Pulmonary Function Tests (PFTs)

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FREQUENT REQUEST….

- **Please do pulmonary function tests on this patient who is short of breath**

Objectives

- What are PFTs?
- Reason for testing
- Different types of tests
- How to decide which one to order

What are pulmonary function tests?

- Group of procedures that evaluate the way the lung is working
- How it ventilates
- How it oxygenates
- The size of the lung
- Muscle strength
- Exercise tolerance
- Provide information on the degree of impairment and potential causes

Types of tests

- **Spirometry**
  - Bronchodilator response
  - Methacholine testing
- **Lung volumes**
- **Diffusion - DLCO**

Types of tests

- **MIP/MEP** (maximal inspiratory pressure/maximal expiratory pressure)
- **6 Minute Walk Test** (6MWT)
- **Cardiopulmonary exercise testing**
- **Pulse oximetry/ABG**

Why do PFTs?

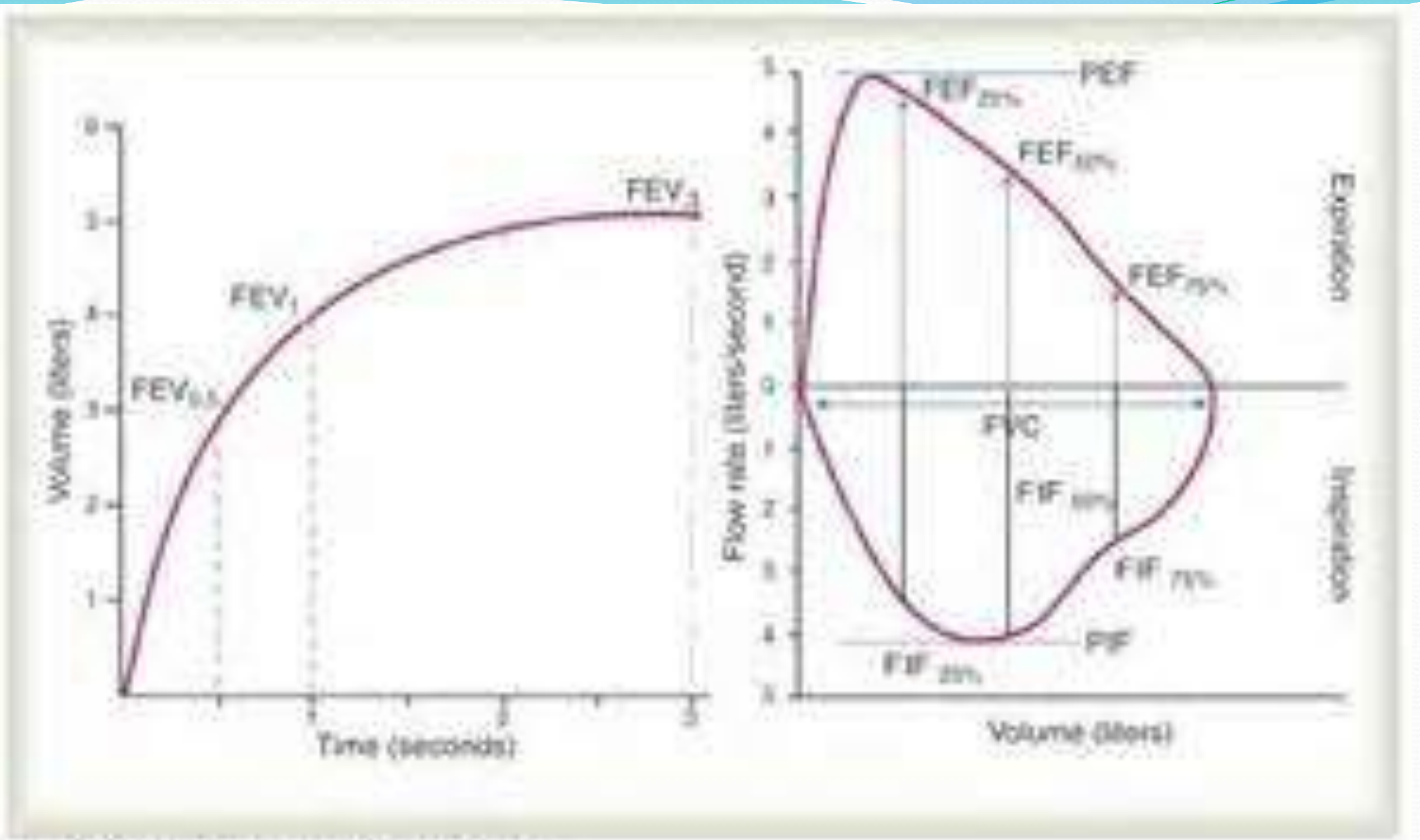
- Detect disease
- Monitor extent and course of disease
- Evaluate treatment
- Measure effects of exposures
- Assess risk for surgical procedures

Pulmonary function tests

- Measurements require:
- Subjects:
  - effort
  - cooperation
- Technician:
  - attention to acceptability
  - repeatability

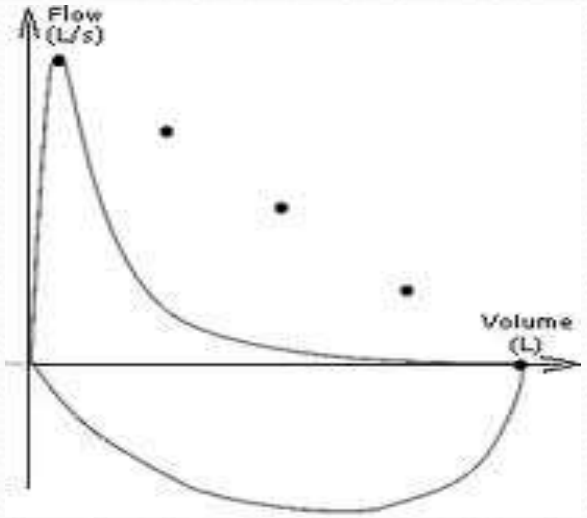
Spirometry

- Most common of the lung function tests
- Pattern of air movement into and out of the lungs during controlled ventilatory maneuvers
- Spirometry measures:
  - many different volumes (how much air is moved)
  - and flow rates (how fast the air moves).


FEV3
FEV1
FEV0.5
Volume (liters)
Time (seconds)
PEF
FEF25%
FEF50%
FEF75%
FVC
FIF50%
FIF75%
PIF
FIF25%
Flow rate (liters/second)
Volume (liters)
Expiration
Inspiration

Obstructive Lung Disease

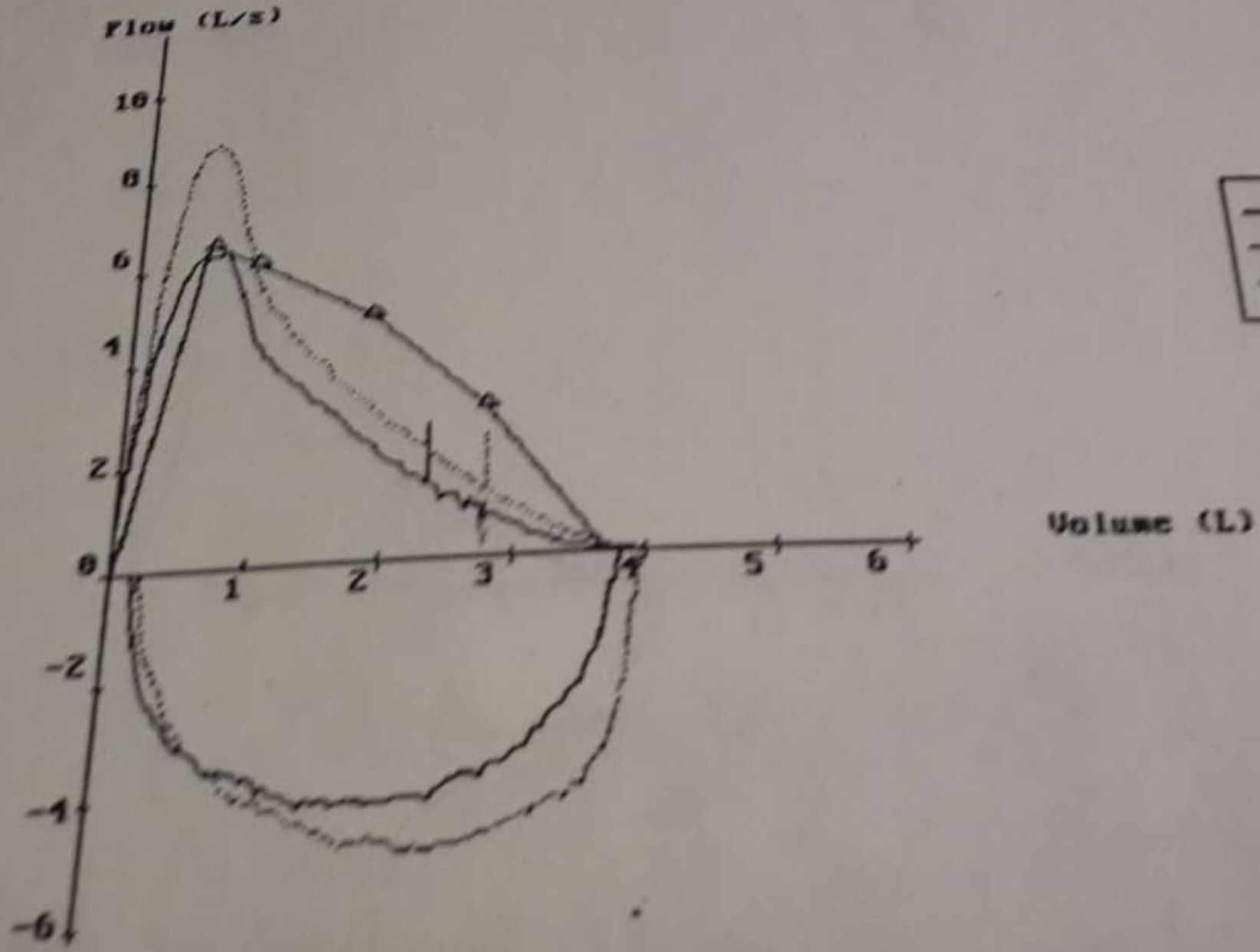
- Shape of flow-volume loop
- FEV1/FVC ratio (< 70)
- FEV1
- Bronchodilator response



Asthma

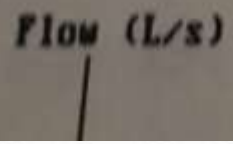
- Used to make diagnosis
  - Decreased FEV1/FVC,
  - Bronchodilator response FEV1 change by 200ml and 12%
- To assess effectiveness of treatment
  - Controlled vs uncontrolled
- Methacholine challenge
- Exercise induced asthma

FEF25% [illegible]
FET (sec)
MVV (L/m)



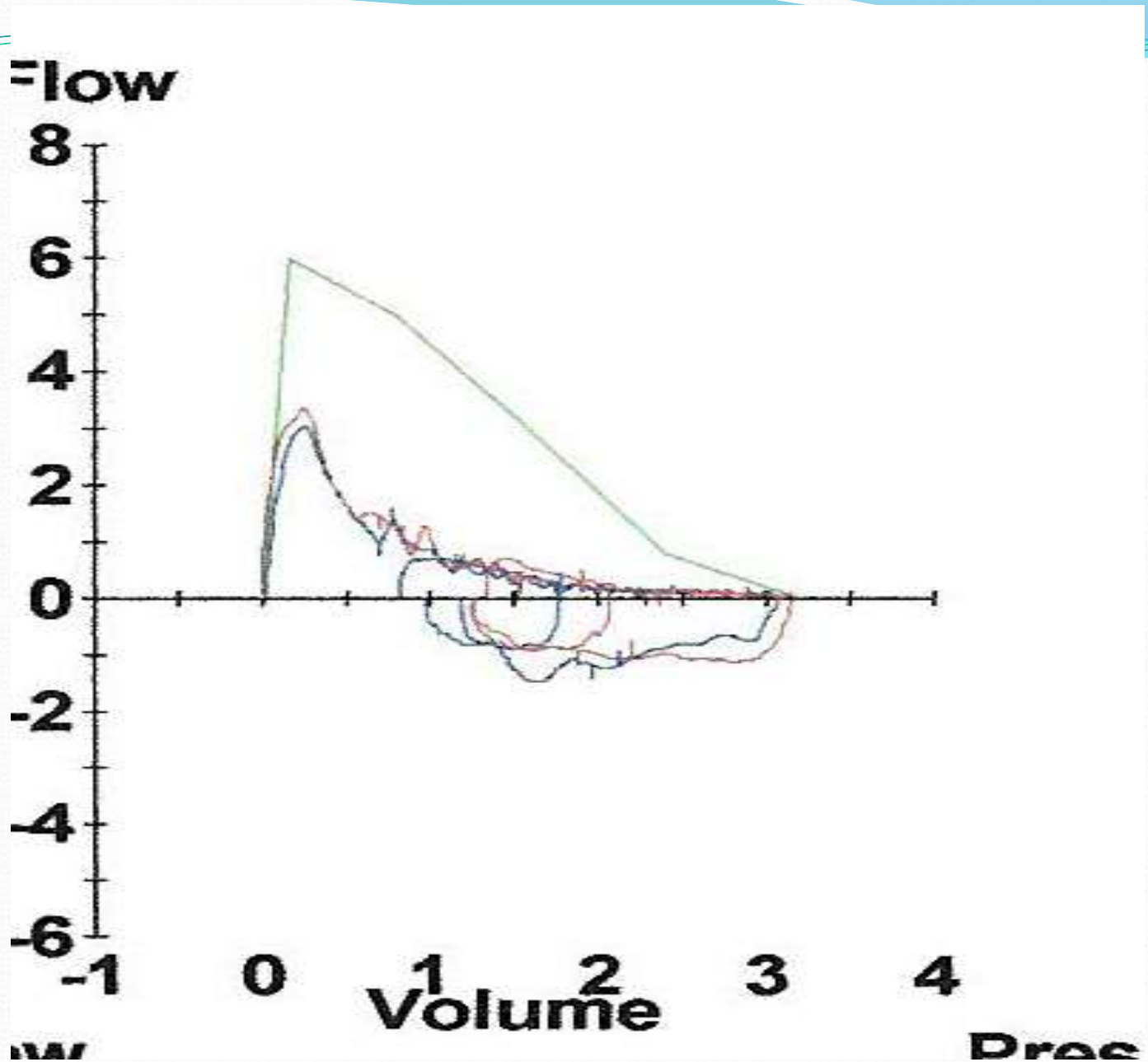
Specialist Note:

	Pre-Dilator			Post-Dilator		
	Actual	% Pred	Pred	Actual	% Pred	%Change
irometry (BTPS)						
FVC (L)	3.80	103	3.70	3.96	107	4
FEV1 (L)	2.36	81	2.90	2.80	97	19
FEV1/FVC (%)	62		78	71		
Peak Flow (L/s)	6.40	97	6.58	8.80	134	38
FEF50% (L/s)	2.32	47	4.89	2.88	59	24
FEF25% (L/sec)	0.80	27	2.93	1.04	35	30
FEF25%-75% (L/s)	1.63	44	3.73	2.06	55	26
FET (sec)	8.33			6.67		
MVV (L/m)			113			



Chronic obstructive pulmonary disease (COPD)

- Frequently radiologists diagnose COPD on Chest radiograph
- Need Spirometry to make diagnosis
- Use FEV1 to assess severity
  - with exacerbations and dyspnea scale


Flow
8
6
4
2
0
-2
-4
-6
-1
0
1
2
3
4
Volume
Pres

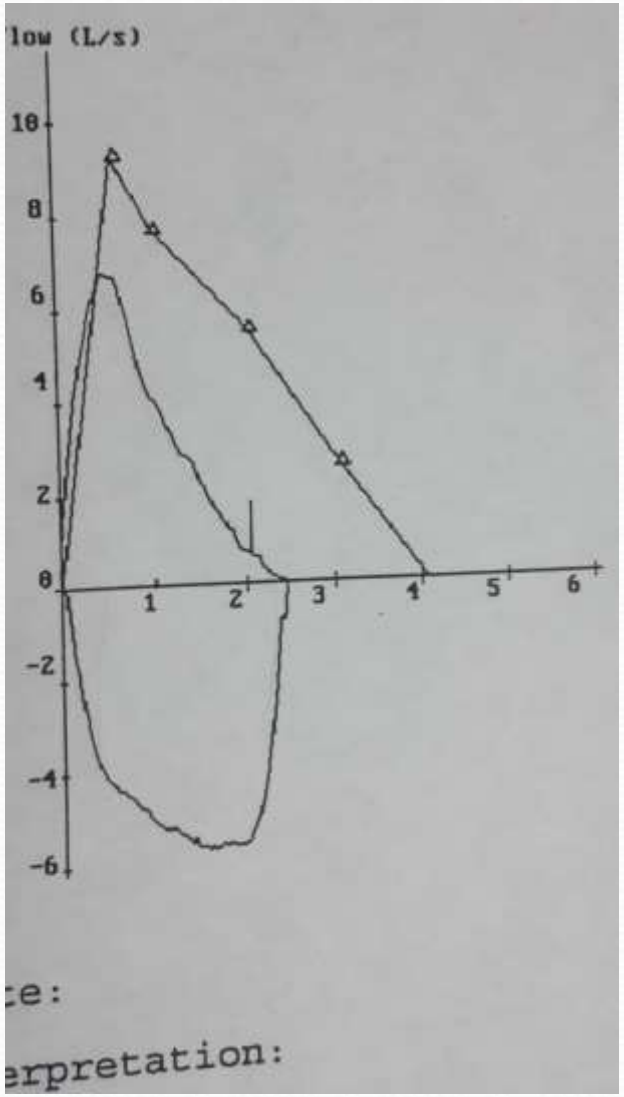
PFT Lab Report

Diagnosis:

		Ref		Pre	% Ref	Post	% Ref	%Chg
ometry								
FVC	Liters	3.22	(2.5 - 3.9)	3.11	97	3.16	98	2
FEV1	Liters	2.56	(2.0 - 3.1)	** 1.19	** 46	** 1.24	** 48	4
FEV1/FVC	%	77	(67.5 - 86.2)	** 38		** 39		
FEF25-75%	L/sec	2.02	(0.7 - 3.3)	** 0.26	** 13	** 0.28	** 14	10
FEF25%	L/sec	4.96	(2.8 - 7.1)	** 0.97	** 20	** 1.39	** 28	43
FEF50%	L/sec	2.94	(2.5 - 3.4)	** 0.24	** 8	** 0.37	** 13	54
FEF75%	L/sec	0.79	(0.2 - 1.4)	** 0.11	** 14	** 0.15	** 20	43
PEF	L/sec	5.98	(4.2 - 7.8)	** 3.05	** 51	** 3.72	** 62	22
FEF/FIF50				0.20		0.37		83

Lung Volumes

- Shape of Flow-volume loop
- FEV1/FVC normal
- FVC or VC reduced



Body plethysmography

Lung Volumes

- Confirming “restriction” when vital capacity (VC) or FVC is reduced on spirometry.
- The causes of a restrictive pattern (reduced VC, RV and TLC) can be divided into three categories:

- Intrinsic (eg, interstitial lung disease)
- Extrinsic (eg, kyphoscoliosis)
- Neuromuscular (eg, Amyotrophic Lateral Sclerosis)

Tech: BMI: 37.37 Pos: Ht(cm): 172.72

	Pre-Dilator Actual	% Pred	Pred	Post-Dilator Actual	% Pred	%Change
Spirometry (BTPS)						
FVC (L)	1.44	45	3.22	1.44	45	0
FEV1 (L)	1.08	57	1.88	1.24	66	15
FEV1/FVC (%)	75		58	86		
Peak Flow (L/s)	3.20	54	5.96	3.20	54	0
FEF50% (L/s)	1.52	40	3.83	2.08	54	37
FEF25% (L/sec)	0.40	37	1.09	0.64	59	60
FEF25%-75% (L/s)	1.28	56	2.29	1.60	70	25
FET (sec)	5.00			4.80		
MVV (L/m)			89			
Lung Volumes (L: BTPS)						
Total Lung Cap	2.96	53	5.55			
Vital Capacity	1.36	42	3.22			
Insp Capacity	0.80	37	2.15			
Funct Resid Cap	2.16	64	3.40			
Exp Reserve Vol	0.56	52	1.07			
Residual Volume	1.60	69	2.33			
RV/TLC Ratio	54		42			

Diffusion abnormalities

- Reflects properties of the alveolar-capillary membrane
- The ease with which oxygen moves from inhaled air to the red blood cells in the pulmonary capillaries.
- Uptake of most soluble gases is limited by pulmonary blood flow
- When alveolar-capillary surface area is reduced there is a reduction in the blood volume in the lungs.
  - idiopathic pulmonary fibrosis
  - emphysema

Diffusing Capacity

DLCO	mL/mmHg/min	21.5	(15.8 - 27.2)	** 10.2	** 47
DL Adj	mL/mmHg/min	21.5	(15.8 - 27.2)	** 10.2	** 47
DLCO/VA	mL/mHg/min/L	4.22	(3.1 - 5.4)	** 2.42	** 57
DL/VA Adj	mL/mHg/min/L	4.22	(3.1 - 5.4)	** 2.42	** 57
VA	Liters			4.21	

DLCO - Obstructive disease

- Chronic "obstructive" bronchitis - normal DLCO
- Emphysema – low DLCO
- Asthma - normal or high DLCO values
- Bronchiolitis obliterans – reduced DLCO
- The DLCO does not correlate well with the degree of dyspnea in COPD
- Helps with predicting exercise intolerance

DLCO – Restrictive disease

- Low DLCO - interstitial lung disease (ILD)
- A normal DLCO associated with low volumes - extrapulmonary cause of the restriction
  - obesity
  - pleural effusion or thickening
  - neuromuscular weakness
  - kyphoscoliosis

DLCO - ILD

- Detection of mild disease
  - Chest irradiation and cancer chemotherapy
  - Use of drugs known to have pulmonary toxicity (eg, amiodarone, bleomycin)
  - Connective tissue disease (eg, systemic sclerosis)
- Changes in follow-up values of DLCO more sensitive to improvement or worsening than are changes in TLC or VC

DLCO - Pulmonary vascular disease

- Decreased DLCO:
  - Chronic recurrent pulmonary emboli or chronic thromboembolic pulmonary hypertension
  - Idiopathic pulmonary arterial hypertension
  - Pulmonary vascular involvement from connective tissue disorders
    - systemic sclerosis, systemic lupus erythematosus, mixed connective tissue disease, rheumatoid arthritis

Maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP)

- MIPs and MEPs aid in evaluating respiratory muscle weakness.
- Most widely used test to assess muscle pressure
  - has no adverse effects and is non invasive
- MIP reflects strength of diaphragm and other inspiratory muscles
- MEP reflects strength of abdominal muscles and other expiratory muscles

Useful in:

- Amyotrophic lateral sclerosis [ALS]
- Myasthenia gravis
- Polymyositis
- Guillain-Barré syndrome
- Systemic conditions that affect skeletal muscle strength

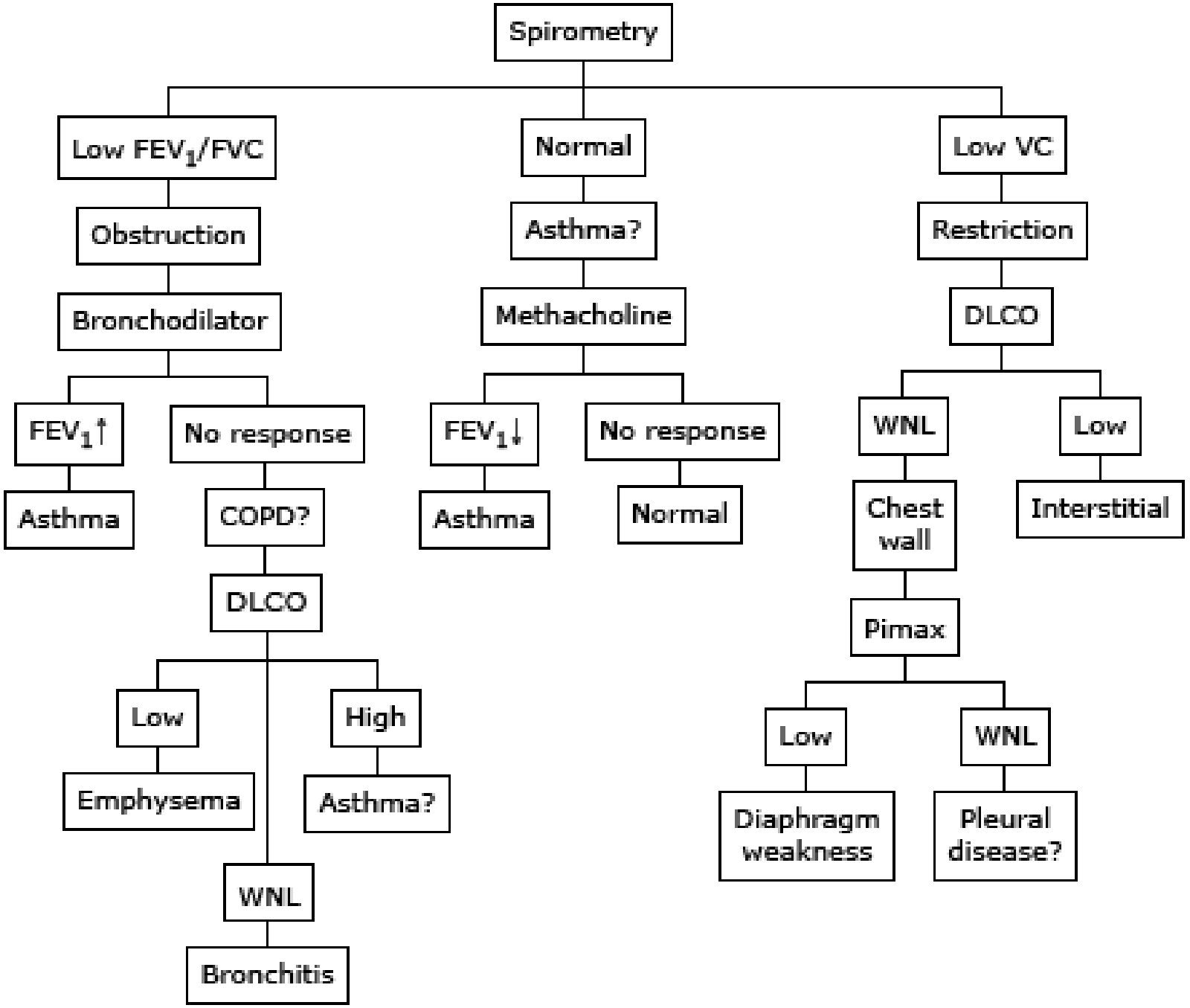
6 Minute Walk Test (6 MWT)

- This test measures distance that a patient can quickly walk on a flat, hard surface in a period of 6 minutes
- Does not provide specific information on the function of different organs and systems involved in exercise or the mechanism of exercise limitation
- Reflects functional exercise level for daily activities
- Usually incorporate pulse oximetry to assess oxygen needs

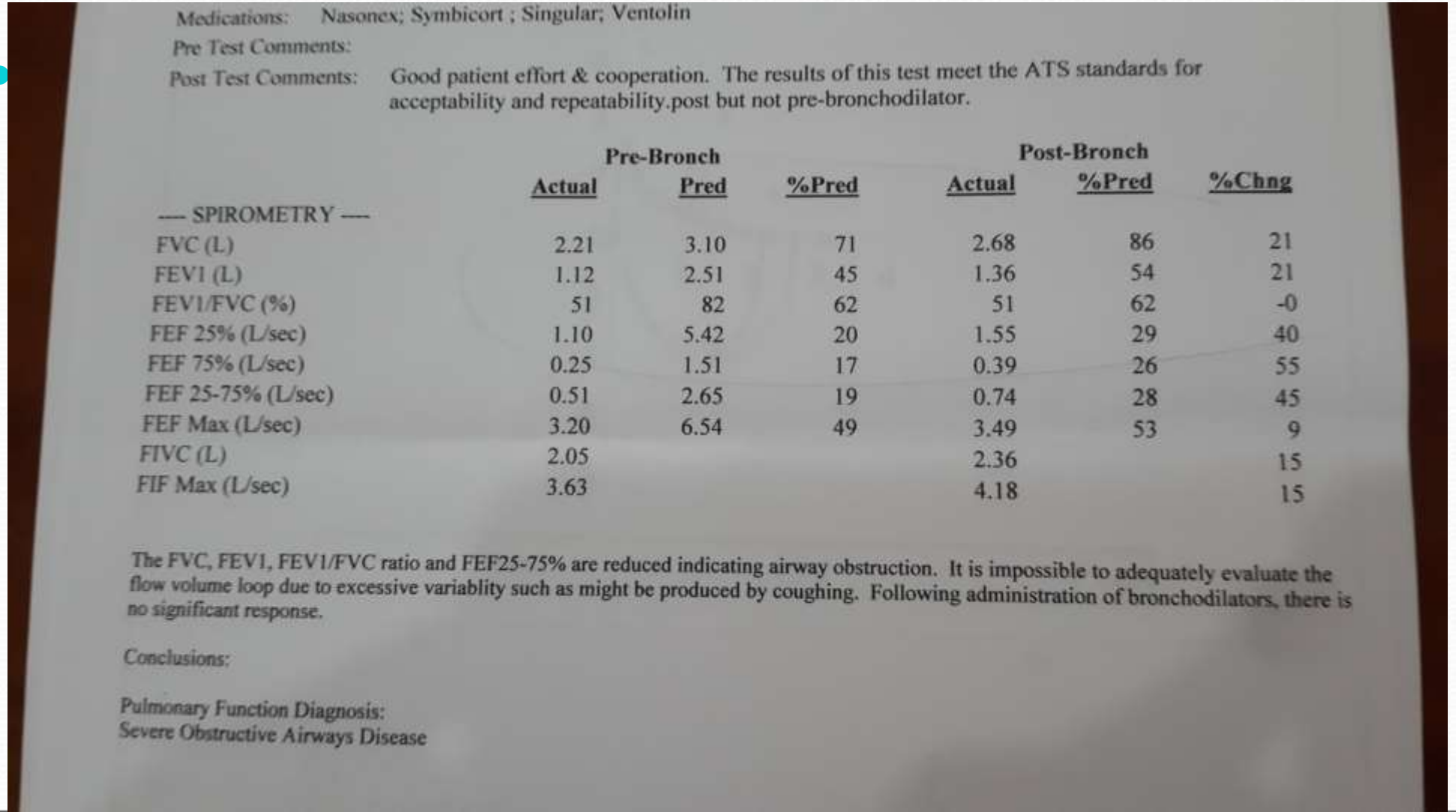
Uses

- Pre treatment and posttreatment comparisons
- Functional status
- Predictor of morbidity and mortality

- **TO SUM IT ALL UP....**


Spirometry
Low FEV1/FVC
Normal
Low VC
Obstruction
Asthma?
Restriction
Bronchodilator
Methacholine
DLCO
FEV1↑
No response
FEV1↓
No response
WNL
Low
Asthma
COPD?
Asthma
Normal
Chest wall
Interstitial
DLCO
Pimax
Low
High
Low
WNL
Emphysema
Asthma?
Diaphragm weakness
Pleural disease?
WNL
Bronchitis

CASE 1



Medications: Nasonex; Symbicort ; Singular; Ventolin

Pre Test Comments:

Post Test Comments: Good patient effort & cooperation. The results of this test meet the ATS standards for acceptability and repeatability.post but not pre-bronchodilator.

	Pre-Bronch			Post-Bronch		
	Actual	Pred	%Pred	Actual	%Pred	%Chng
— SPIROMETRY —						
FVC (L)	2.21	3.10	71	2.68	86	21
FEV1 (L)	1.12	2.51	45	1.36	54	21
FEV1/FVC (%)	51	82	62	51	62	-0
FEF 25% (L/sec)	1.10	5.42	20	1.55	29	40
FEF 75% (L/sec)	0.25	1.51	17	0.39	26	55
FEF 25-75% (L/sec)	0.51	2.65	19	0.74	28	45
FEF Max (L/sec)	3.20	6.54	49	3.49	53	9
FIVC (L)	2.05			2.36		15
FIF Max (L/sec)	3.63			4.18		15

The FVC, FEV1, FEV1/FVC ratio and FEF25-75% are reduced indicating airway obstruction. It is impossible to adequately evaluate the flow volume loop due to excessive variablity such as might be produced by coughing. Following administration of bronchodilators, there is no significant response.

Conclusions:

Pulmonary Function Diagnosis:
Severe Obstructive Airways Disease

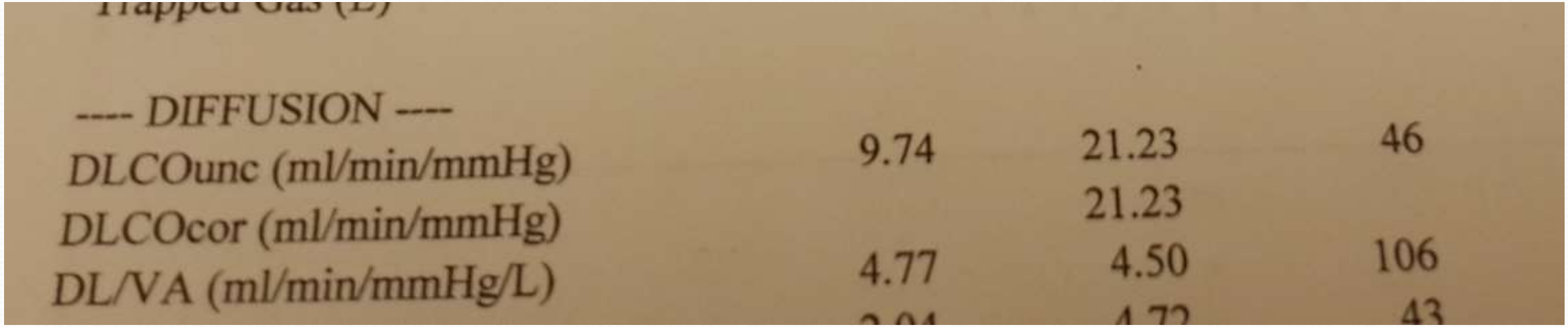
CASE 2

	Pre-Bronch		
	Actual	Pred	%Pred
---- SPIROMETRY ----			
FVC (L)	1.74	2.88	60
FEV1 (L)	1.50	2.40	62
FEV1/FVC (%)	86	84	102
FEF 25% (L/sec)	4.98	5.30	94
FEF 75% (L/sec)	0.66	1.74	38
FEF 25-75% (L/sec)	1.81	2.79	65
FEF Max (L/sec)	5.17	6.34	81
FIVC (L)	1.77		
FIF Max (L/sec)	4.20		

Case 2

---- LUNG VOLUMES ----			
SVC (L)	1.56	2.88	54
IC (L)	1.06	2.14	49
ERV (L)	0.51	0.74	69
TGV (L)	1.60	2.58	62
RV (Pleth) (L)	1.10	1.41	78
TLC (Pleth) (L)	2.66	4.72	56
RV/TLC (Pleth) (%)	41	30	137
Trapped Gas (L)			

Case 2



Trapped Gas (L)			
---- DIFFUSION ----			
DLCOunc (ml/min/mmHg)	9.74	21.23	46
DLCOcor (ml/min/mmHg)		21.23	
DL/VA (ml/min/mmHg/L)	4.77	4.50	106
	2.04	4.72	43

SUMMARY

- There is more to lung function testing than spirometry
  - Lung volumes, DLCO, MIPs, MEPs, 6MWT
- Patient needs to be able to cooperate
- Request the most useful test for your patient
- Interpret results in clinical context

THANK YOU

Lung volumes

- In obesity, VC and TLC may remain within normal limits, but functional residual capacity (FRC) can exponentially decrease.
- Increased lung volumes, particularly residual volume (RV), are commonly observed in airway obstruction.
- TLC may be normal, but is frequently increased in the late stages of COPD.

Lung Volumes

TLC	Liters	5.47	(4.5 - 6.4)	** 6.93	** 127
VC	Liters	3.33	(2.6 - 4.1)	3.11	93
FRC PL	Liters	2.98	(2.2 - 3.8)	** 4.94	** 166
ERV	Liters	1.04	(0.8 - 1.3)	0.99	95
RV	Liters	2.10	(1.5 - 2.7)	** 3.82	** 182
RV/TLC	%	42	(29.9 - 54.6)	** 55	

Lung Volumes