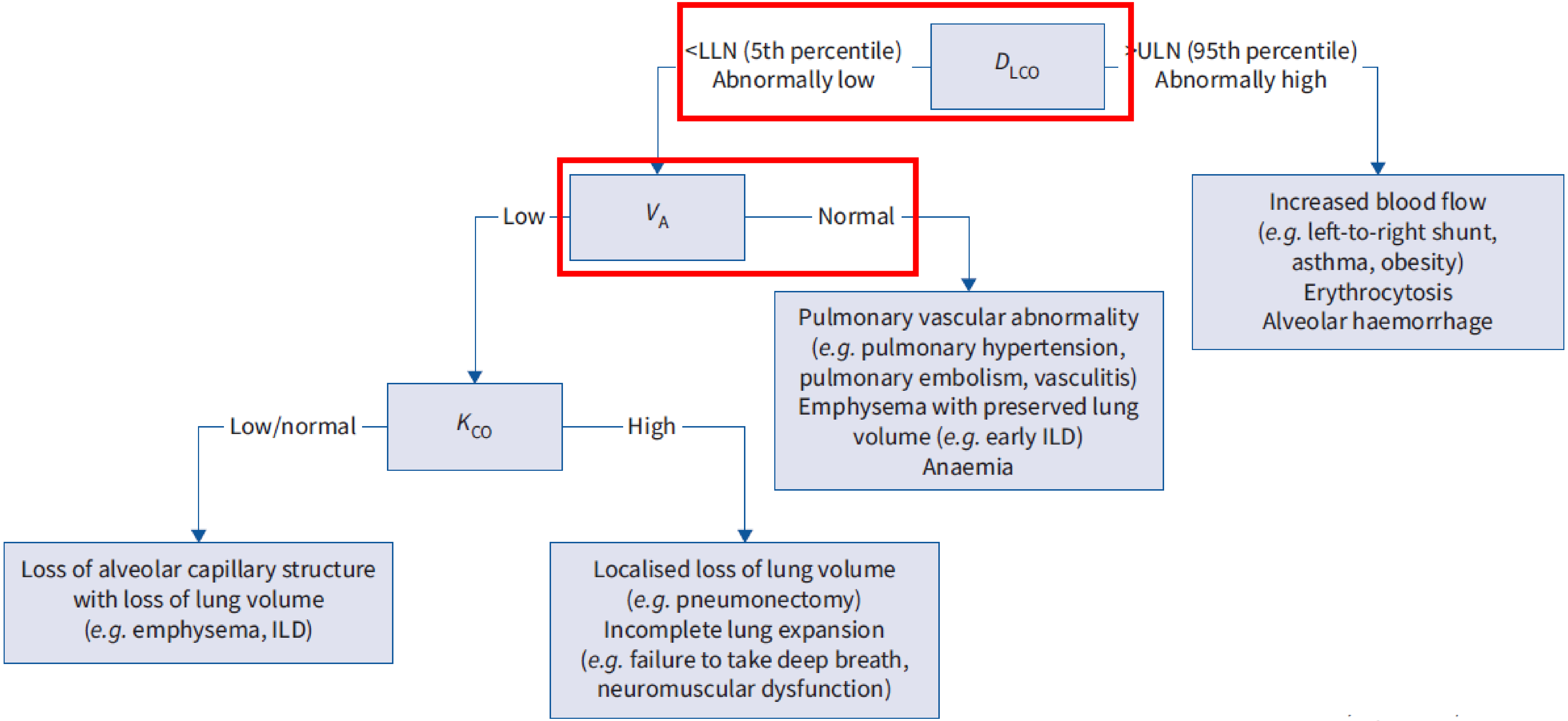
Interpreting D_LCO

Condition	VA	K_{CO}	D_LCO
Incomplete lung expansion	↓↓↓	↑↑	↓
Discrete loss of alveolar units	↓↓↓	↑	↓↓
Diffuse loss of alveolar units	↓↓	↓	↓↓↓
Pulmonary emphysema	↓	↓↓	↓↓↓
Pulmonary vascular disorders	normal	↓↓	↓↓
High pulmonary blood volume	normal	↑	↑
Alveolar haemorrhage	↓	↑↑↑	↑↑

Single-breath method. VA: alveolar volume; KCO: carbon monoxide transfer coefficient; '

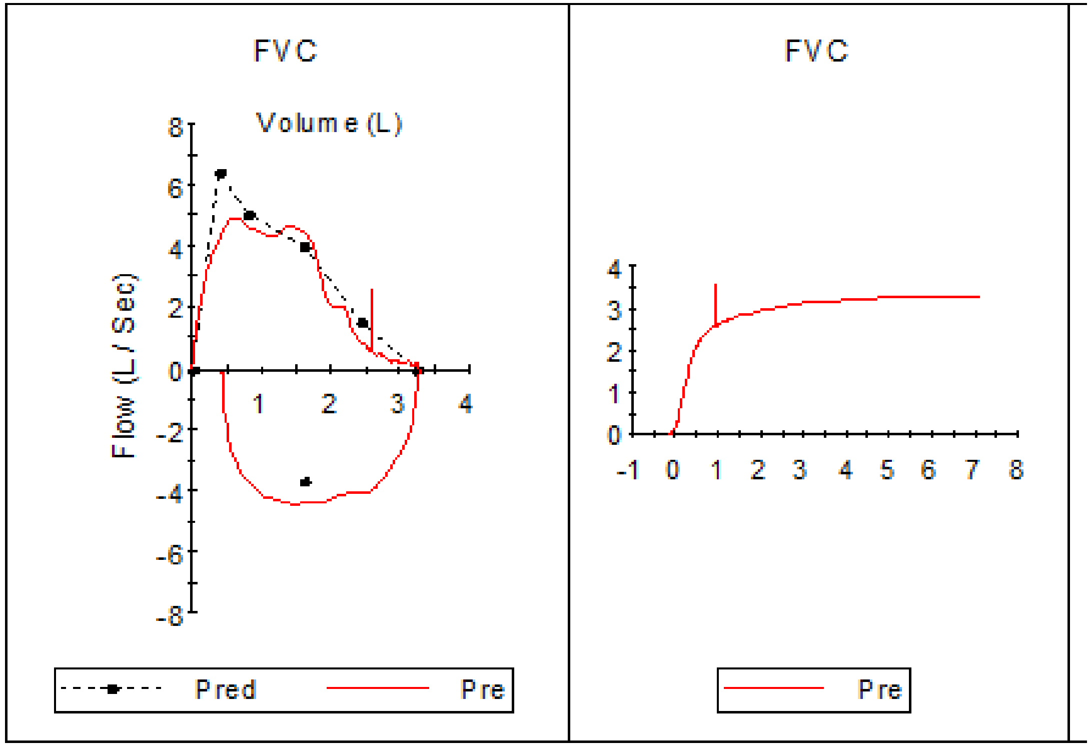
Fitting, Swiss Med Wkly 2004

ERS-ATS D_LCO Interpretation Algorithm



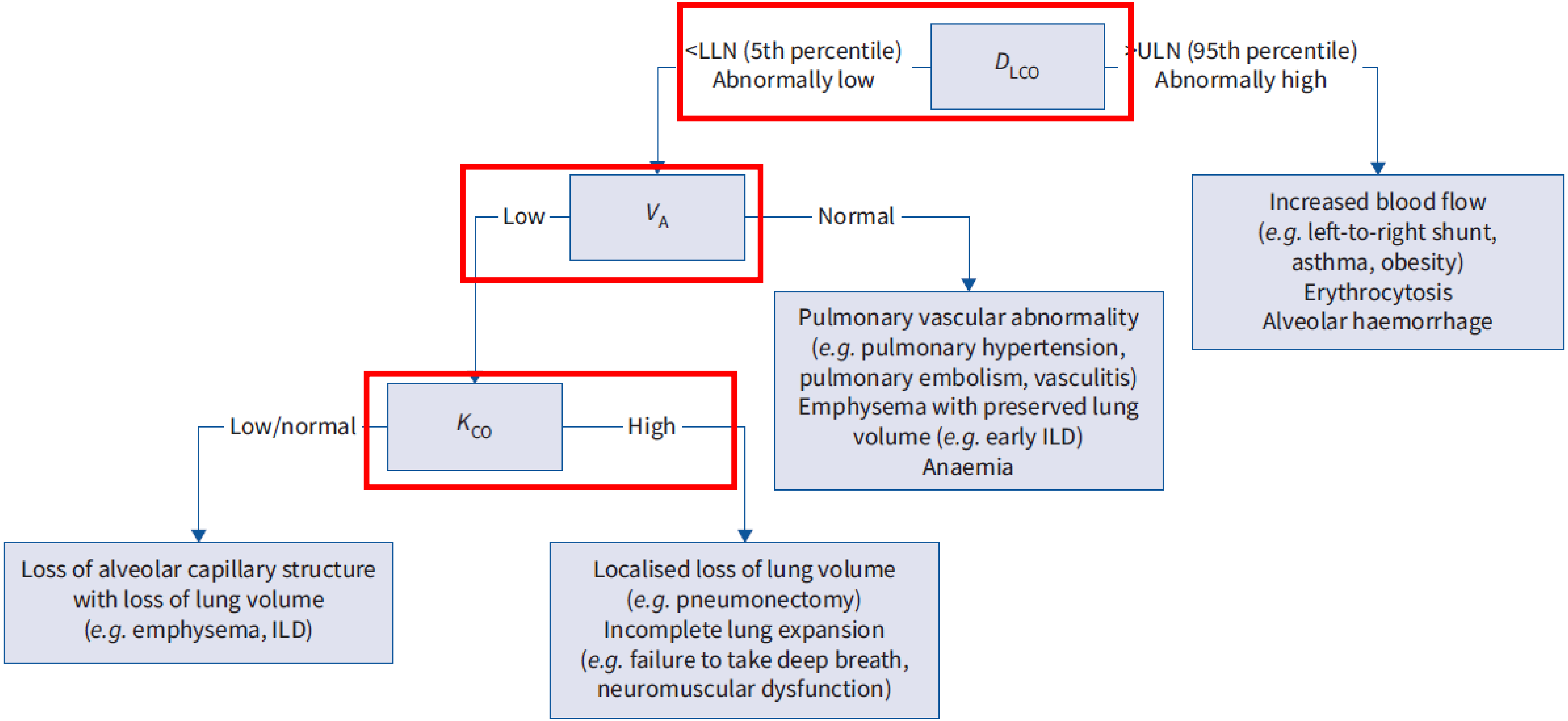
Eur Respir J 2022; 60: 2101499

	Pre-BD				
	Actual	LLN	Z Score	Pred	%Pred
---- SPIROMETRY ----					
FVC (L)	3.28	2.56	+0.11	3.24	101
FEV1 (L)	2.60	2.07	-0.08	2.63	98
FEV1/FVC (%)	79.14	70.46	-0.38	81.50	97
TestGrade(ATS)	AA				
FEF 25-75% (L/sec)	2.62	1.60	-0.17	2.75	95
PEF (L/min)	341.4				
---- Slow Vital Capacity ---					
SVC (L)	3.25	2.56	+0.03	3.24	100
IC (L)	2.91			2.09	138
ERV (L)	0.34			1.15	29
FEV1/SVC (%)	80.01			81.17	98
---- DIFFUSION ----					
DLCOunc (ml/min/mmHg)	13.51	15.41	-2.50	19.62	68
DLCOcor (ml/min/mmHg)	13.51	14.25	-2.00	18.15	74
VA (L)	4.66	3.64	+0.45	4.43	105
IVC (L)	3.19				
Kco (ml/min/mmHg/L)	2.90	3.52	-2.82	4.48	64
TestGrade(DLCO)	AA				

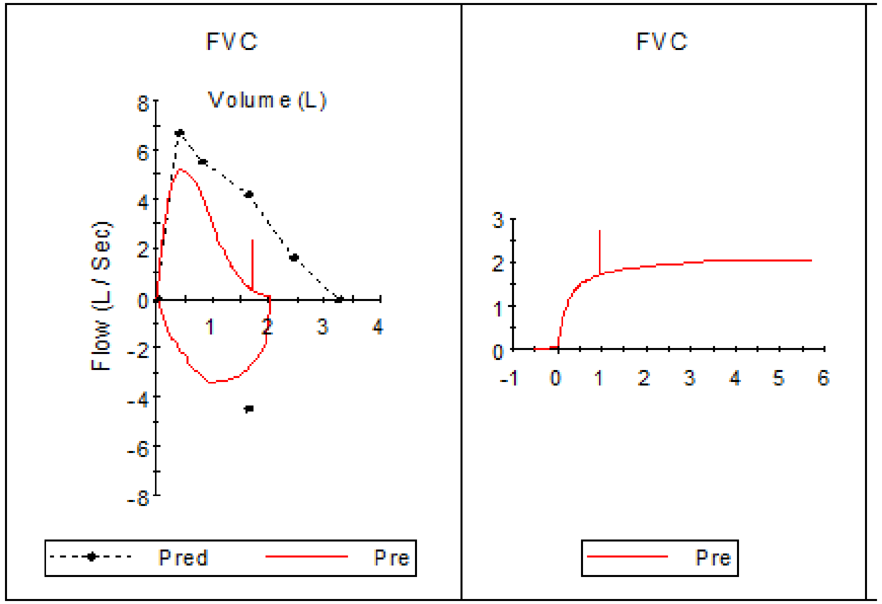


- 46 year old woman. BMI 28.
- Normal spirometry
- Low DLCO (mild) with normal VA but low KCO
- Pulmonary embolism

ERS-ATS D_LCO Interpretation Algorithm

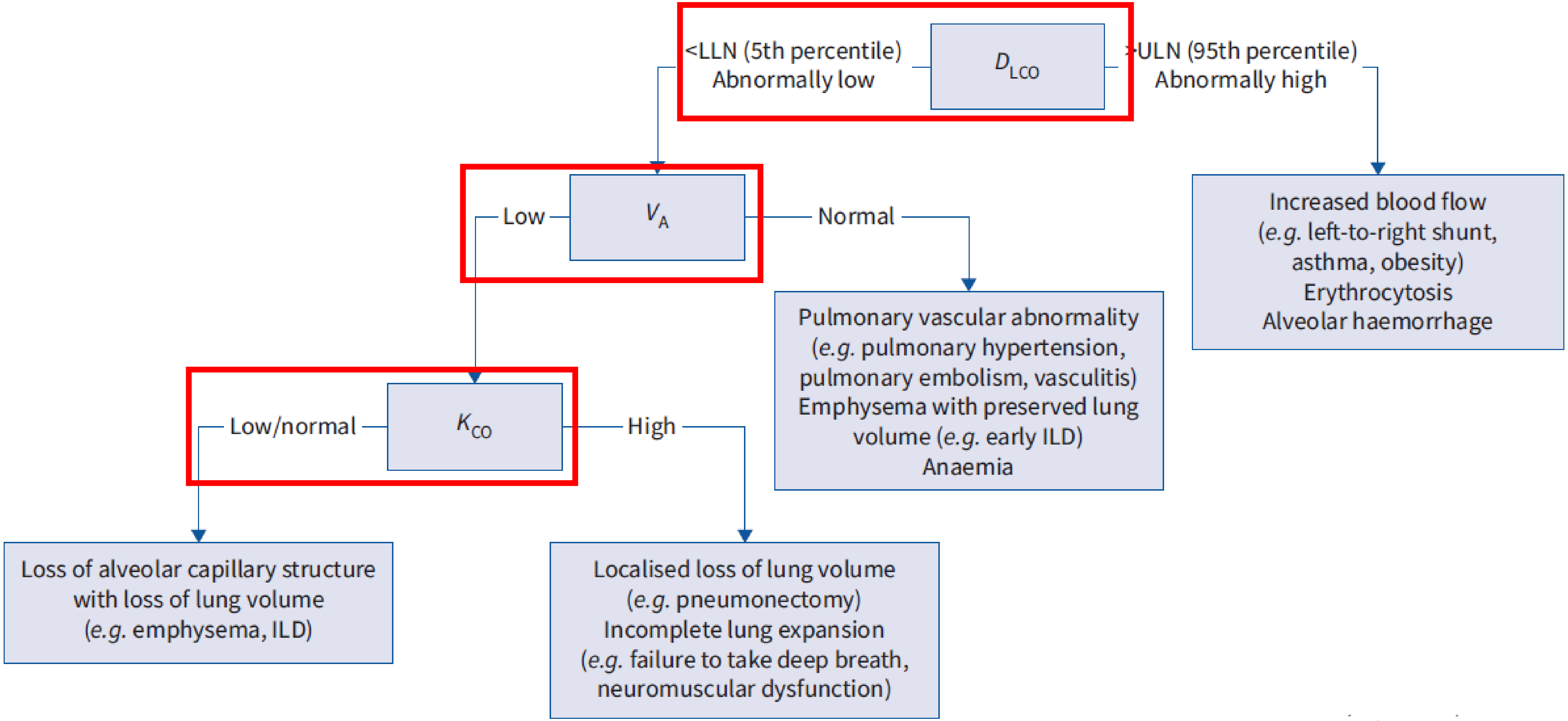


	Pre-BD				
	Actual	**LLN**	**Z Score**	**Pred**	**%Pred**
---- SPIROMETRY ----					
FVC (L)	2.04	2.54	-2.84	3.25	62
FEV1 (L)	1.72	2.07	-2.57	2.68	64
FEV1/FVC (%)	84.26	71.98	+0.27	82.69	101
TestGrade(ATS)	AA				
FEF 25-75% (L/sec)	2.09	1.54	-0.91	2.86	72
PEF (L/min)	325.2				
---- Slow Vital Capacity ---					
SVC (L)	1.96	2.54	-3.05	3.25	60
IC (L)	1.58			2.31	68
ERV (L)	0.37			0.94	39
FEV1/SVC (%)	87.98			82.36	106
---- LUNG VOLUMES ----					
TLC (Pleth) (L)	3.13	4.11	-3.83	5.19	60
TGV (L)	1.55	1.83	-2.53	2.87	53
RV (Pleth) (L)	1.18	0.87	-1.19	1.63	72
RV/TLC (Pleth) (%)	37.57	20.07	+1.21	30.99	121
---- AIRWAYS RESISTA					
Raw (cmH2O/L/s)	1.97	1.15	+0.26	1.86	106
sGaw (1/cmH2O*s)	0.30	0.14	+2.49	0.20	144
---- DIFFUSION ----					
DLCOunc (ml/min/mmHg)	17.22	17.37	-1.70	21.95	78
DLCOcor (ml/min/mmHg)		17.37		21.95	
VA (L)	3.06	4.15	-3.94	5.02	61
IVC (L)	1.92				
Kco (ml/min/mmHg/L)	5.62	3.47	+1.91	4.40	127
TestGrade(DLCO)	AA				



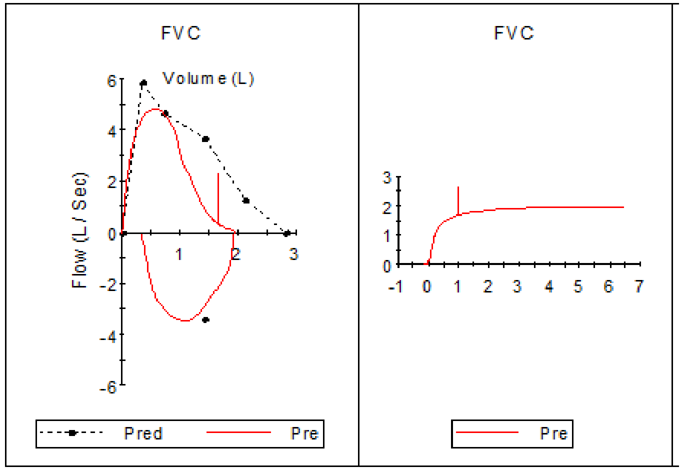
- 48 year old woman, post-COVID, BMI = 48
- Simple restriction
- Low DLCO (mild) from low VA, high KCO
- Effects of obesity

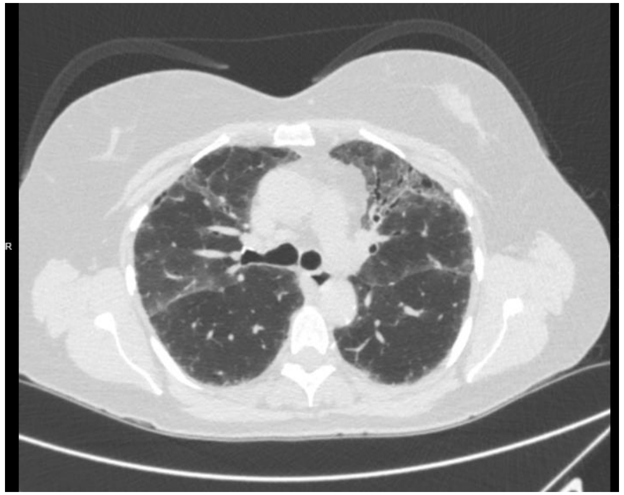
ERS-ATS D_LCO Interpretation Algorithm



Eur Respir J 2022; 60: 2101499

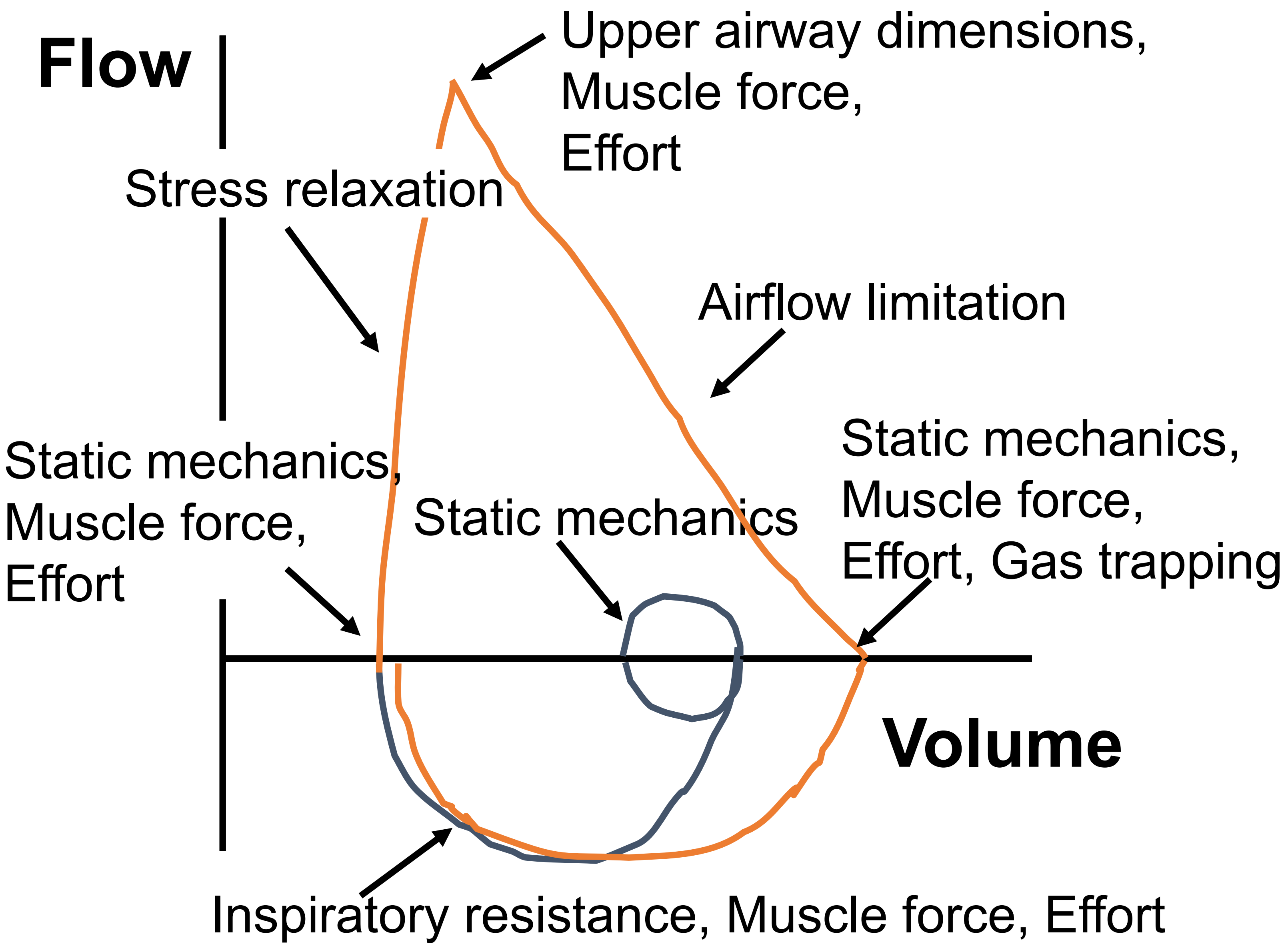
	Pre-BD				
	Actual	LLN	Z Score	Pred	%Pred
---- SPIROMETRY ----					
FVC (L)	1.95	2.17	-2.20	2.84	68
FEV1 (L)	1.68	1.72	-1.78	2.26	74
FEV1/FVC (%)	86.14	68.19	+0.96	80.06	107
TestGrade(ATS)	AA				
FEF 25-75% (L/sec)	2.33	1.14	+0.20	2.18	106
PEF (L/min)	293.4				
---- Slow Vital Capacity ---					
SVC (L)	1.97	2.17	-2.14	2.84	69
IC (L)	1.33			2.00	66
ERV (L)	0.64			0.84	76
FEV1/SVC (%)	85.00			79.71	106
---- LUNG VOLUMES ----					
TLC (Pleth) (L)	3.08	3.45	-2.70	4.53	67
TGV (L)	1.75	1.48	-1.49	2.53	69
RV (Pleth) (L)	1.10	1.01	-1.75	1.77	62
RV/TLC (Pleth) (%)	35.84	27.56	-0.48	38.48	93
---- AIRWAYS RESISTA					
Raw (cmH2O/L/s)	1.53	1.15	-0.76	1.86	82
sGaw (1/cmH2O*s)	0.31	0.14	+2.80	0.20	149
---- DIFFUSION ----					
DLCOunc (ml/min/mmHg)	10.13	13.99	-3.54	18.18	55
DLCOcor (ml/min/mmHg)		13.99		18.18	
VA (L)	3.07	3.38	-2.33	4.17	73
IVC (L)	1.94				
Kco (ml/min/mmHg/L)	3.29	3.41	-1.84	4.40	74
TestGrade(DLCO)	AA				





- 58 year old woman. SOB. BMI 28
- Simple restriction
- Low DLCO (moderate) from low VA and low KCO
- Chest CT: interstitial lung disease

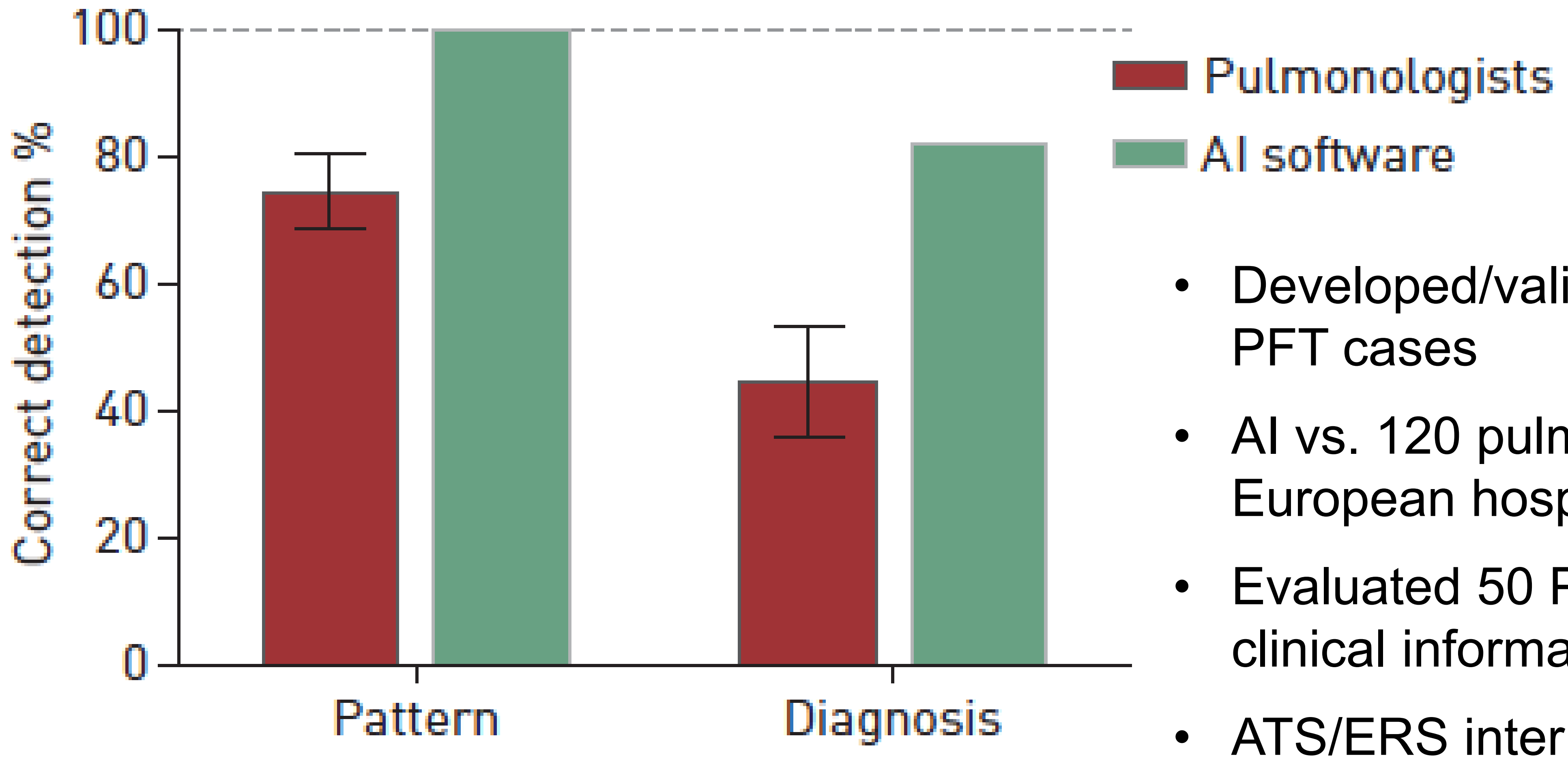
Perspective…



What About AI?

Artificial intelligence outperforms pulmonologists in the interpretation of pulmonary function tests

Topalovic, ERJ 2019



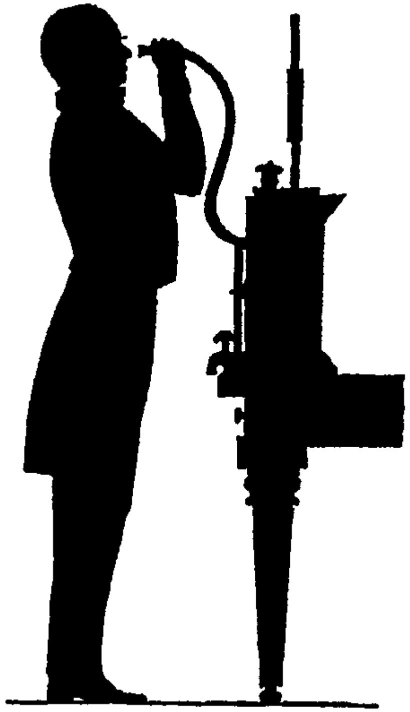
- Developed/validated from 1500 PFT cases
- AI vs. 120 pulmonologists/16 European hospitals
- Evaluated 50 PFT cases with clinical information
- ATS/ERS interpretation algorithm = gold standard

Questions and Discussion

Thank you!

John Hutchinson (1846)
"Father of the Spirometer"

Position of the body in filling the chest before breathing into the Spirometer.



Low breathing capacity predicted poor survival:
the "vital capacity"

Breathing capacity varies with height, different populations