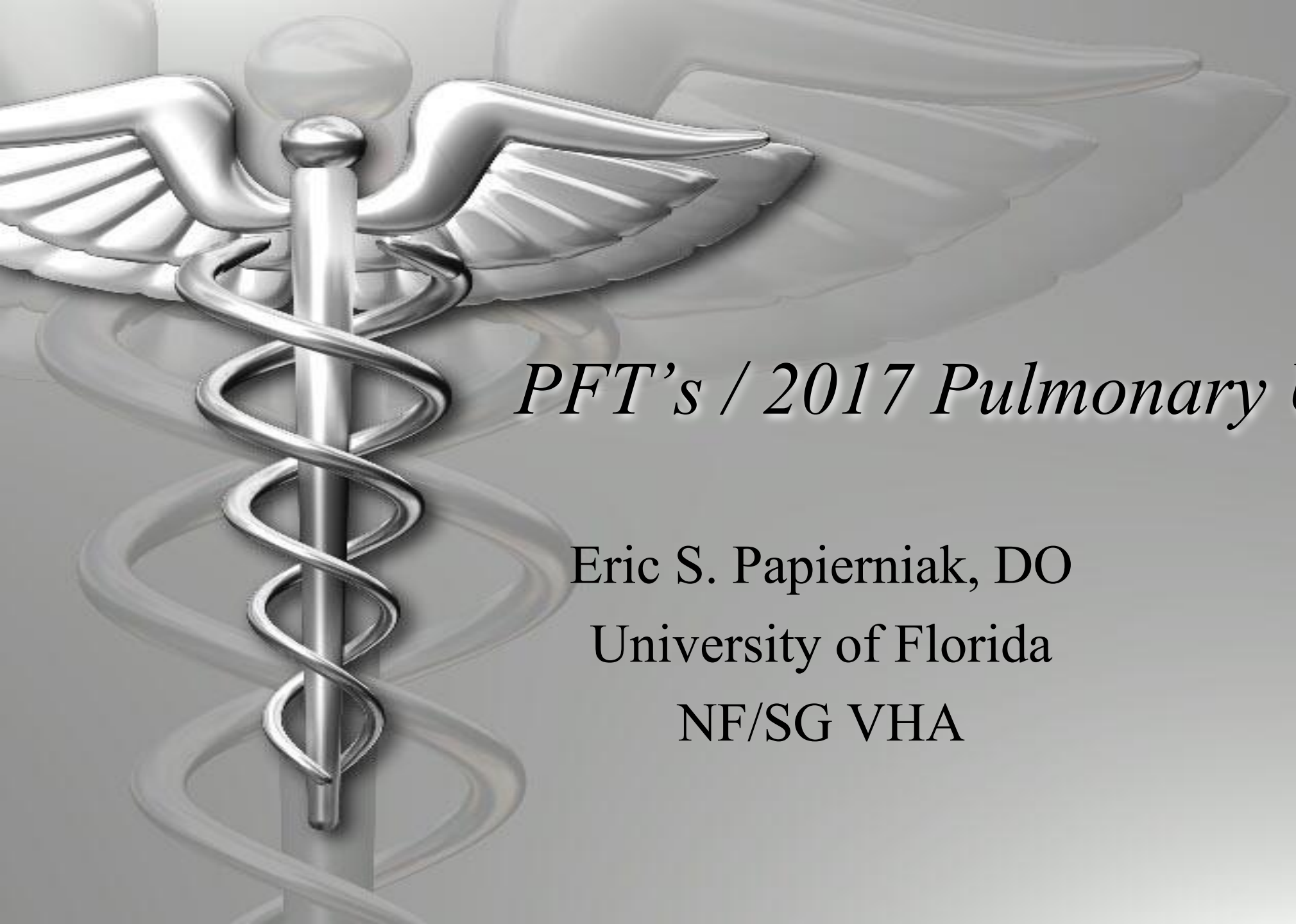


PFT's / 2017 Pulmonary Update

Eric S. Papierniak, DO
University of Florida
NF/SG VHA

Outline

- Overview of pulmonary function testing
  - Uses/indications/limitations
  - Technical aspects
  - Basics of interpretation
- 2017 Update of Pulmonology Topics
  - COPD
  - Asthma
  - Other

Major uses of PFT's

- Diagnosis
  - Very useful in the differential diagnosis of SOB
  - The crucial part of the diagnostic criteria of asthma and COPD
- Monitoring
  - Monitor progression of all types of lung disease
  - Screen for drug toxicity (amiodarone, bleomycin)

Major uses of PFT's

- Diagnosis
  - SOB and cough are both nonspecific symptoms
  - PFT's can often rule out lung disease
  - There is ample data demonstrating that a clinical diagnosis of asthma or COPD is very unreliable and in one recent example, 1/3 of patients without confirmed obstruction did not have the condition

The JAMA Network

From: **Reevaluation of Diagnosis in Adults With Physician-Diagnosed Asthma**

JAMA. 2017;317(3):269-279. doi:10.1001/jama.2016.19627

During past 12 mo				
Dyspnea	354 (86.3)	157 (77.3)	9.0 (2.4 to 15.6)	.005
Wheeze	337 (82.2)	137 (67.5)	14.7 (7.3 to 22.1)	<.001
Current				
Chest tightness	113 (27.6)	42 (20.7)	6.9 (−0.2 to 13.9)	.07
Cough	217 (52.9)	99 (48.8)	4.2 (−4.2 to 12.6)	.33
Dyspnea	174 (42.4)	69 (34.0)	8.4 (0.4 to 16.5)	.04
Sputum production	170 (41.5)	68 (33.5)	8.0 (−0.1 to 16.0)	.06
Wheeze	149 (36.3)	39 (19.2)	17.1 (10.0 to 24.3)	<.001
AQLQ score, mean (95% CI)[b]				
Symptom	5.28 (5.17 to 5.40)	5.62 (5.48 to 5.76)	−0.34 (−0.53 to −0.15)	<.001
Activity	5.66 (5.55 to 5.77)	5.85 (5.71 to 5.99)	−0.19 (−0.37 to −0.02)	.04
Emotion	5.51 (5.39 to 5.64)	5.76 (5.59 to 5.93)	−0.25 (−0.46 to −0.04)	.02
Environmental stimuli	5.29 (5.16 to 5.42)	5.51 (5.33 to 5.70)	−0.22 (−0.46 to 0.01)	.06
Total	5.44 (5.35 to 5.55)	5.70 (5.57 to 5.85)	−0.26 (−0.43 to −0.09)	.004
Patients with comorbidities, No. (%)				
History of GERD	122 (29.8)	49 (24.1)	5.6 (−1.8 to 13.0)	.14
Diabetes	25 (6.1)	17 (8.4)	−2.3 (−6.7 to 2.2)	.29
Hypertension	95 (23.2)	63 (31.0)	−7.9 (−15.4 to −0.3)	.04
Vocal cord dysfunction	10 (2.4)	9 (4.4)	−2.0 (−5.2 to 1.2)	.18
Depression	130 (31.7)	72 (35.5)	−3.8 (−11.7 to 4.2)	.35

Table Title:

Baseline Characteristics of Individuals Whose Diagnosis of Current Asthma Was Confirmed or Ruled Out

Date of download: 6/24/2017

Copyright © 2017 American Medical Association. All rights reserved.

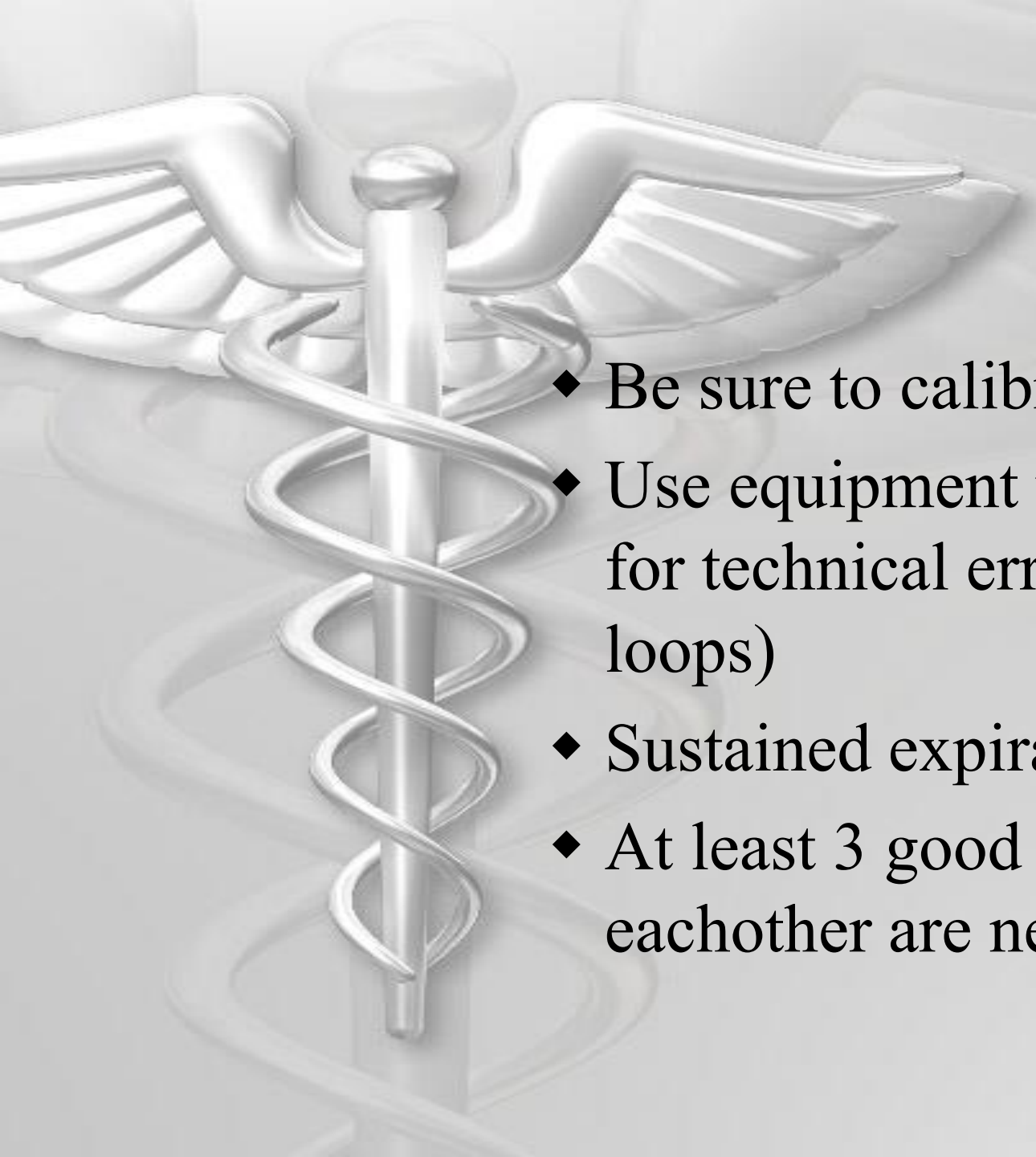
Monitoring: When to get PFTs

- COPD: At diagnosis and annually thereafter for monitoring of disease progression
- Asthma: At diagnosis, and after at least 3 months on stable therapy in all patients to determine 'personal best' values. Monitoring: every 6-12 months (children) or 1-2 years (adults)

Limitations of PFT's

- Weak correlation with prognosis and even severity of symptoms in COPD[1]
- Reversibility criteria have not been validated clinically and don't predict response to therapy[2]
- Reversibility can be seen in COPD and by itself does not differentiate it from asthma[3]
- Minor controversy about cutoffs

1: Lancet Resp Med 2015;3(6):443-50 2: Eur Resp J 1992; 5(6):659-64 3:Chest 2011;140:1055-63



Technical aspects

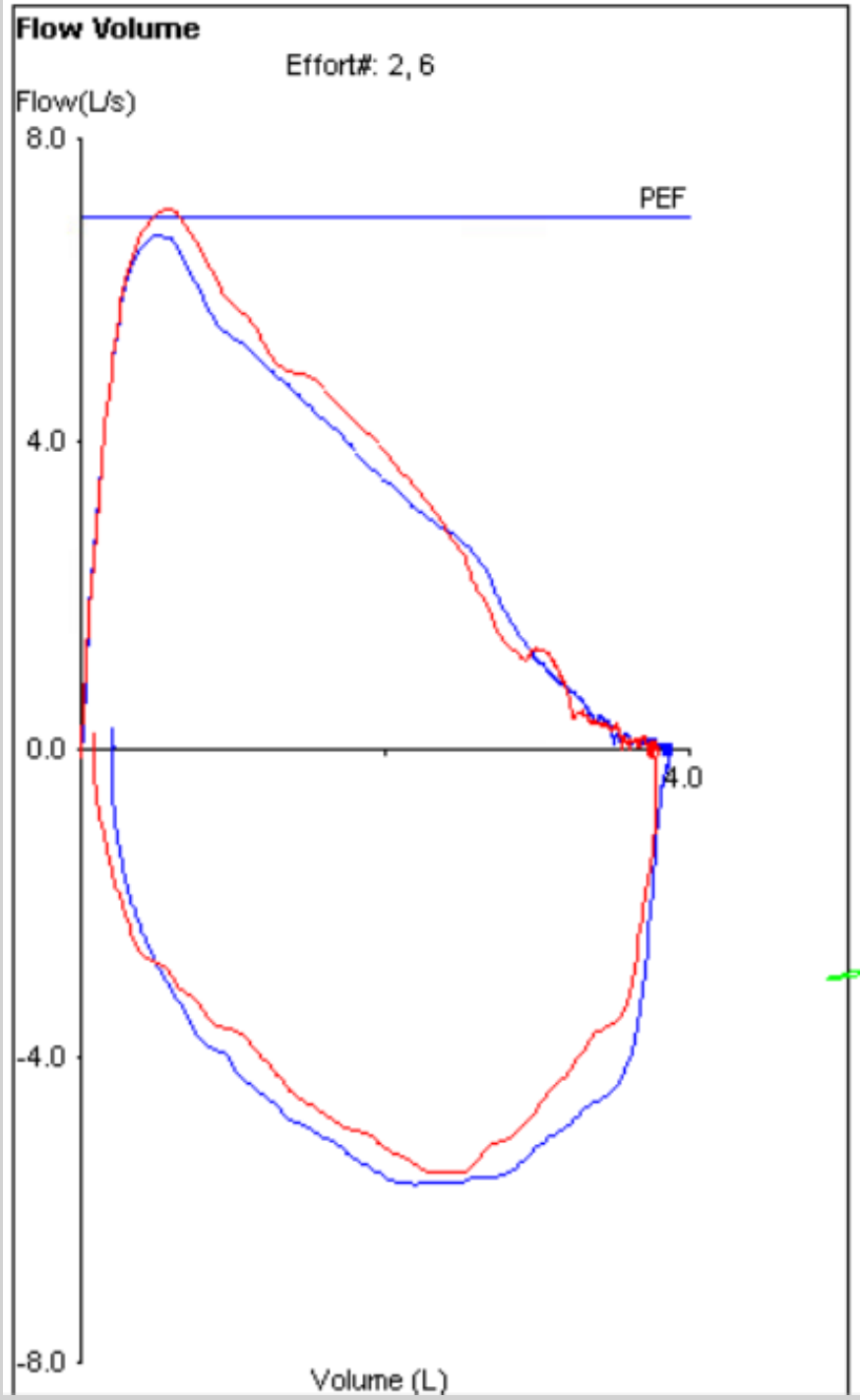
- Be sure to calibrate equipment regularly
- Use equipment that provides hard copies to look for technical errors (e.g., smooth flow/volume loops)
- Sustained expiratory effort for at least 5 seconds
- At least 3 good efforts within 100-150mL of eachother are necessary for an adequate study

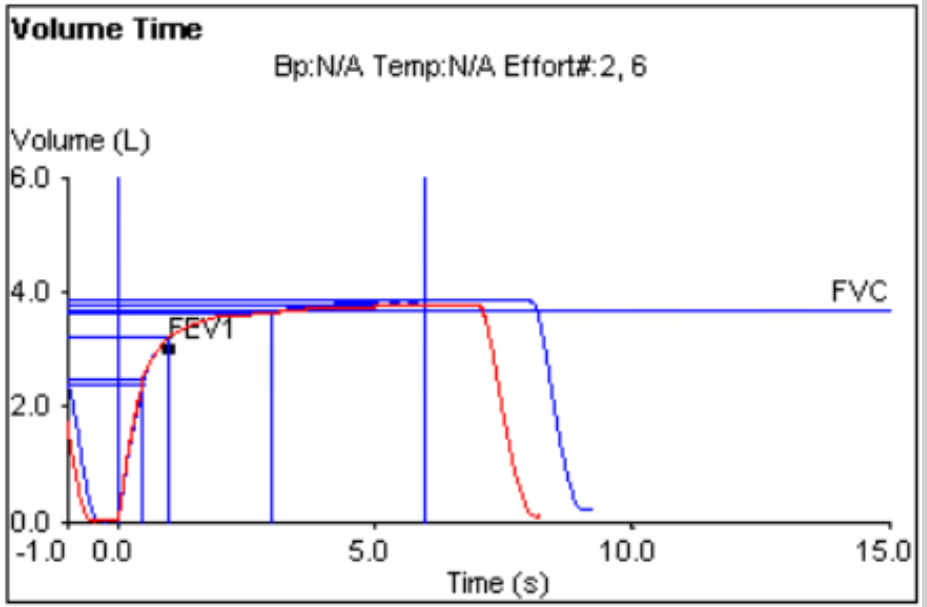
Technical aspects

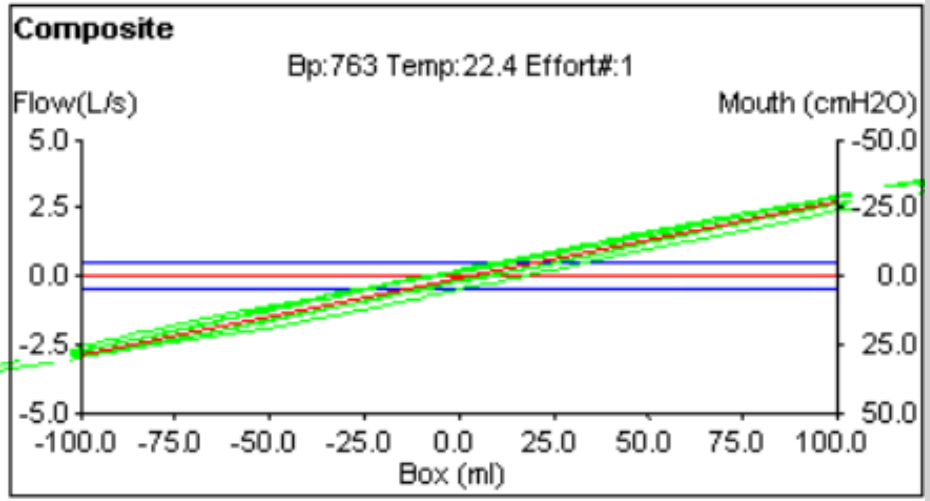
- Post-bronchodilator testing should be done 10-15 minutes after administration of albuterol (4 puffs)
- Ipratropium can also be used but need to wait 30-45 minutes

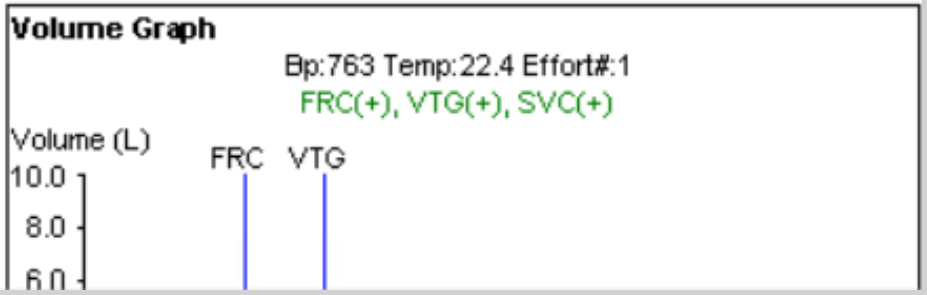
PFT interpretation

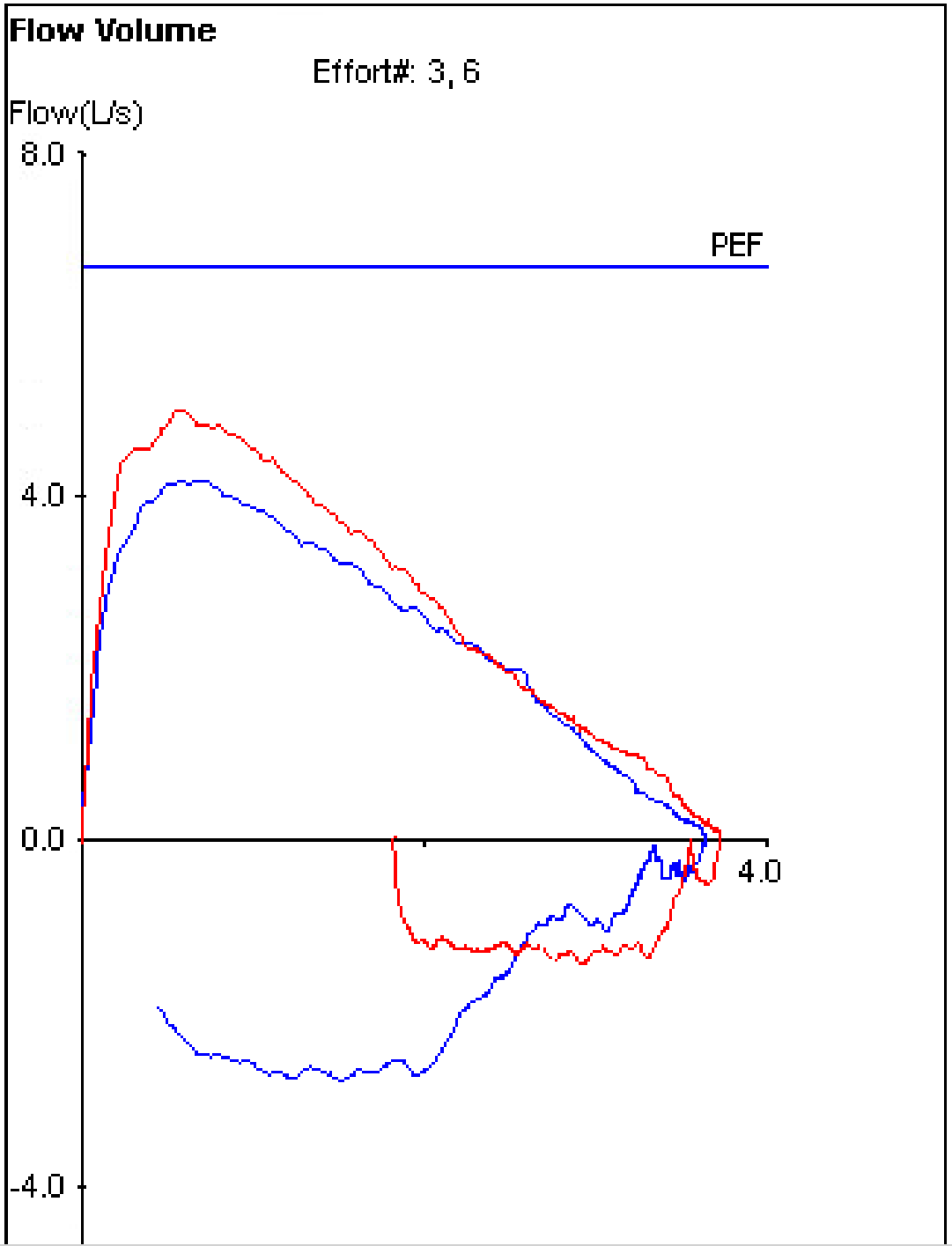
- Start with flow-volume loop
  - Assess test quality

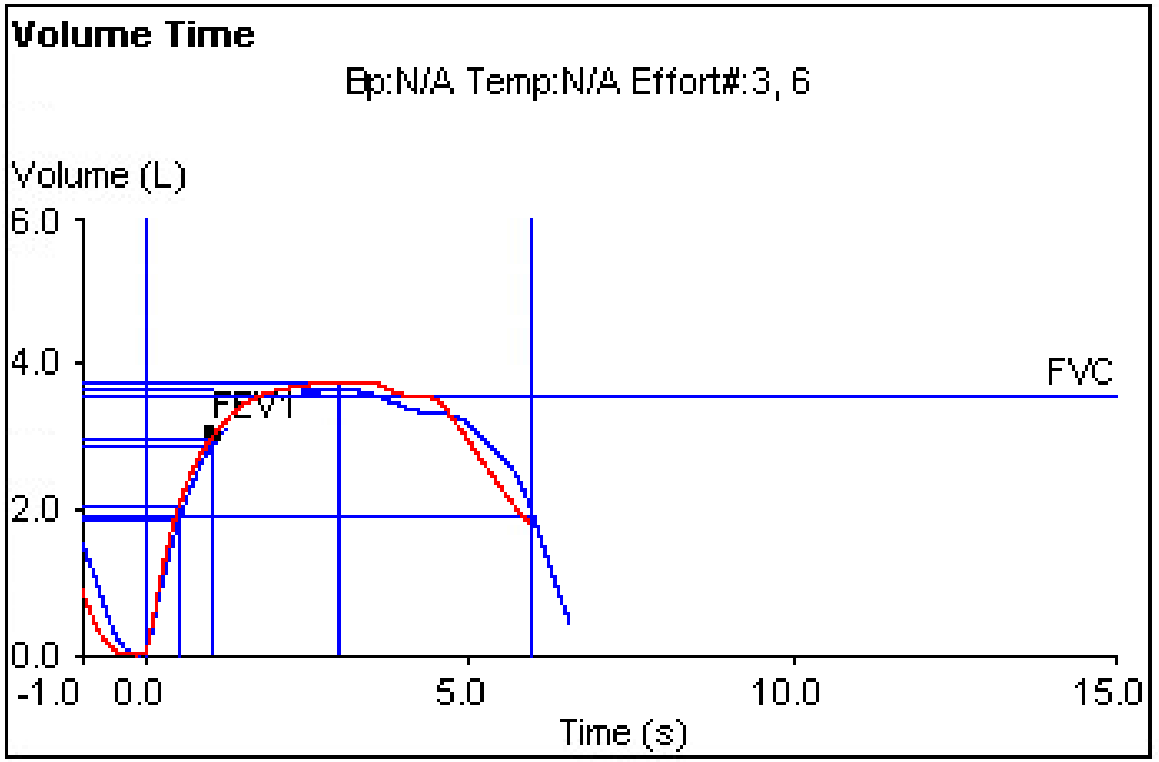

Flow Volume
Effort#: 2, 6
Flow(L/s)
8.0
4.0
0.0
-4.0
-8.0
PEF
4.0
Volume (L)

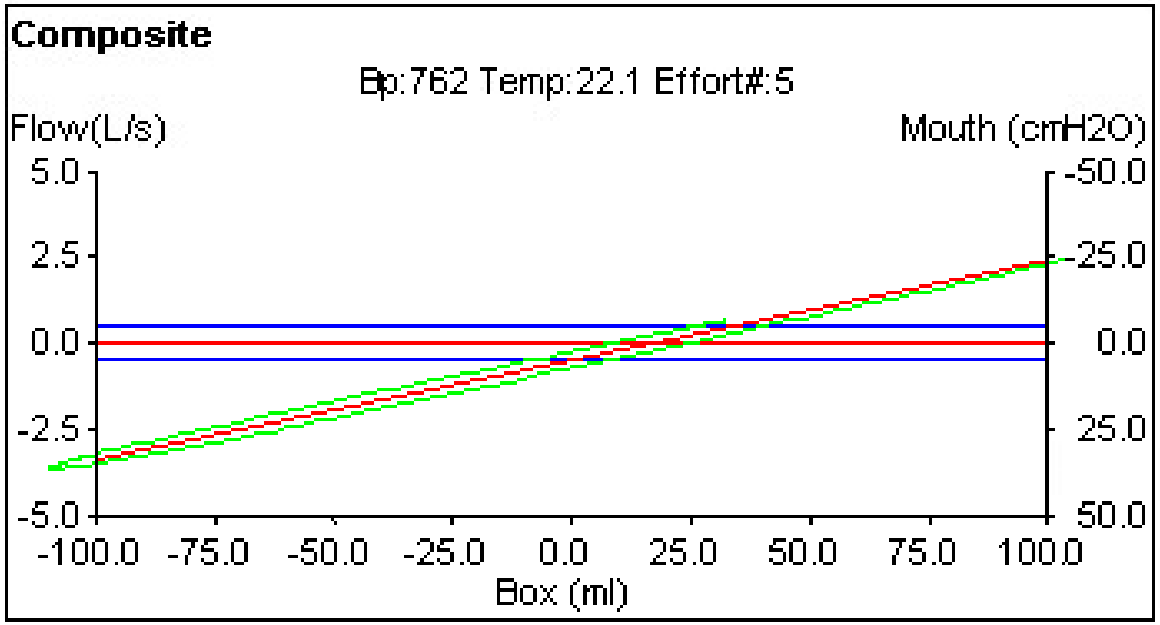

Volume Time
Bp:N/A Temp:N/A Effort#:2, 6
Volume (L)
6.0
4.0
2.0
0.0
FVC
FEV1
-1.0
0.0
5.0
10.0
15.0
Time (s)

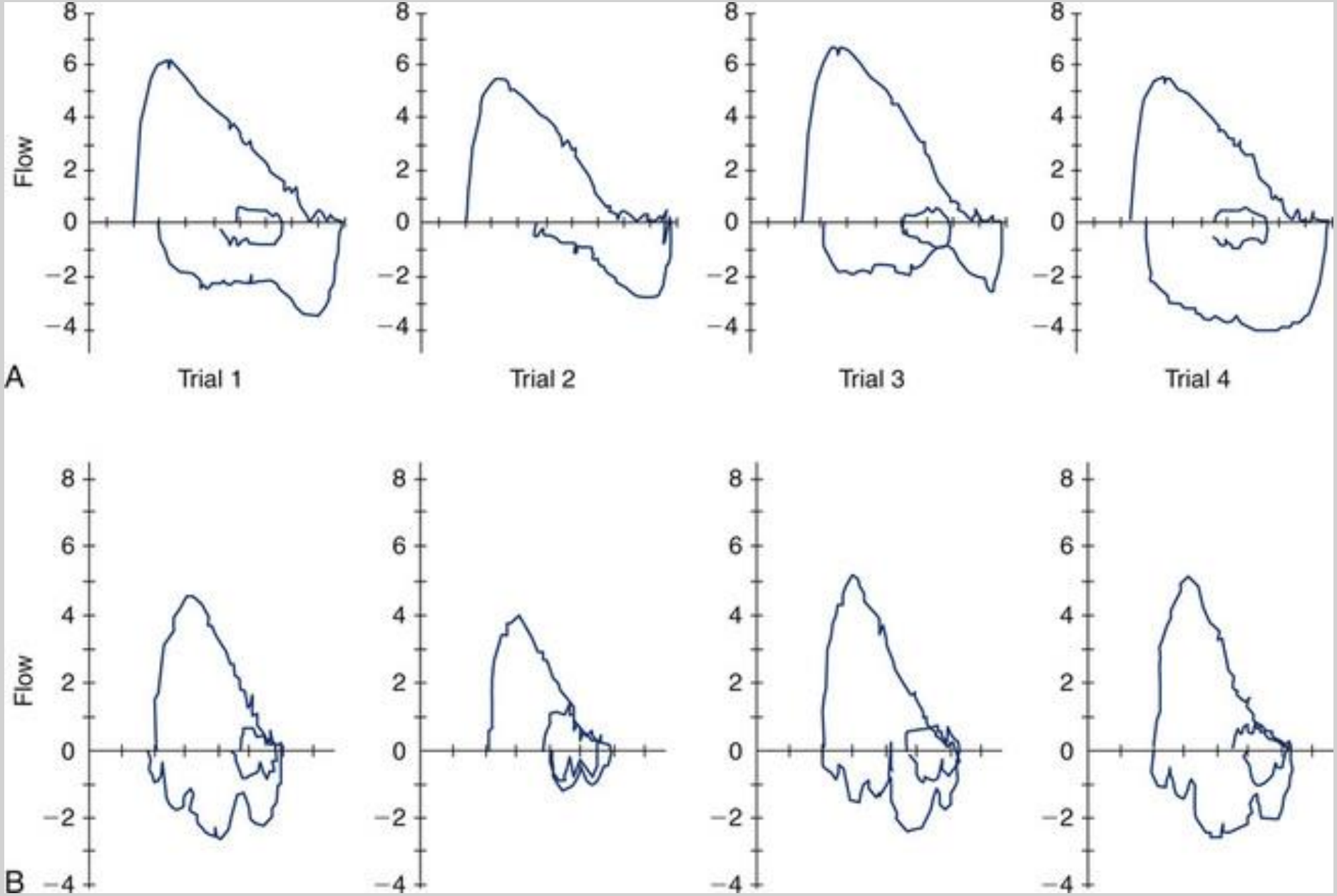

Composite
Bp:763 Temp:22.4 Effort#:1
Flow(L/s)
Mouth (cmH2O)
5.0
2.5
0.0
-2.5
-5.0
-50.0
-25.0
0.0
25.0
50.0
-100.0
-75.0
-50.0
-25.0
0.0
25.0
50.0
75.0
100.0
Box (ml)

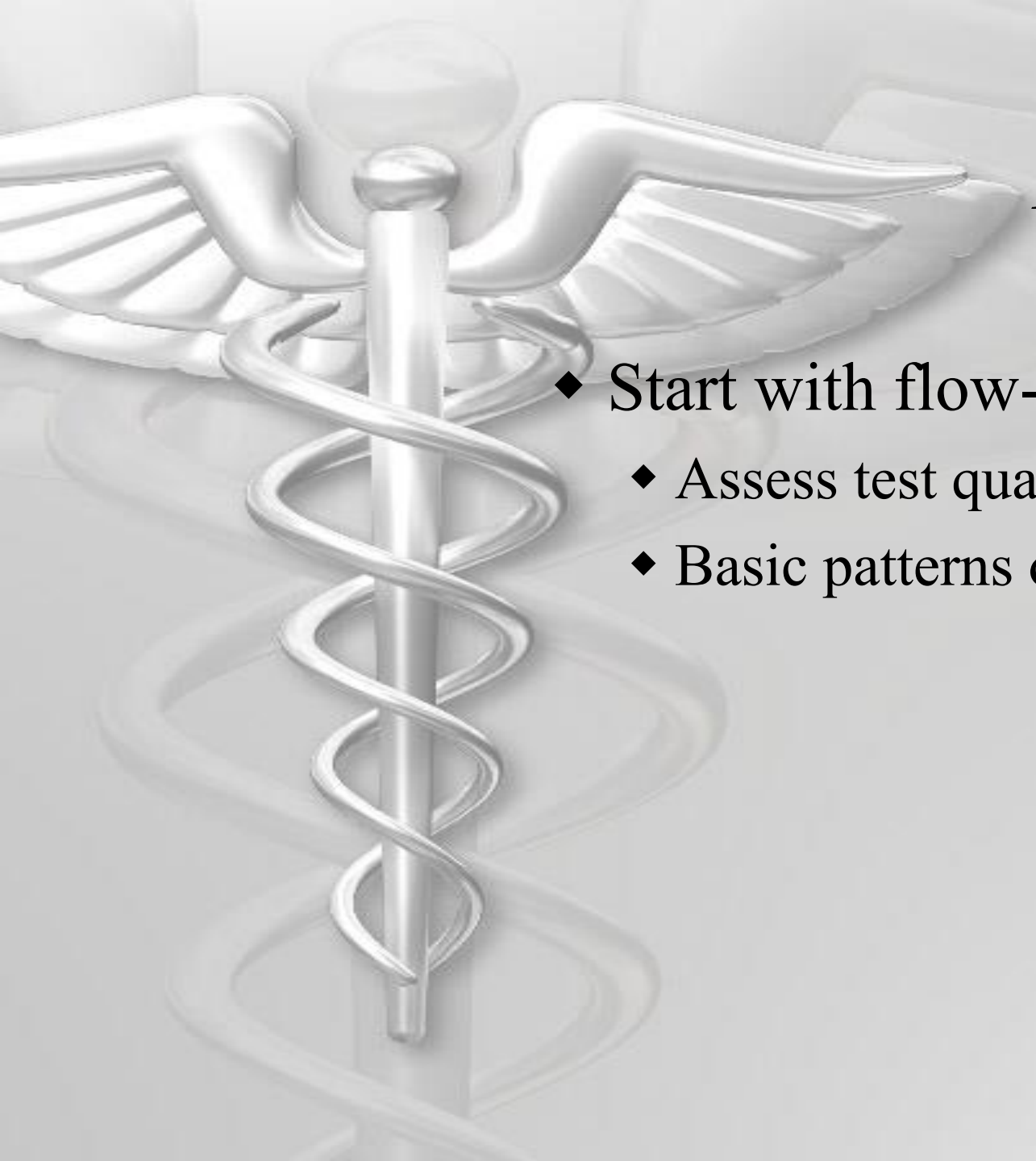

Volume Graph
Bp:763 Temp:22.4 Effort#:1
FRC(+), VTG(+), SVC(+)
Volume (L)
FRC
VTG
10.0
8.0
6.0


Flow Volume
Effort#: 3, 6
Flow(L/s)
8.0
PEF
4.0
0.0
4.0
-4.0


Volume Time
Bp:N/A Temp:N/A Effort#:3, 6
Volume (L)
6.0
4.0
2.0
0.0
FVC
FEV1
-1.0
0.0
5.0
10.0
15.0
Time (s)

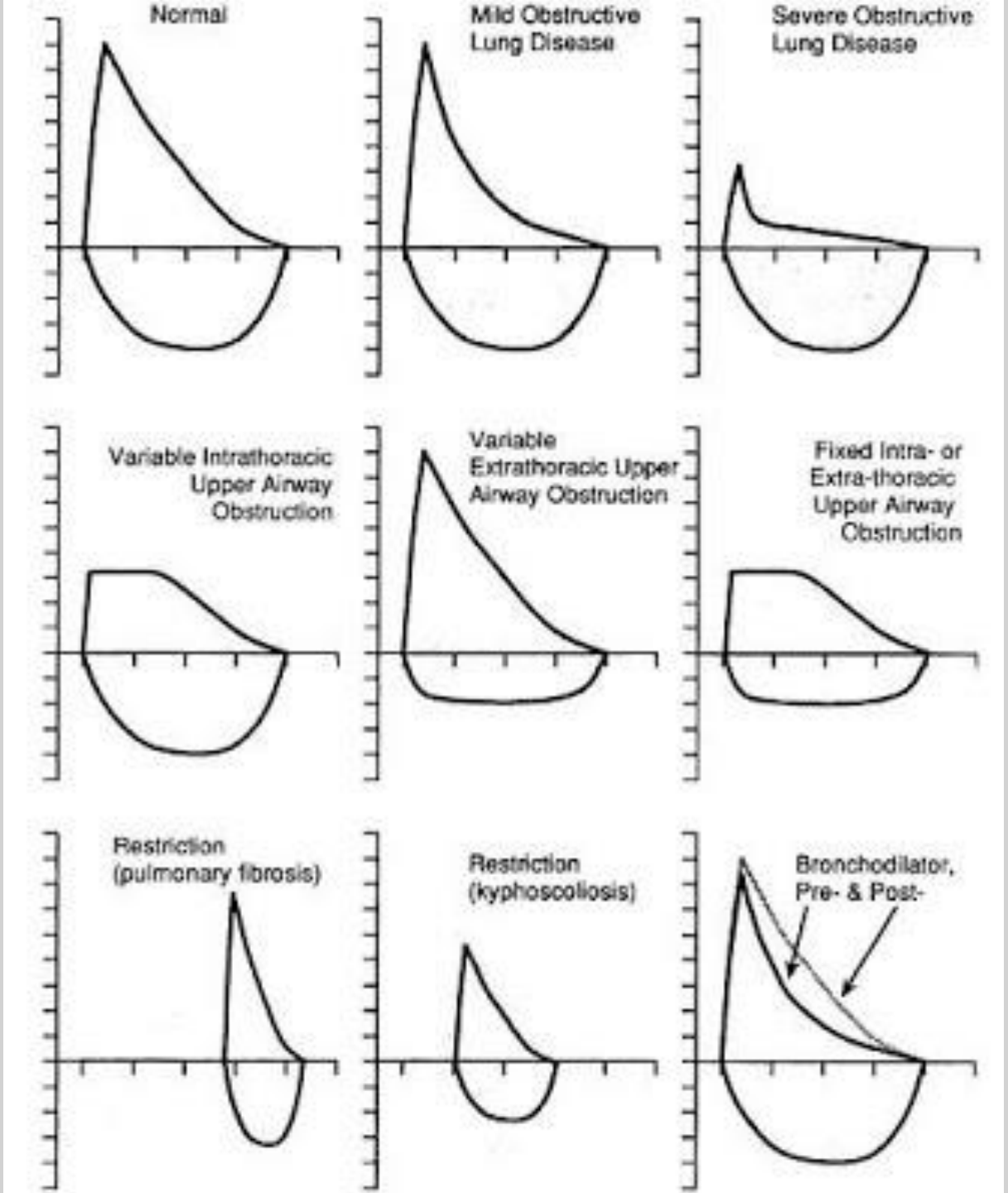

Composite
Bp:762 Temp:22.1 Effort#:5
Flow(L/s)
Mouth (cmH2O)
5.0
2.5
0.0
-2.5
-5.0
-50.0
-25.0
0.0
25.0
50.0
-100.0
-75.0
-50.0
-25.0
0.0
25.0
50.0
75.0
100.0
Box (ml)


Flow
8
6
4
2
0
−2
−4
A
Trial 1
Trial 2
Trial 3
Trial 4
Flow
B

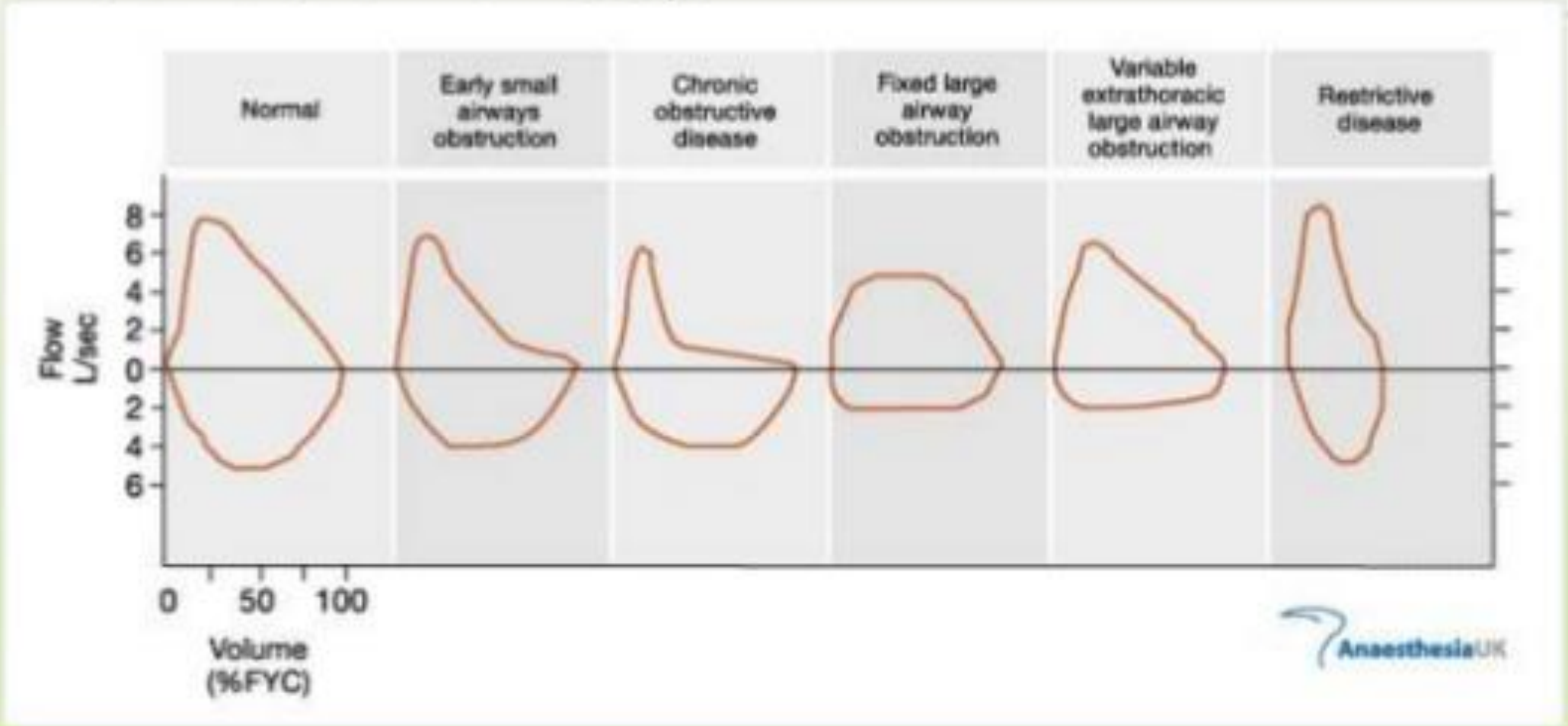


Basics of interpretation

- Start with flow-volume loop
  - Assess test quality
  - Basic patterns of disease

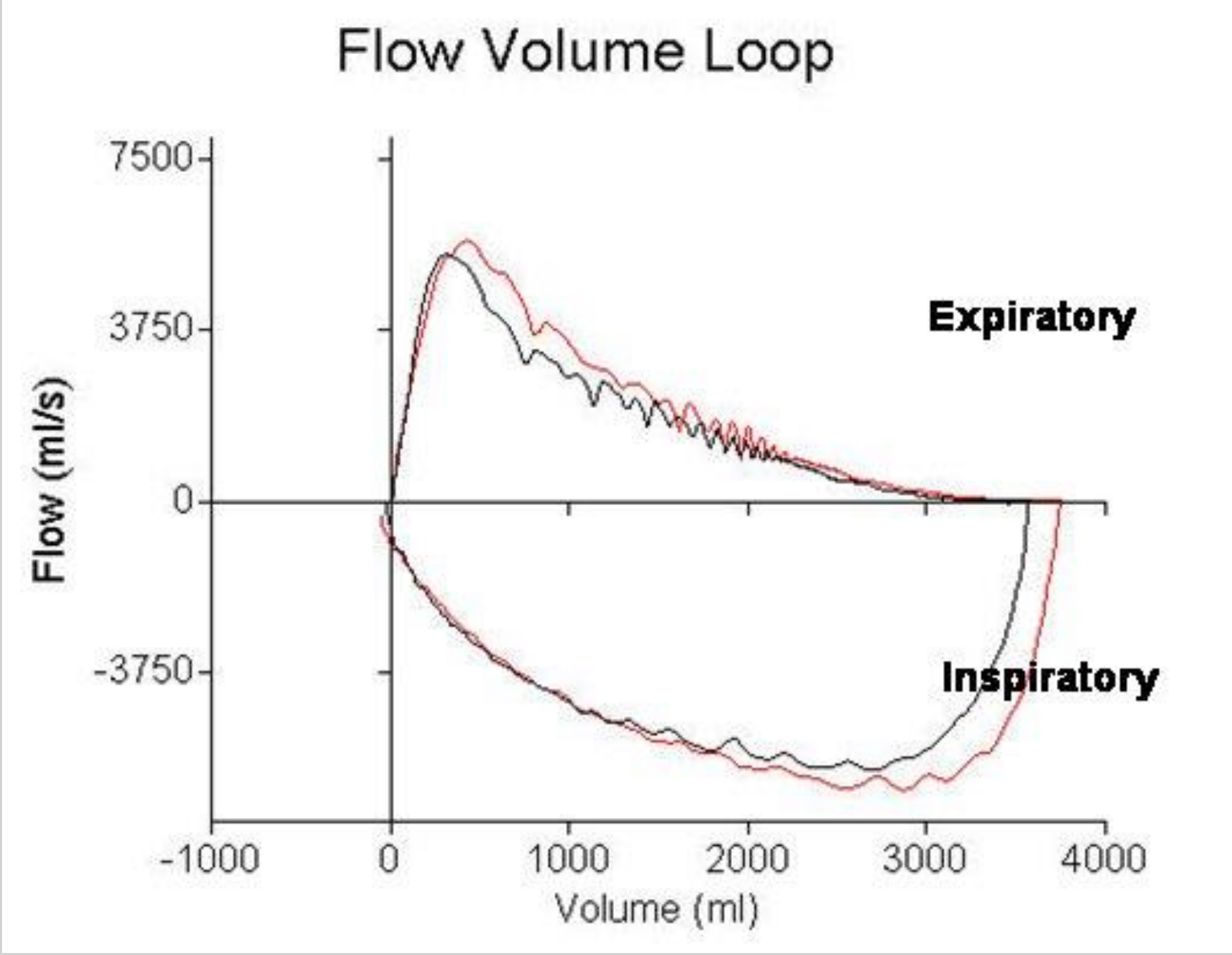

Normal
Mild Obstructive Lung Disease
Severe Obstructive Lung Disease
Variable Intrathoracic Upper Airway Obstruction
Variable Extrathoracic Upper Airway Obstruction
Fixed Intra- or Extra-thoracic Upper Airway Obstruction
Restriction (pulmonary fibrosis)
Restriction (kyphoscoliosis)
Bronchodilator, Pre- & Post-

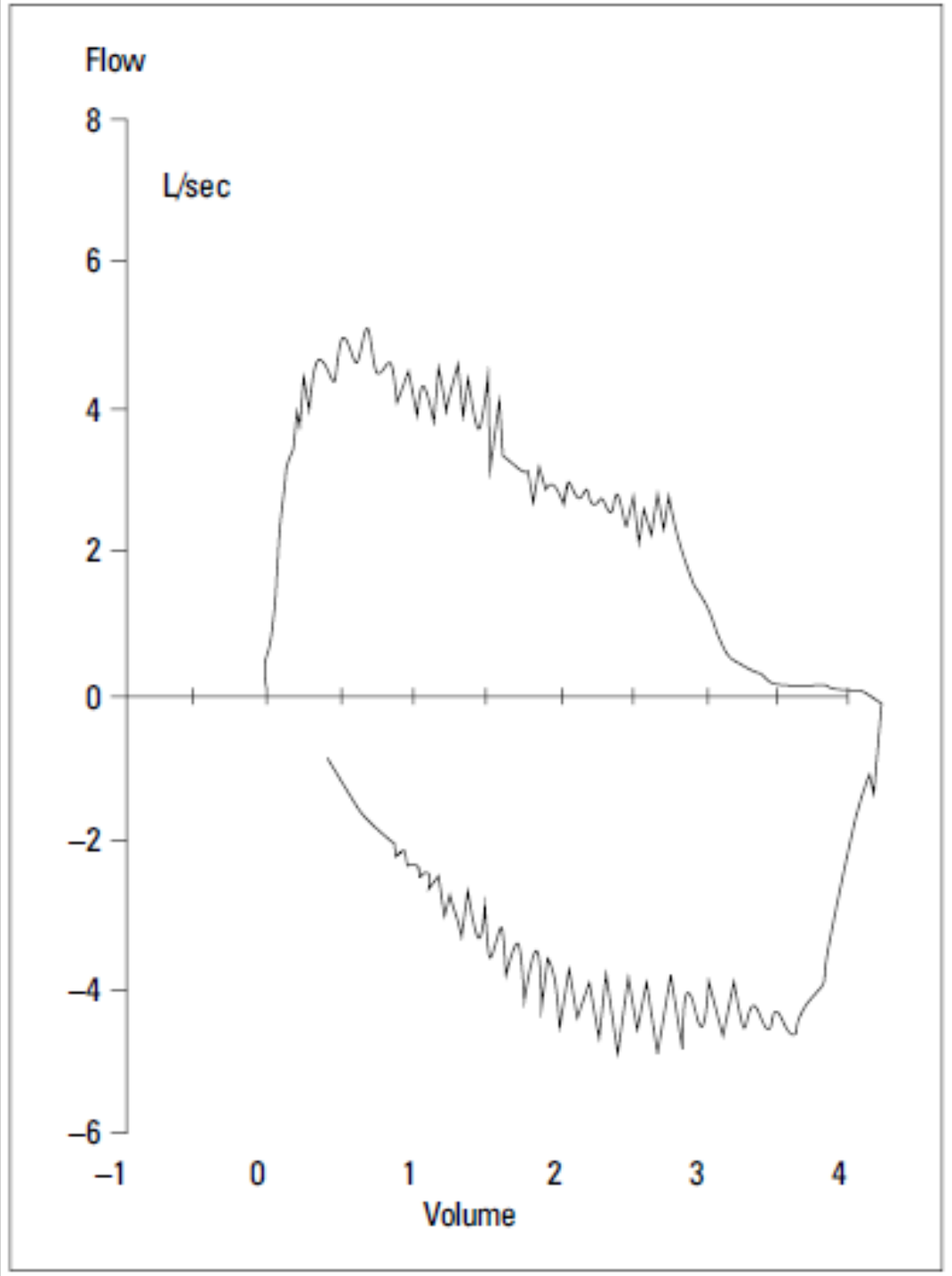
Flow-Volume Loop

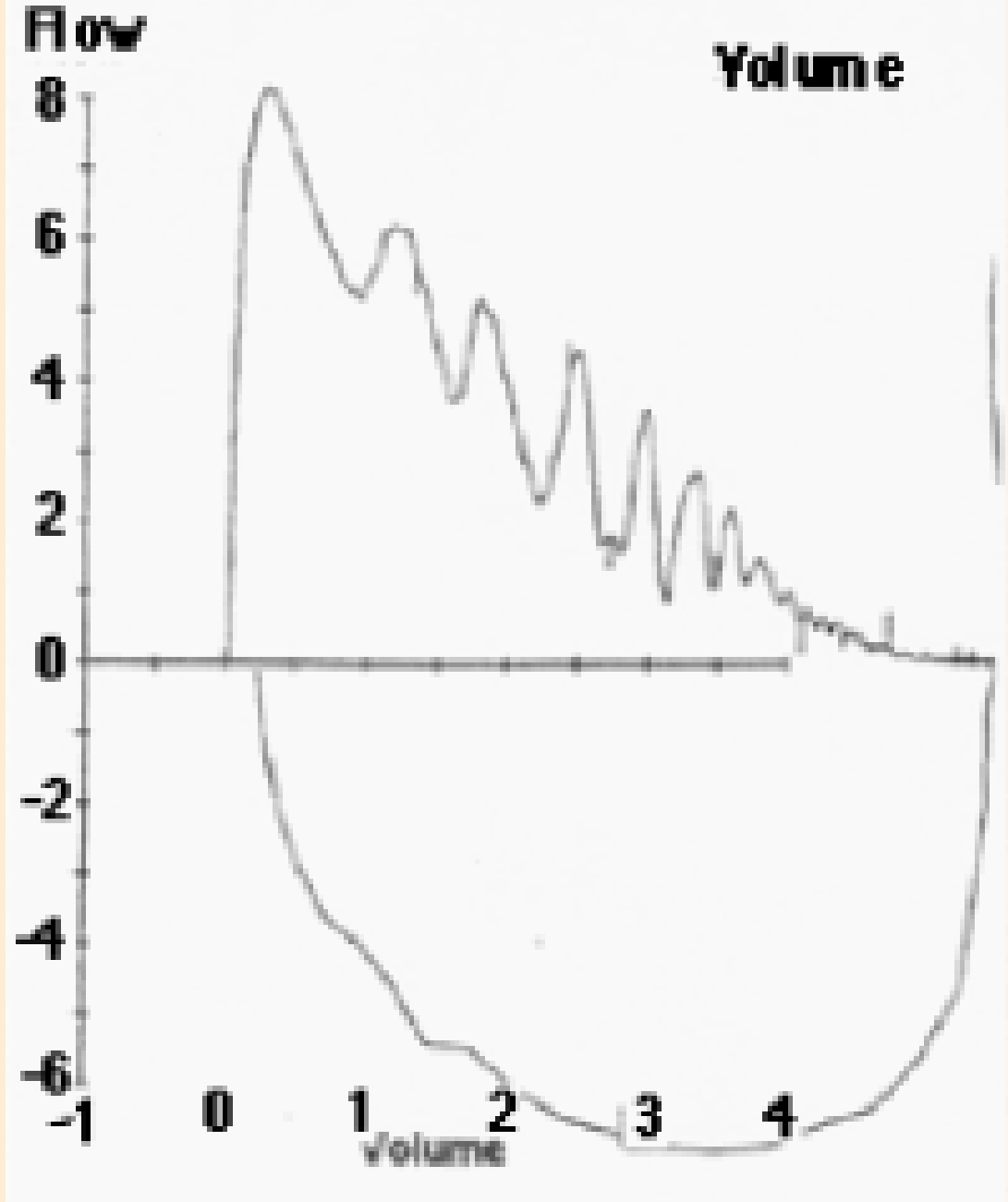


Sawtooth pattern

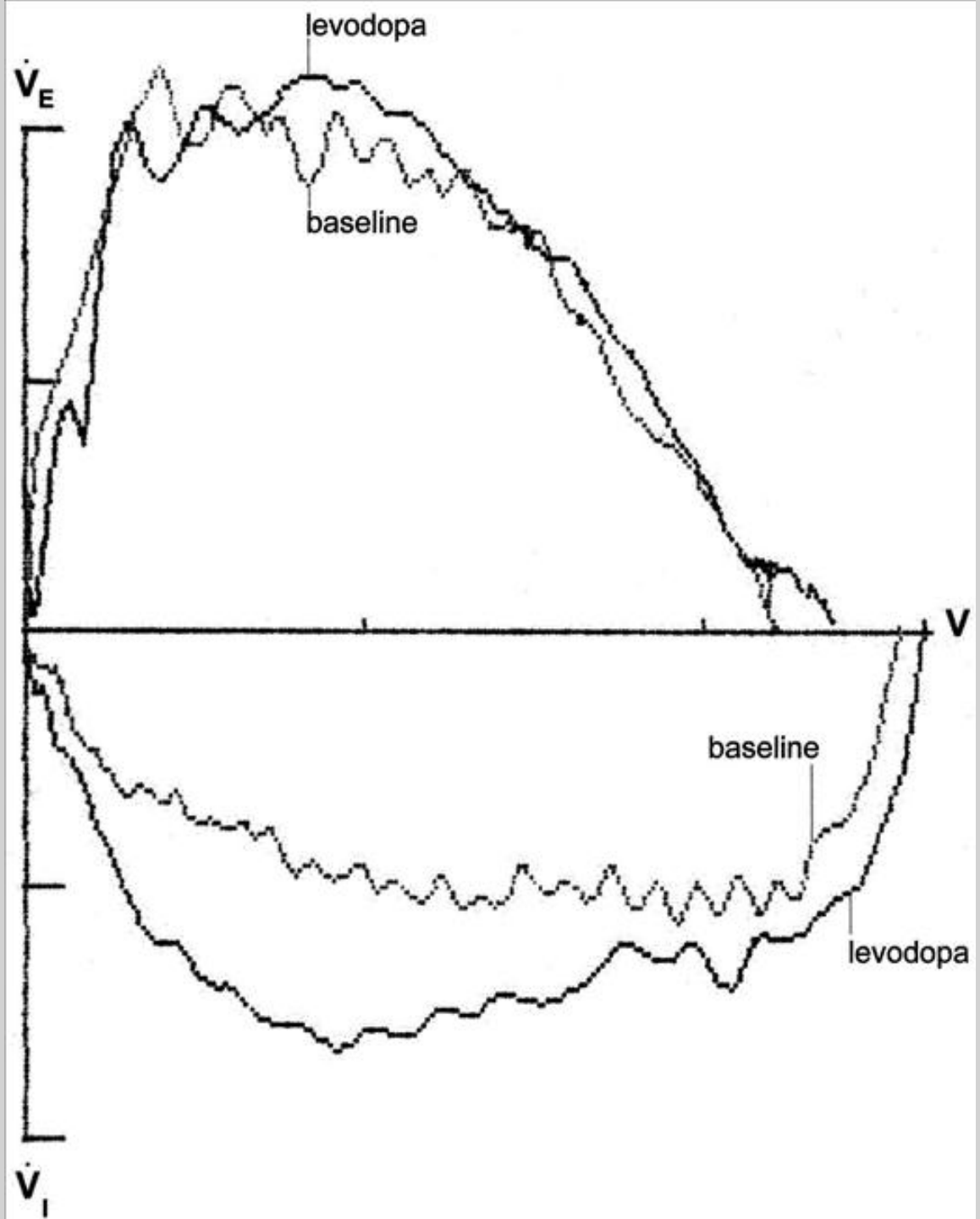
- Will sometimes be seen on flow-volume loops
- Indicates upper airway dysfunction of some kind
- First described in 1981 as a sign of OSA
- Not diagnostic of any other condition but occasionally can be helpful if the diagnosis is not clear


Flow Volume Loop
7500
3750
0
-3750
Flow (ml/s)
Expiratory
Inspiratory
-1000
0
1000
2000
3000
4000
Volume (ml)


Flow
L/sec
8
6
4
2
0
–2
–4
–6
–1
0
1
2
3
4
Volume



Cough


levodopa
$\dot{V}_E$
baseline
V
baseline
levodopa
$\dot{V}_I$

Basics of interpretation

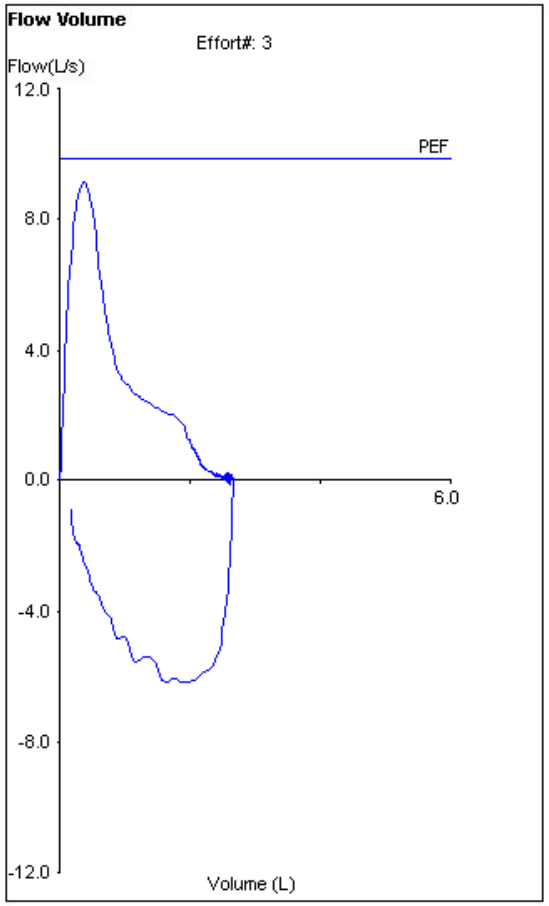
- Start with flow-volume loop
  - Assess test quality
  - Basic patterns of disease
- FEV1/FVC ratio
  - Diagnostic of obstruction if less than 0.7 (70%)
- FEV1 and reversibility
  - Cutoff for “normal” is 80% of predicted

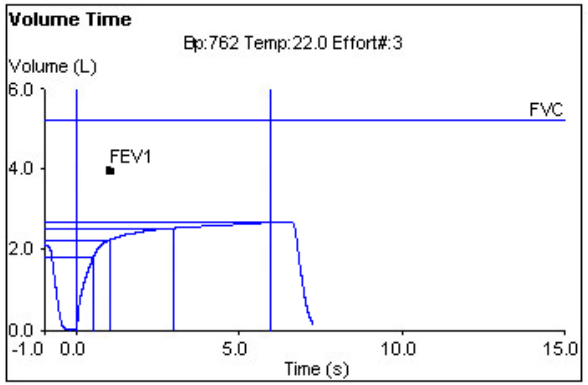
Basics of interpretation

- Examples

Patient 1

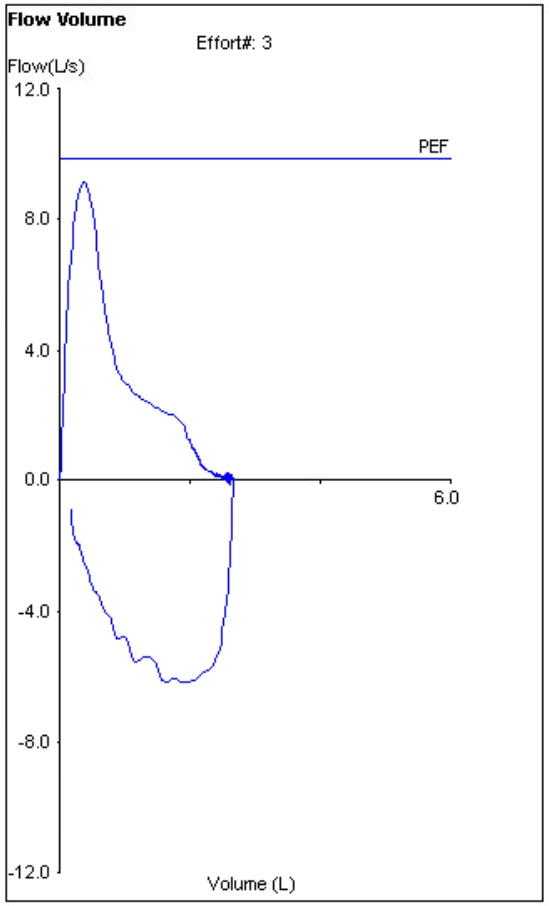
- 73 yo male, former smoker, with SOB and dry cough for about 2 years

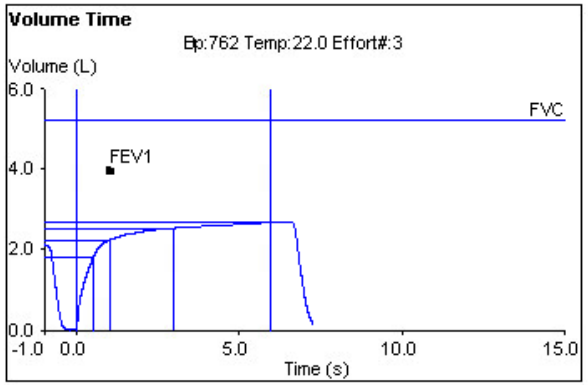




Flow-volume loop

- Adequate effort?
- Pattern?



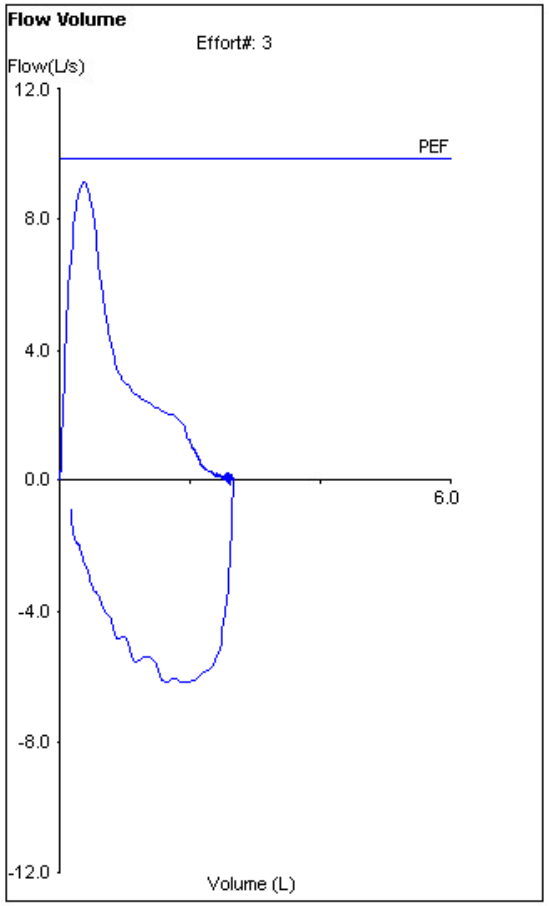


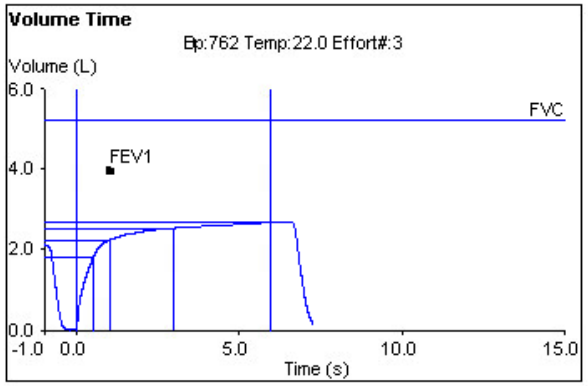
Spirometry

- Ratio: > 70
- FEV1 57% - moderate/severely reduced

Spirometry

	Units	Pre Drug Reported	Pre Drug % Predicted	Predicted	Post Drug Reported	Post Drug % Predicted	%Change
FVC	L,btps	2.67 <	52 <	5.17			
FEV1	L,btps	2.23 <	57 <	3.93			
FEV1/FVC	%	83	110	76			
FEFmax	L/s	9.20	94	9.82			
FEF25-75%	L/s	2.40	73 <	3.26			
FEF25%	L/s	5.90					
FEF50%	L/s	2.44					
FEF75%	L/s	1.26					
MVV	L/min,btps			132.81			
BP	mmHg	762					
PImax /MIP	cmH2O			-82.26			
PEmax /MEP	cmH2O			127.22			





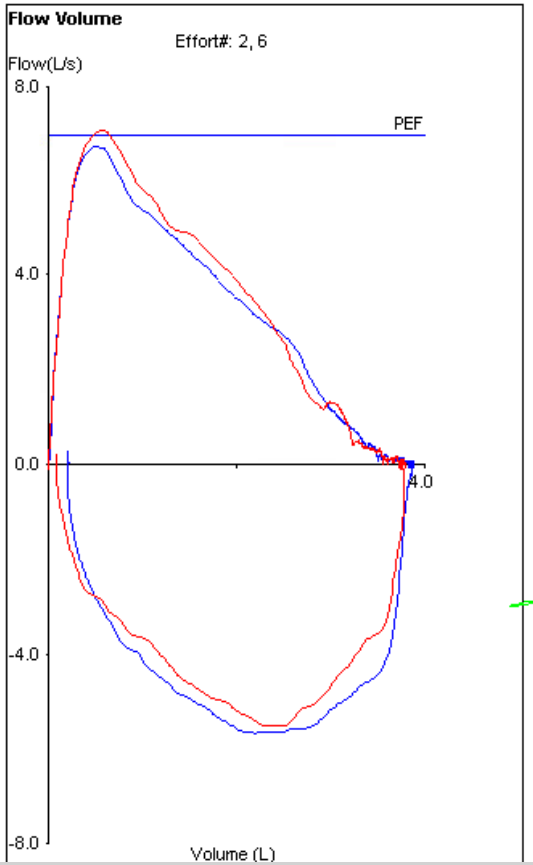
Restriction - Possible interstital lung disease

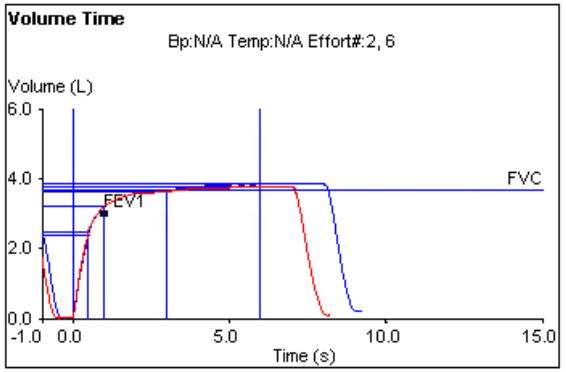
Spirometry

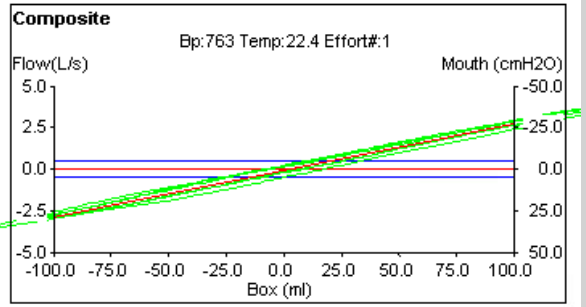
	Units	Pre Drug Reported	Pre Drug % Predicted	Predicted	Post Drug Reported	Post Drug % Predicted	%Change
FVC	L,btps	2.67 <	52 <	5.17			
FEV1	L,btps	2.23 <	57 <	3.93			
FEV1/FVC	%	83	110	76			
FEFmax	L/s	9.20	94	9.82			
FEF25-75%	L/s	2.40	73 <	3.26			
FEF25%	L/s	5.90					
FEF50%	L/s	2.44					
FEF75%	L/s	1.26					
MVV	L/min,btps			132.81			
BP	mmHg	762					
PImax /MIP	cmH2O			-82.26			
PEmax /MEP	cmH2O			127.22			

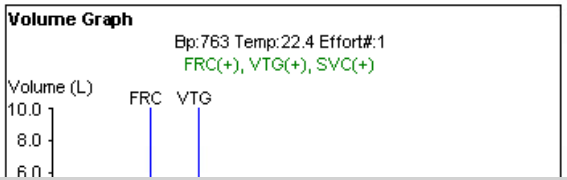
Patient 2

- 54 yo male with dyspnea on exertion, smoked for “a few years” but not currently









Spirometry

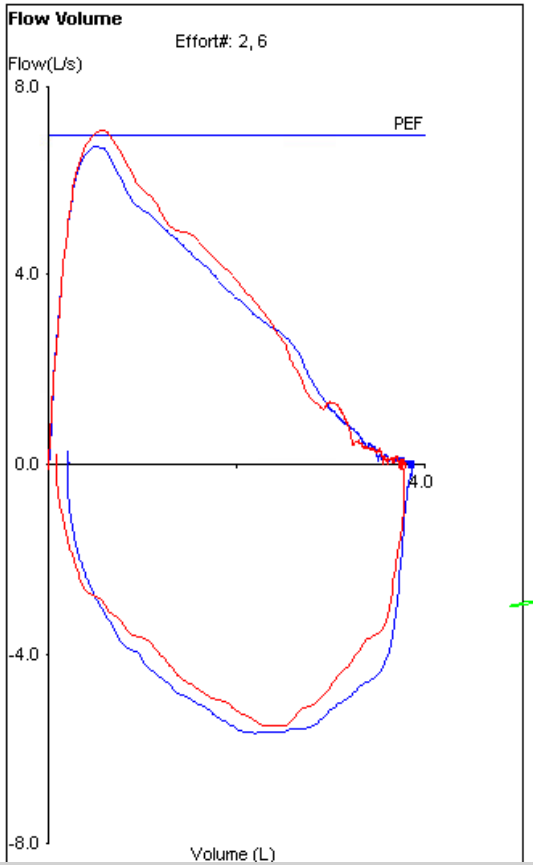
Flow-volume loop

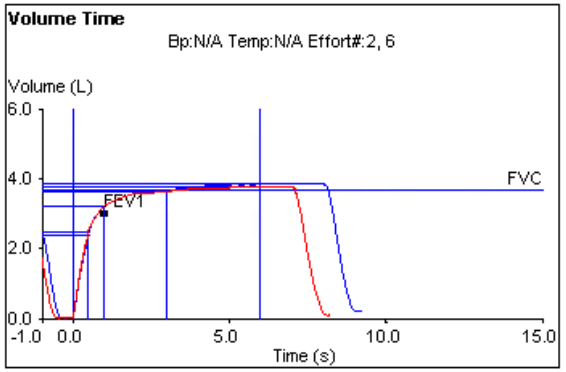
Spirometry

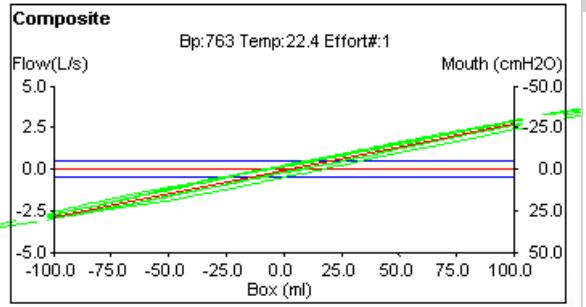
	Units	Pre Drug Reported	Pre Drug % Predicted	Predicted	Post Drug Reported	Post Drug % Predicted	%Change
FVC	L,btps	3.89	106	3.68	3.80	103	-2
FEV1	L,btps	3.18	106	3.00	3.19	106	0
FEV1/FVC	%	82	100	82	84	102	3
FEFmax	L/s	6.71	97	6.96	7.05	101	5
FEF25-75%	L/s	3.26	105	3.10	3.34	108	3
FEF25%	L/s	5.44			5.97		10
FEF50%	L/s	3.65			4.12		13
FEF75%	L/s	1.45			1.32		-9
MVV	L/min,btps	112.03	108	103.91	98.52	95	-12
BP	mmHg	762			762		
PImax /MIP	cmH2O			-72.42			
PEmax /MEP	cmH2O			92.91			

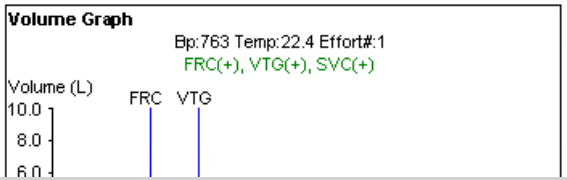
Lung Volumes, Body Box

	Units	Pre Drug Reported	Pre Drug % Predicted	Predicted	Post Drug Reported	Post Drug % Predicted	%Change
VC	L,btps	3.59	97	3.68			
IC	L,btps	2.16	83	2.60			
ERV	L,btps	1.43	132 >	1.08			
FRC	L,btps	3.21	120	2.68			
RV	L,btps	1.78	112	1.60			
TLC	L,btps	5.37	102	5.28			
RV/TLC	%	33	110	30			
VTG	L,btps	3.27					









Normal – seek non-pulmonary cause of SOB

Spirometry

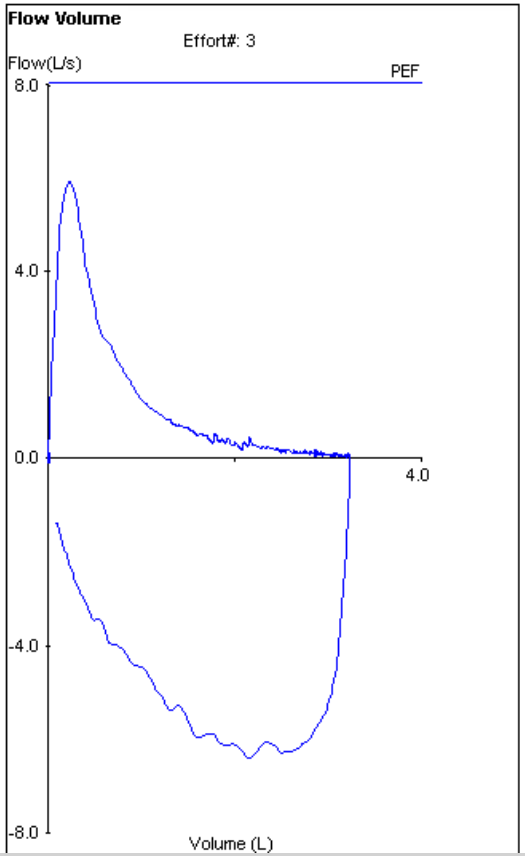
	Units	Pre Drug Reported	Pre Drug % Predicted	Predicted	Post Drug Reported	Post Drug % Predicted	%Change
FVC	L,btps	3.89	106	3.68	3.80	103	-2
FEV1	L,btps	3.18	106	3.00	3.19	106	0
FEV1/FVC	%	82	100	82	84	102	3
FEFmax	L/s	6.71	97	6.96	7.05	101	5
FEF25-75%	L/s	3.26	105	3.10	3.34	108	3
FEF25%	L/s	5.44			5.97		10
FEF50%	L/s	3.65			4.12		13
FEF75%	L/s	1.45			1.32		-9
MVV	L/min,btps	112.03	108	103.91	98.52	95	-12
BP	mmHg	762			762		
PImax /MIP	cmH2O			-72.42			
PEmax /MEP	cmH2O			92.91			

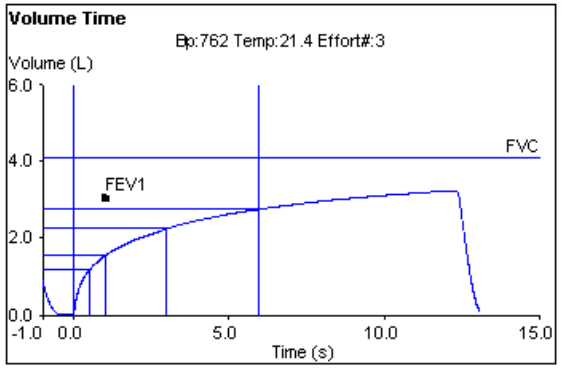
Lung Volumes, Body Box

	Units	Pre Drug Reported	Pre Drug % Predicted	Predicted	Post Drug Reported	Post Drug % Predicted	%Change
VC	L,btps	3.59	97	3.68			
IC	L,btps	2.16	83	2.60			
ERV	L,btps	1.43	132 >	1.08			
FRC	L,btps	3.21	120	2.68			
RV	L,btps	1.78	112	1.60			
TLC	L,btps	5.37	102	5.28			
RV/TLC	%	33	110	30			
VTG	L,btps	3.27					

Patient 3

- 62 yo male, current smoker, with chronic cough



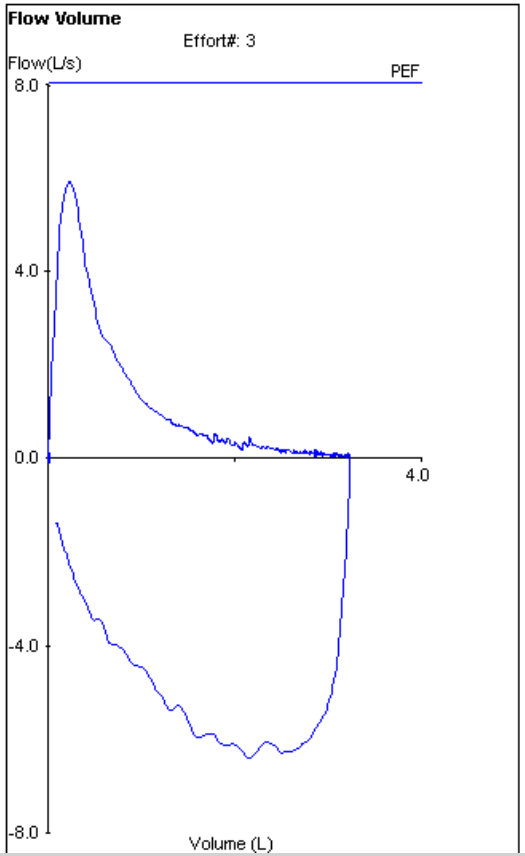


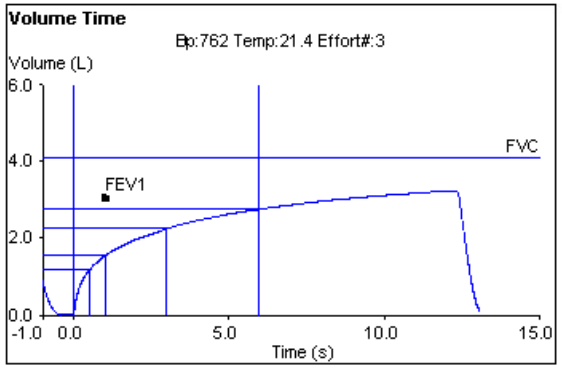
Spirometry

Flow-volume loop

Spirometry

	Units	Pre Drug Reported	Pre Drug % Predicted	I
FVC	L,btps	3.23	79 <	
FEV1	L,btps	1.55 <	51 <	
FEV1/FVC	%	48 <	64 <	
FEFmax	L/s	5.94 <	74 <	
FEF25-75%	L/s	0.45 <	19 <	
FEF25%	L/s	1.92		
FEF50%	L/s	0.49		
FEF75%	L/s	0.22		
MVV	L/min,btps			
BP	mmHg	762		
PImax /MIP	cmH2O			
PEmax /MEP	cmH2O			





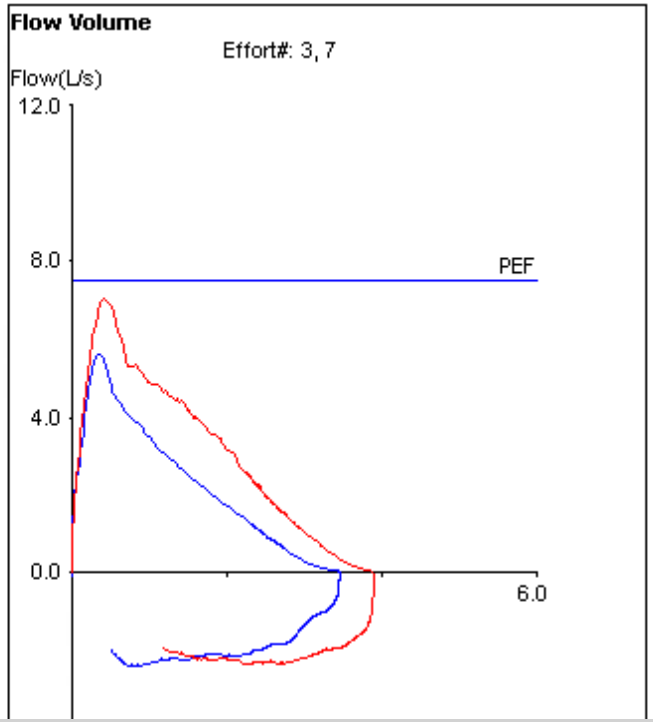
Moderate-severe obstruction - COPD

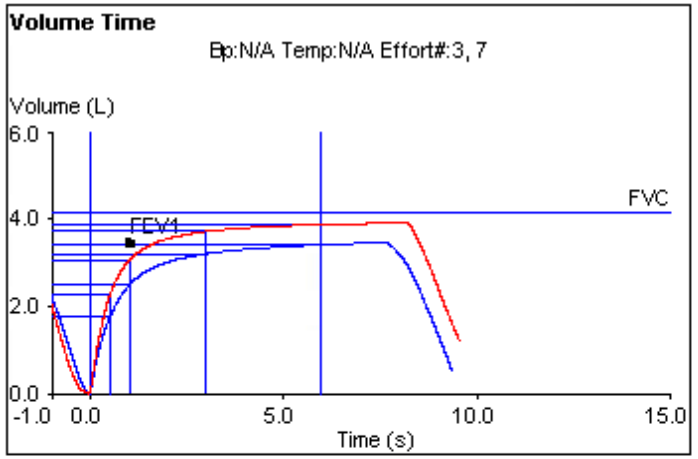
Spirometry

	Units	Pre Drug Reported	Pre Drug % Predicted	I
FVC	L,btps	3.23	79 <	
FEV1	L,btps	1.55 <	51 <	
FEV1/FVC	%	48 <	64 <	
FEFmax	L/s	5.94 <	74 <	
FEF25-75%	L/s	0.45 <	19 <	
FEF25%	L/s	1.92		
FEF50%	L/s	0.49		
FEF75%	L/s	0.22		
MVV	L/min,btps			
BP	mmHg	762		
PImax /MIP	cmH2O			
PEmax /MEP	cmH2O			

Patient 4

- 32 yo female, current smoker, c/o SOB



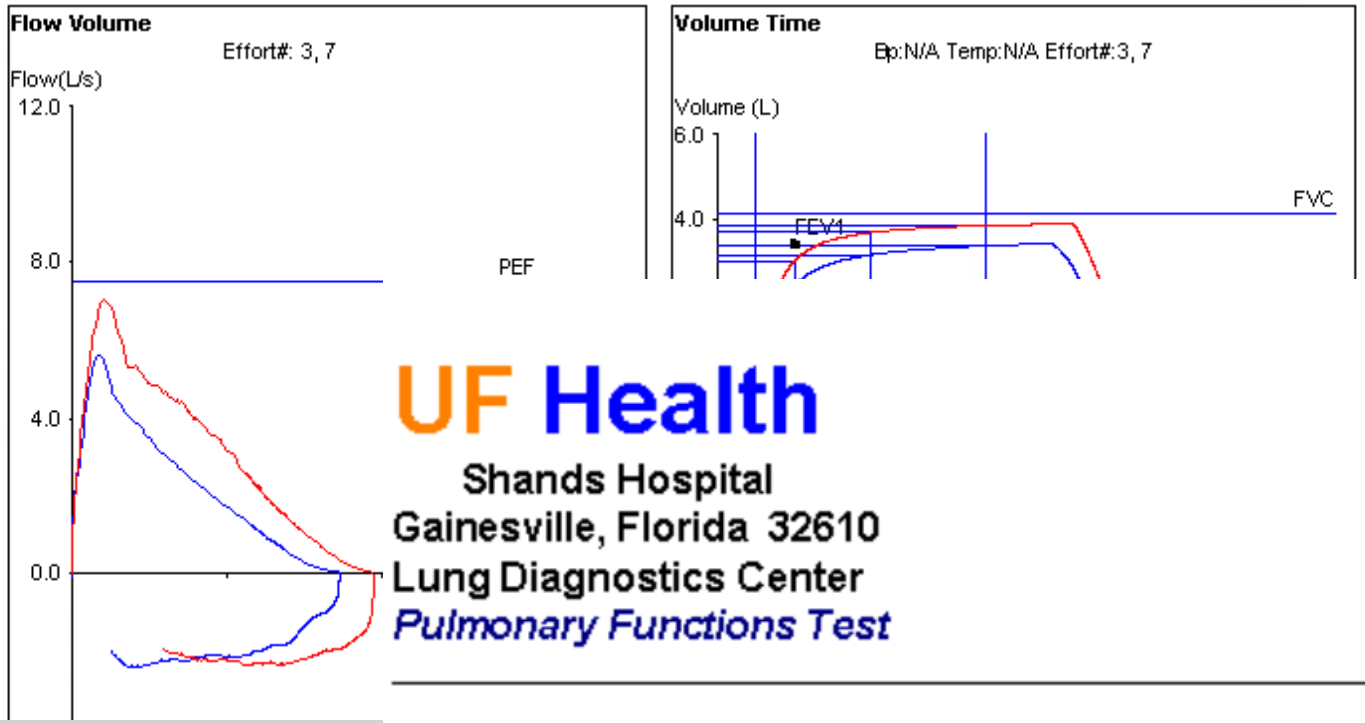


Flow-volume loop

Spirometry

Spirometry

	Units	Pre Drug Reported	Pre Drug % Predicted	Predicted	Post Drug Reported	Post Drug % Predicted	%Change
FVC	L,btps	3.50	85	4.14	3.91	94	12
FEV1	L,btps	2.49 <	72 <	3.45	3.06	89	23
FEV1/FVC	%	71 <	84	84	78	93	10
FEFmax	L/s	5.58 <	75 <	7.48	7.04	94	26
FEF25-75%	L/s	1.84 <	52 <	3.57	2.70	76 <	47
FEF25%	L/s	3.88			4.98		28
FEF50%	L/s	2.16			3.35		55
FEF75%	L/s	0.83			1.20		45
MVV	L/min,btps	61.48	53 <	116.49	82.12	70 <	34
BP	mmHg	763			762		0
PImax /MIP	cmH2O			-77.83			
PEmax /MEP	cmH2O			97.10			



Flow-volume loop

Spirometry

UF Health

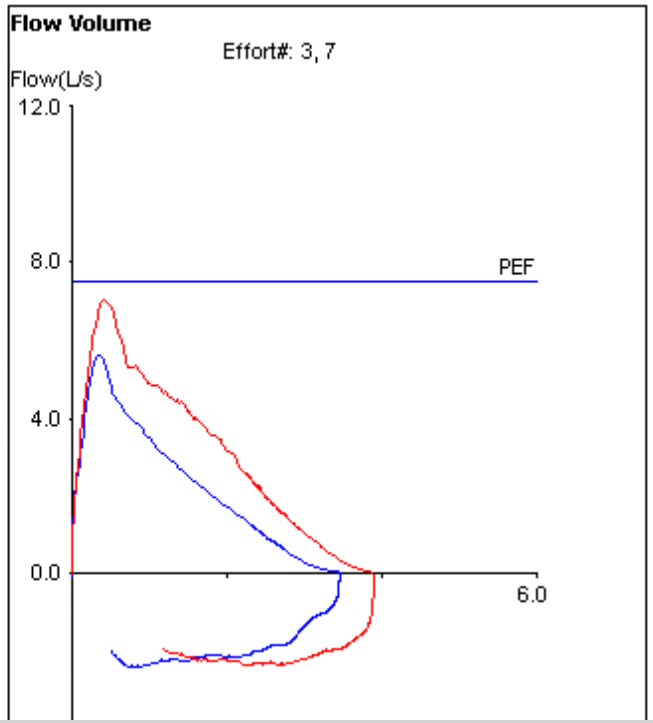
Shands Hospital
Gainesville, Florida 32610
Lung Diagnostics Center
Pulmonary Functions Test

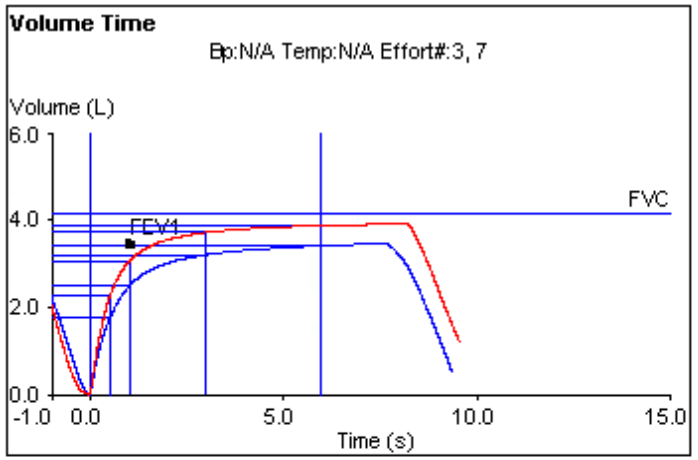
MRID: [redacted] **Visit Type:** OP
Name:
CSN #:
Room Number: Adult Med Plaza
Study Date: 6/21/2017 03:36 PM

Birth Date: **Age:** 32 **Gender:** Female **Height:** 67.0 in, 170.2 cm
Smoke Status: Smokes, lives with **Race:** White or Caucasian **Weight:** 361.3 lbs, 164.2 kg
Pack years: 16.00 **Smoke Time:** 16 Years **Quit Time:** Years
Diagnosis: Wheezing
Referring Physician:
Predicted: 01 EigenWang NHANESIII Caucasian **UID** 429,077,078.00

							t Drug edicted	%Change
FEF75%	L/s	0.83			1.20			45
MVV	L/min,btps	61.48	53 <	116.49	82.12	70 <		34
BP	mmHg	763			762			0
PImax /MIP	cmH2O			-77.83				
PEmax /MEP	cmH2O			97.10				

							t Drug edicted	%Change
							94	12
							89	23
							93	10
							94	26
							76 <	47
								28
								55





Asthma and morbid obesity

Spirometry

	Units	Pre Drug Reported	Pre Drug % Predicted	Predicted	Post Drug Reported	Post Drug % Predicted	%Change
FVC	L,btps	3.50	85	4.14	3.91	94	12
FEV1	L,btps	2.49 <	72 <	3.45	3.06	89	23
FEV1/FVC	%	71 <	84	84	78	93	10
FEFmax	L/s	5.58 <	75 <	7.48	7.04	94	26
FEF25-75%	L/s	1.84 <	52 <	3.57	2.70	76 <	47
FEF25%	L/s	3.88			4.98		28
FEF50%	L/s	2.16			3.35		55
FEF75%	L/s	0.83			1.20		45
MVV	L/min,btps	61.48	53 <	116.49	82.12	70 <	34
BP	mmHg	763			762		0
PImax /MIP	cmH2O			-77.83			
PEmax /MEP	cmH2O			97.10			

Questions?

Pulmonary update 2017

- COPD guidelines (www.goldcopd.org)
- Asthma guidelines (www.ginasthma.org)
- Smoking cessation

COPD

- 2017 GOLD “guidelines” represent the first major revision since 2011
- The ATS also put out a “guideline” for treatment of exacerbations in late 2016 but it’s frankly not as good

COPD update

- Major overhaul to the diagnosis and severity grading system
- The diagnosis of COPD itself still depends on PFT's but the old "staging" system is (mostly) gone as the FEV1 has been shown to be an unreliable marker of prognosis or symptom burden
- Greater emphasis on recognition and treatment of comorbidities (esp. cardiac)

Classification of Severity of Airflow Limitation in COPD*

In patients with $FEV_1/FVC < 0.70$:

GOLD 1: Mild	$FEV_1 \geq 80\%$ predicted
GOLD 2: Moderate	$50\% \leq FEV_1 < 80\%$ predicted
GOLD 3: Severe	$30\% \leq FEV_1 < 50\%$ predicted
GOLD 4: Very Severe	$FEV_1 < 30\%$ predicted

**Based on Post-Bronchodilator FEV_1*

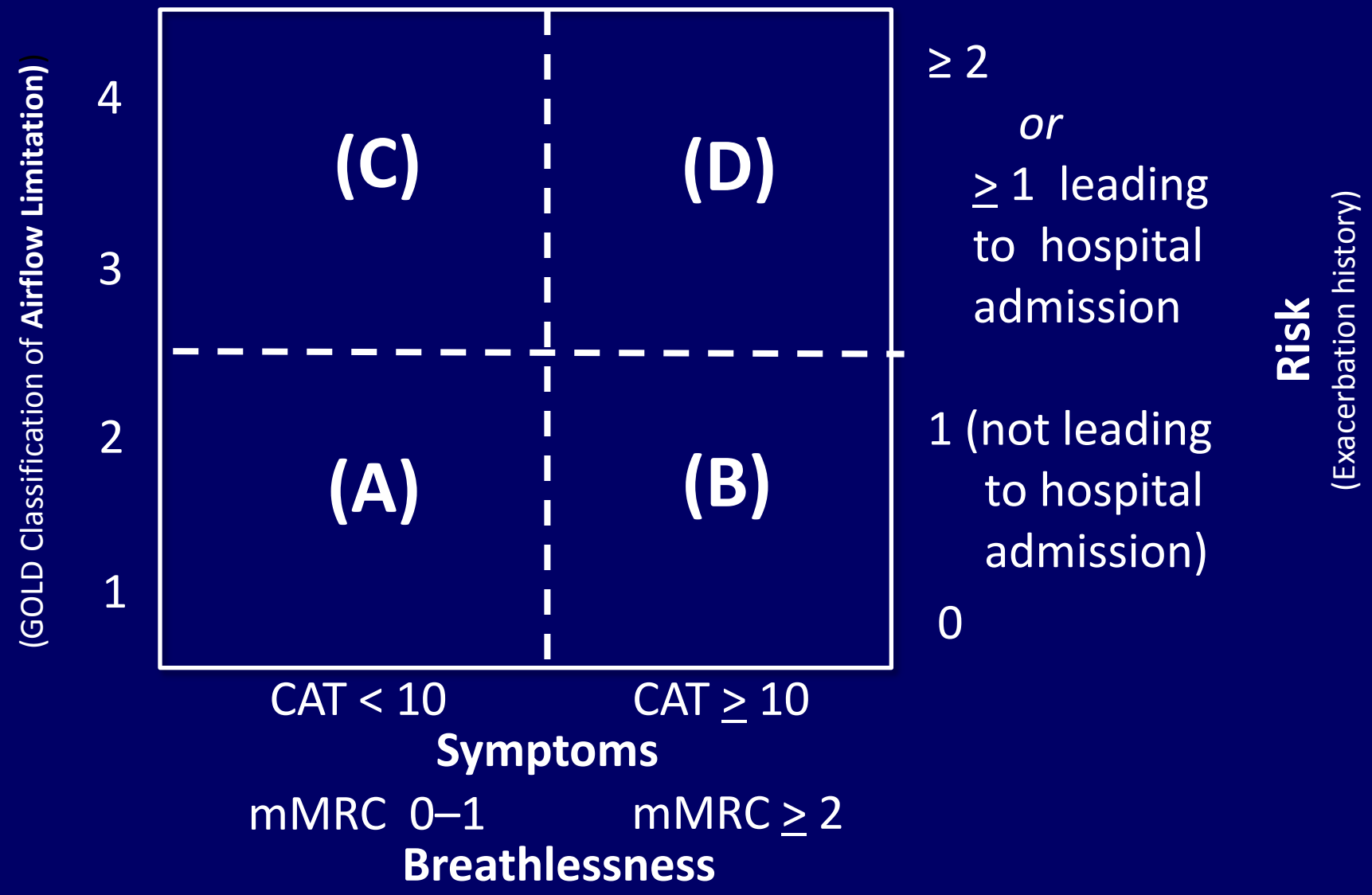
© 2014 Global Initiative for Chronic Obstructive Lung Disease

ABCD System

- The ABCD system was added in 2011 but still relied on the FEV1
- Good concept but by keeping the old severity classification in place it basically just made things more complicated and it was not widely adopted

Global Strategy for Diagnosis, Management and Prevention of COPD

Combined Assessment of COPD

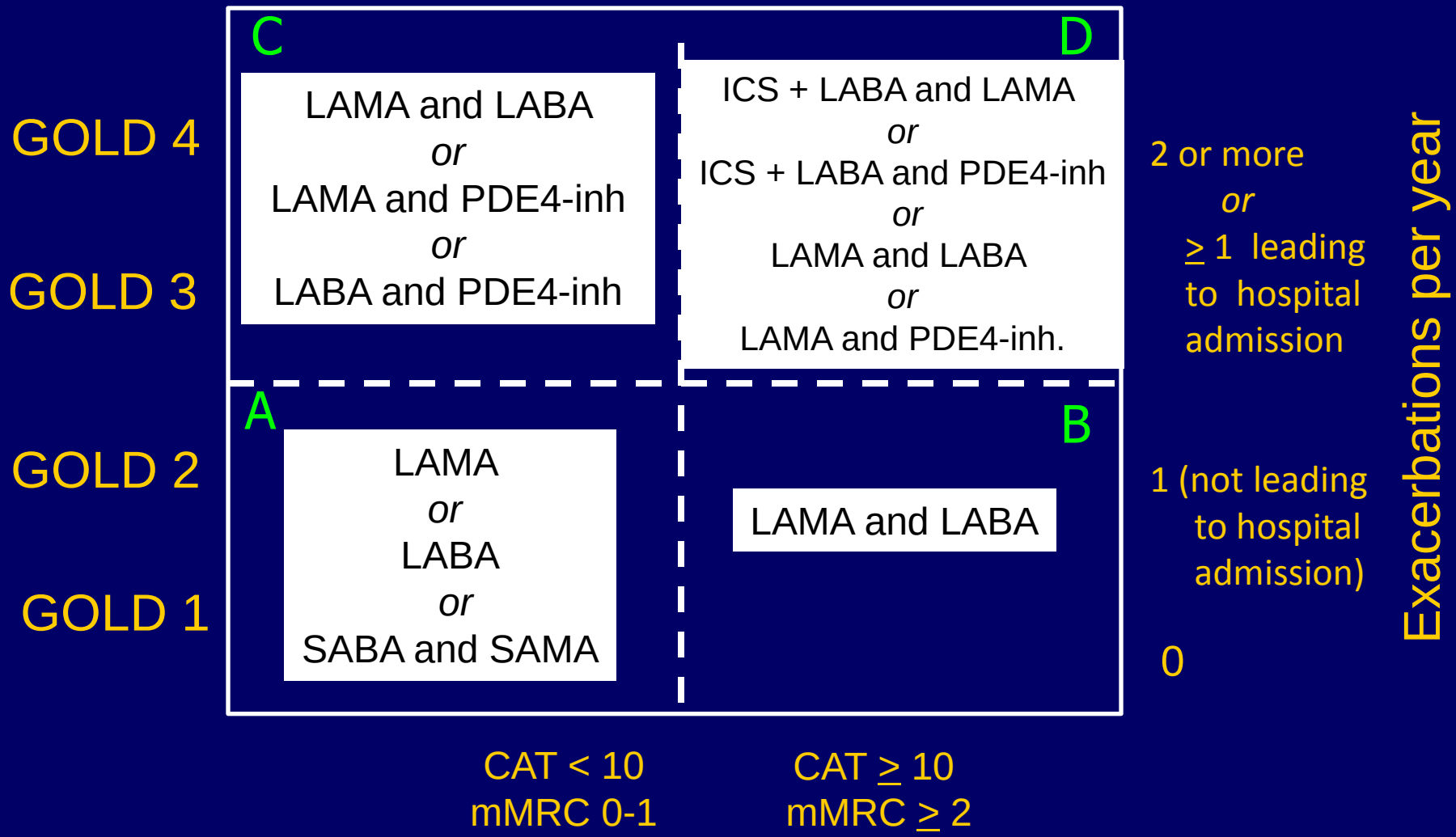


© 2014 Global Initiative for Chronic Obstructive Lung Disease

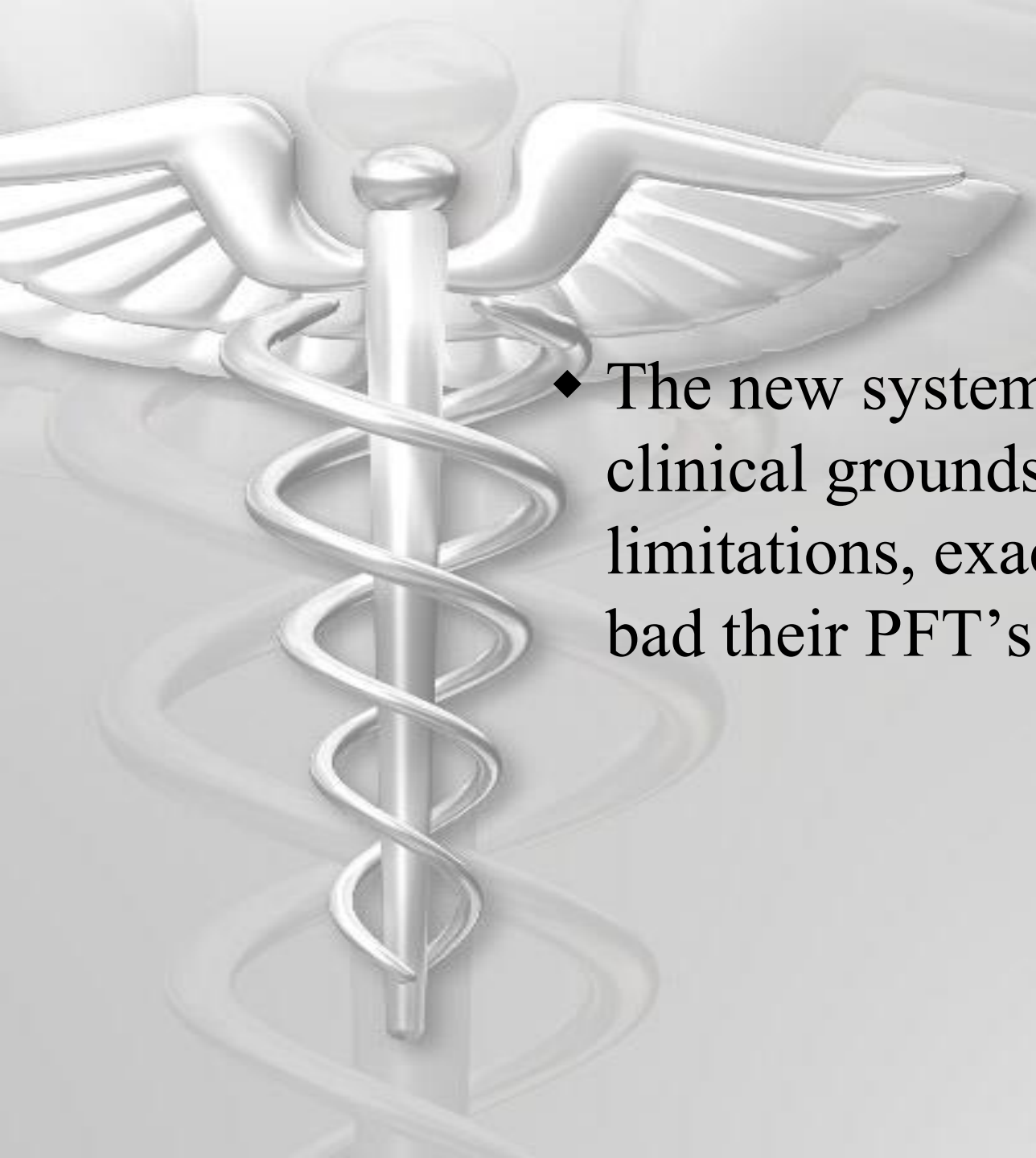
Global Strategy for Diagnosis, Management and Prevention of COPD

Manage Stable COPD: Pharmacologic Therapy

ALTERNATIVE CHOICE



© 2014 Global Initiative for Chronic Obstructive Lung Disease

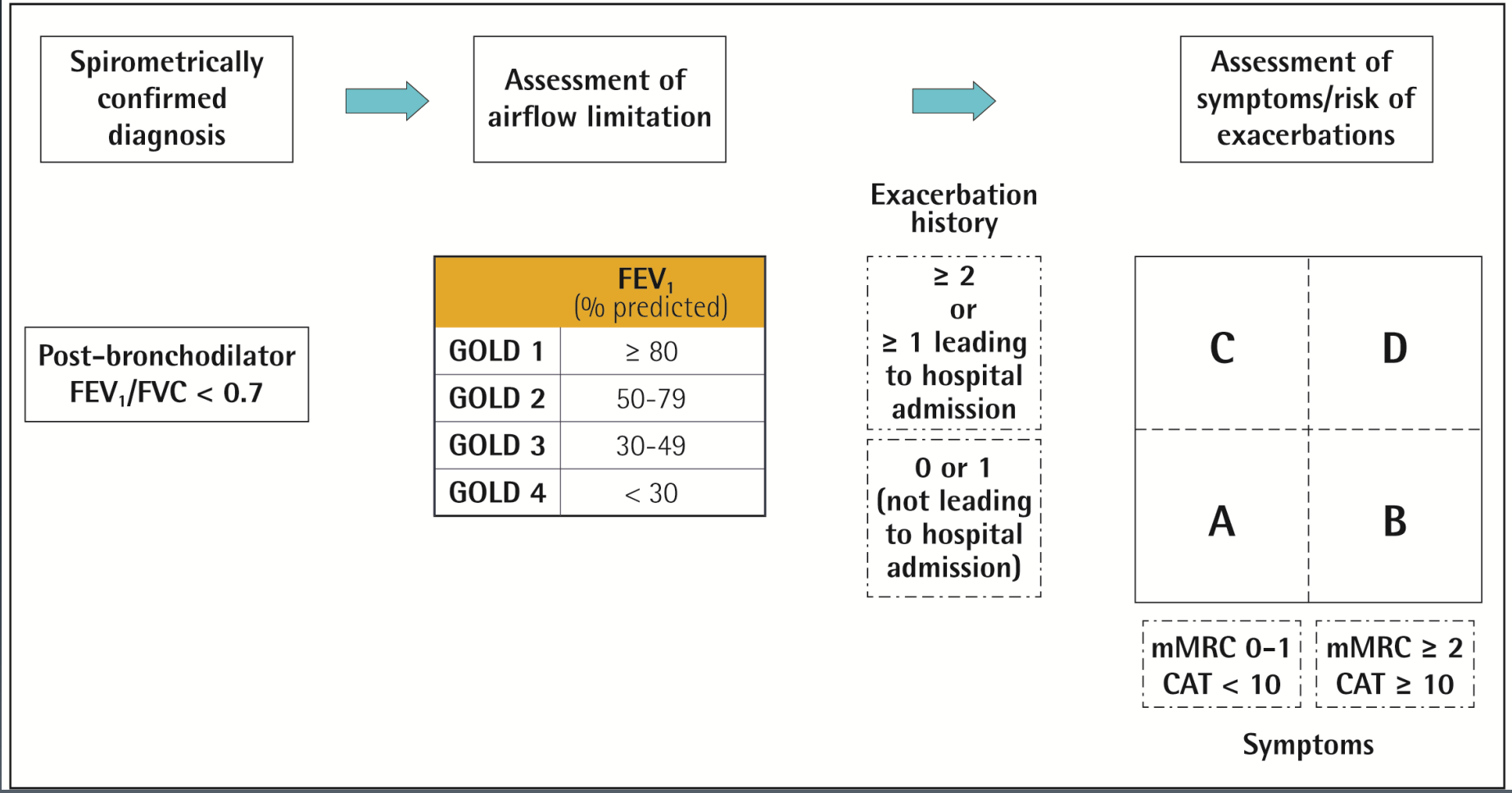


ABCD system

- The new system aims to guide therapy based on clinical grounds (symptoms, functional limitations, exacerbations) and not based on how bad their PFT's look

ABCD Assessment Tool

Figure 2.4. The refined ABCD assessment tool

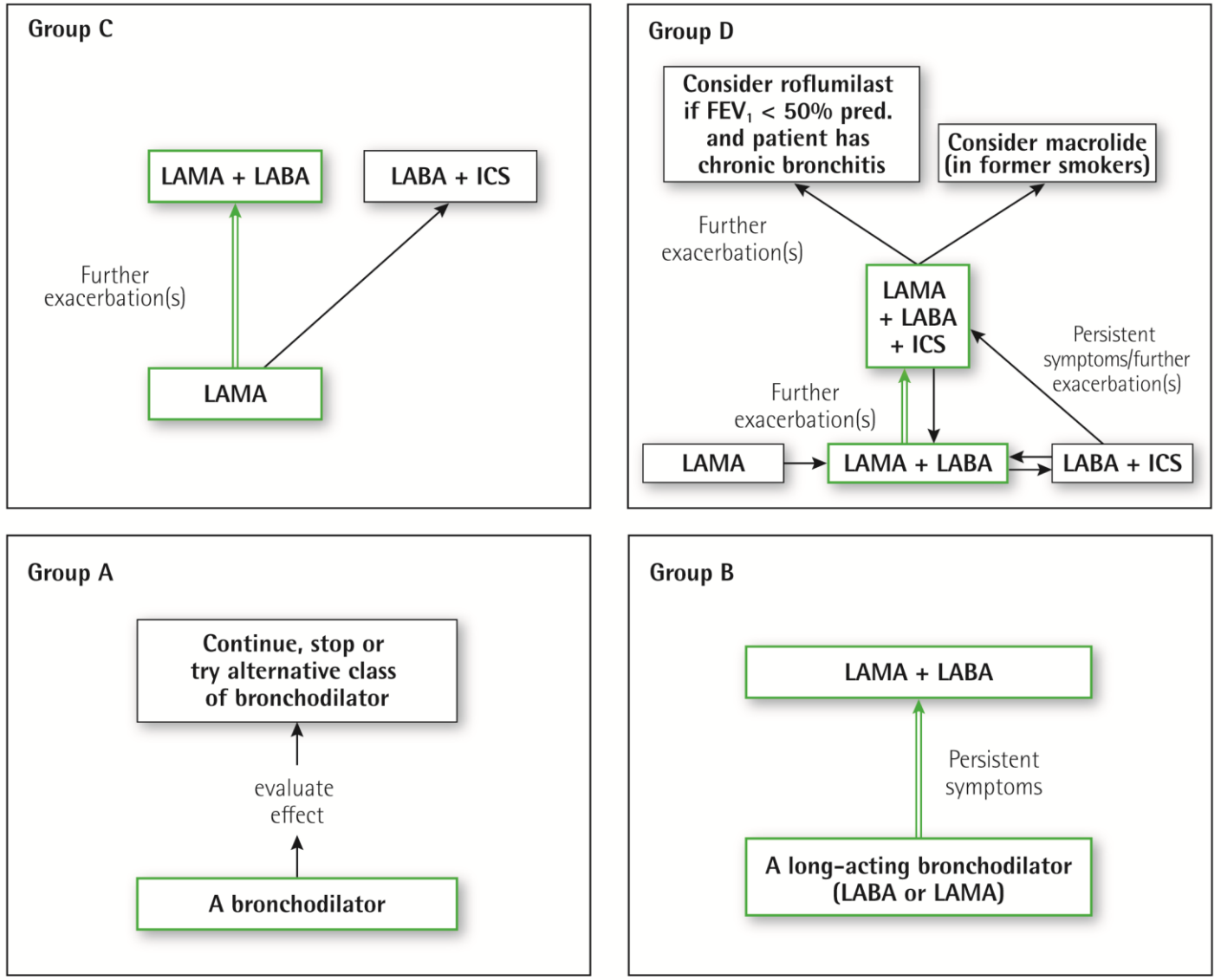


© 2017 Global Initiative for Chronic Obstructive Lung Disease

Simplified ABCD system

C: Mild symptoms, multiple or severe exacerbations	D: Frequent symptoms, multiple or severe exacerbations
A: Mild symptoms, few exacerbations	B: Frequent symptoms, few exacerbations

Figure 4.1. Pharmacologic treatment algorithms by GOLD Grade [highlighted boxes and arrows indicate preferred treatment pathways]



Preferred treatment =

In patients with a major discrepancy between the perceived level of symptoms and severity of airflow limitation, further evaluation is warranted.

© 2017 Global Initiative for Chronic Obstructive Lung Disease

Simplified treatment schema

- Group A: Short acting inhaler(s) PRN, can consider long-acting up front
- Group B: Single agent maintenance inhaler (LAMA preferred)
- Group C: Single or dual agent inhaler (LAMA/LABA preferred)
- Group D: Dual agent inhaler
- Increase as needed based on symptoms or exacerbations

Inhaled steroids in COPD

- Should not be used as a single agent in COPD
- Recent large head to head RCT's show that LABA/ICS combination is inferior to LABA/LAMA combination[1,2]
- High dose ICS (e.g., Advair 500) in particular increases the risk of pneumonia and results in worse overall outcomes[1,3]
- Eosinophilia?

1: N Engl J Med 2016; 374(23):2222-34 2:AJRCCM 2017;195(9)1189-1197 3: Ann Am Thorac Soc 2015; 12(1):27-34

Eosinophilia in COPD

- Higher peripheral eosinophil counts may predict response to steroids and confer a higher exacerbation risk[1-3]
- Probably more valuable than reversibility on PFT's but the available data are inconsistent and the exact cutoff has not been defined
- LABA/LAMA combination still superior regardless of eosinophil counts[4]

1: Lancet Resp Med 2015;3(6):435-42 2: AJRCCM 2015:192(4):523-5 3: Thorax 2016; 71(2):118-25 4: AJRCCM 2017;195(9):1189-1197

Treatment of exacerbations

- Exacerbation treatment recommendations revised slightly:
- Steroids: 40mg prednisone PO daily x 5 days recommended but no more than 7 days
- Antibiotics likely not necessary for the majority of outpatients but can be considered if there is an increase in volume and purulence of sputum.
- Also given for 5-7 days, quinolones no longer recommended due to risk of adverse events

Home oxygen

- Based on a recent large trial oxygen is now only recommended for severe resting hypoxemia (SaO2 <88%)
- No benefit seen for exertional hypoxia and would expect medicare to change reimbursement guidelines at some point

NEJM 2016; 375(17): 1617

Asthma

- In comparison, there are not many revolutionary changes from 2016-2017 versions of the GINA guidelines so will touch on both
- Newer medications and refinements to previously vague recommendations like frequency of PFTs
- Asthma-COPD overlap syndrome is no longer a syndrome – that word was removed to emphasize that it's an overlap of 2 diseases, not a disease in and of itself

Asthma

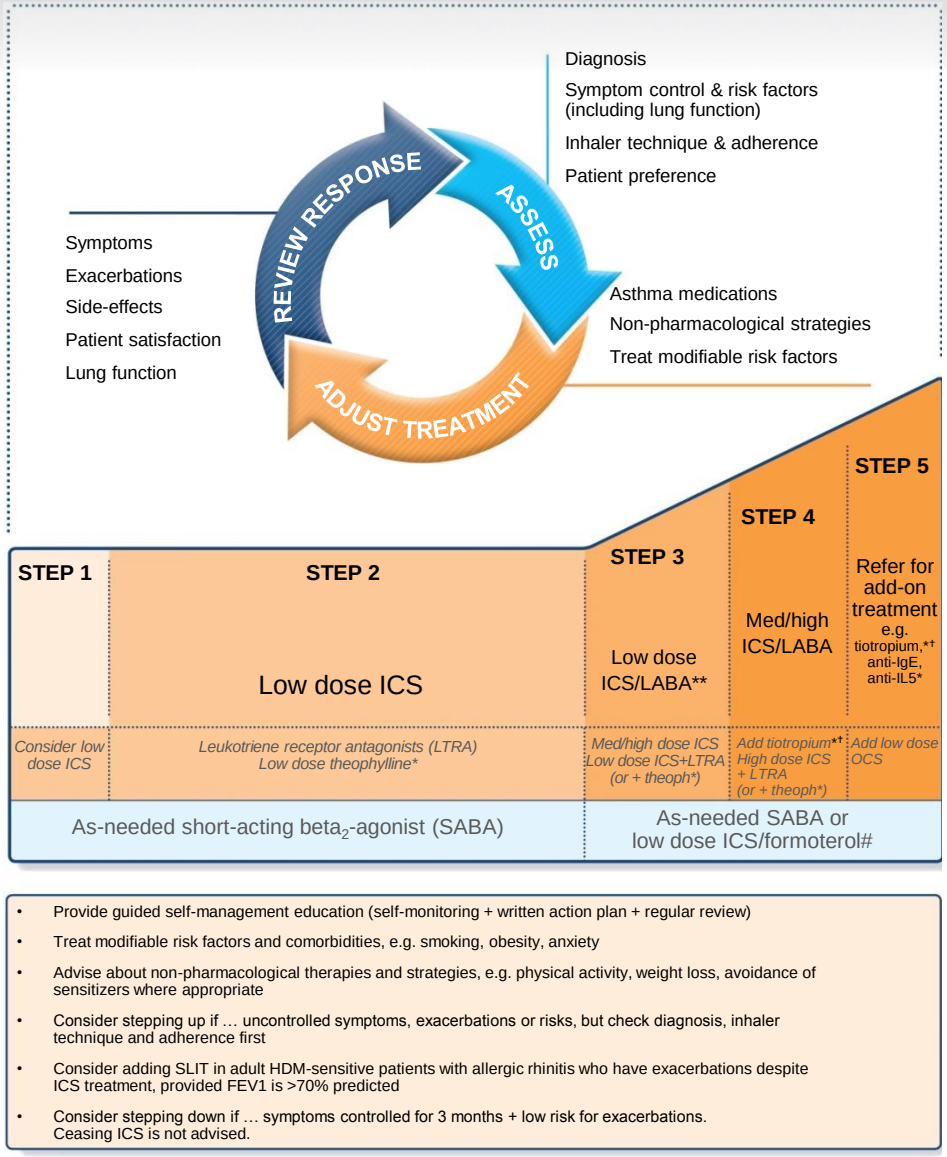
- Most noteworthy changes to the asthma guidelines in 2017 involve newer data regarding allergy treatment:
- Sublingual immunotherapy (SLIT) for dust-mite allergic patients was shown to reduce exacerbations when added on to step 3-4 therapy[1,2]
- Treatment of nasal allergies improves nasal symptoms but not overall asthma control[3]

1:JAMA 2016;315:1715-25 2: J Allergy Clin Immunol 2014;134:568-75.e7 3:J Allergy Clin Immunol 2015;135:701-9.e.5

Asthma – Maintenance therapy

- Newer medications have been added in the past 2 years, including monoclonal antibodies (reslizumab, mepolizumab) as well as tiotropium (Spiriva) for patients age 12 and older

Stepwise approach to control asthma symptoms and reduce risk



SLIT added as an option

© Global Initiative for Asthma itiative for Asthma

Treatment of exacerbations

- Changes in 2016:
- Terminology
- Suggest that doubling of inhaled corticosteroids be added to action plans for home-based management of mild exacerbations
- Can be difficult with combination inhalers and insurance reimbursement

Treatment of exacerbations

- Treatment of moderate-severe exacerbations remains an oral steroid burst (not a taper) of 1-2 mg/kg:
  - Max 50mg qday in adults for 5-7 days
  - Max 40mg qday in children 6-12 years for 3-5 days

Pediatric considerations

- Clarified official recommendation that available data shows that inhaled steroids are safe and do not result in long-term growth inhibition in prepubescent children (6-12 years of age)
- Maternal supplementation with Omega-3 FA's during pregnancy was not shown to reduce the incidence of atopic disease or asthma in early childhood

Am J Clin Nutr 2016;103:128-43

Asthma - Misc

- Data continues to show that Vitamin D supplementation does not improve asthma control or reduce exacerbations
- Expanded discussion about the limitations of exhaled nitric oxide as a diagnostic test, notably that based on the current evidence it cannot be used as the sole test to rule out asthma or determine if patients will respond to inhaled steroids

Smoking cessation

- Varenicline (Chantix) & Buproprion (Zyban/Wellbutrin)
  - FDA “black box” warning about psychiatric side effects has been removed after multiple large studies showed no difference between varenicline, buproprion, nicotine patches, and placebo

Smoking cessation

- E-cigarettes
  - Most patients report using them for smoking cessation or because they are “safer” (as opposed to dealing with no-smoking areas or personal preference)
  - Weak data suggests that they may be equivalent to nicotine patches for cessation but the more likely outcome seems to be that patients simply substitute one for the other

Smoking cessation

- E-cigarettes
  - Potentially “safer” than conventional cigarettes but definitely not risk-free, many carcinogens are still present, just in lower amounts
  - No long-term safety data on other components are available, most notably regarding the effects of vaporized propylene or ethylene glycol that is present in most e-cigarette products

Any questions?

- Assuming I somehow didn’t run out of time