PULMONARY FUNCTION TESTING (PFT)

A JOURNEY FOR DEEP UNDERSTANDING OF HOW THINGS WORK

DR. ABDULLAH AL-JAOUNI, MD

DEC 2025

PFT

A comprehensive **group of diagnostic tests**, not a single procedure, used to quantify the functional status of the respiratory system.

They evaluate the integrated performance of the **airways** (large and small), **lung parenchyma** (alveoli and interstitium), **pulmonary vasculature**, **chest wall** and **respiratory muscles**, and **neural respiratory control**.

- **Standard**:
  - Spirometry
  - Lung volumes
  - Diffusion Capacity of the Lung for Carbon Monoxide (DL_{CO})
- **Specialized**:
  - Arterial Blood Gases (ABG)
  - Exercise oximetry
  - 6 Minute walk test
  - Peak flow
  - Maximum inspiratory and expiratory pressures

PURPOSES OF PFT

1. **Evaluate** the signs and symptoms of lung disease
2. **Classify** asthma and COPD
3. **Assess** the progression of lung disease
4. **Monitor** the effectiveness of therapy
5. **Evaluate** preoperative patients in selected situations

Obstructive Lung Disease

- COPD (chronic bronchitis ↔ emphysema)
- Asthma
- Bronchiectasis
- Cystic fibrosis

Restrictive Lung Disease

- Interstitial lung disease (e.g. pulmonary fibrosis, sarcoidosis)
- Chest wall pathology (e.g. kyphosis, scoliosis)
- Obesity
- Neuromuscular disease (e.g. ALS, muscular dystrophy)

Pulmonary Vascular Disease

- Primary pulmonary hypertension
- Chronic thromboembolic disease

STANDARD PFT

Spirometry

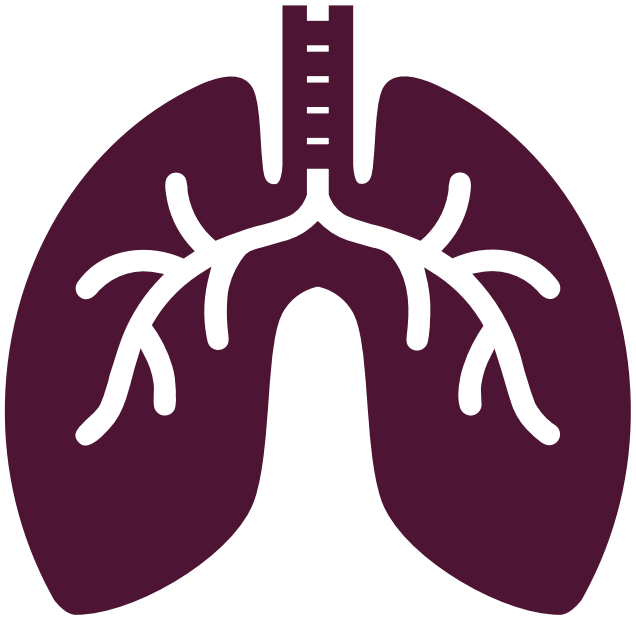
- A test measuring the **volume of air** an individual can inhale or exhale as a function of **time**.

Lung Volumes (and Capacities)

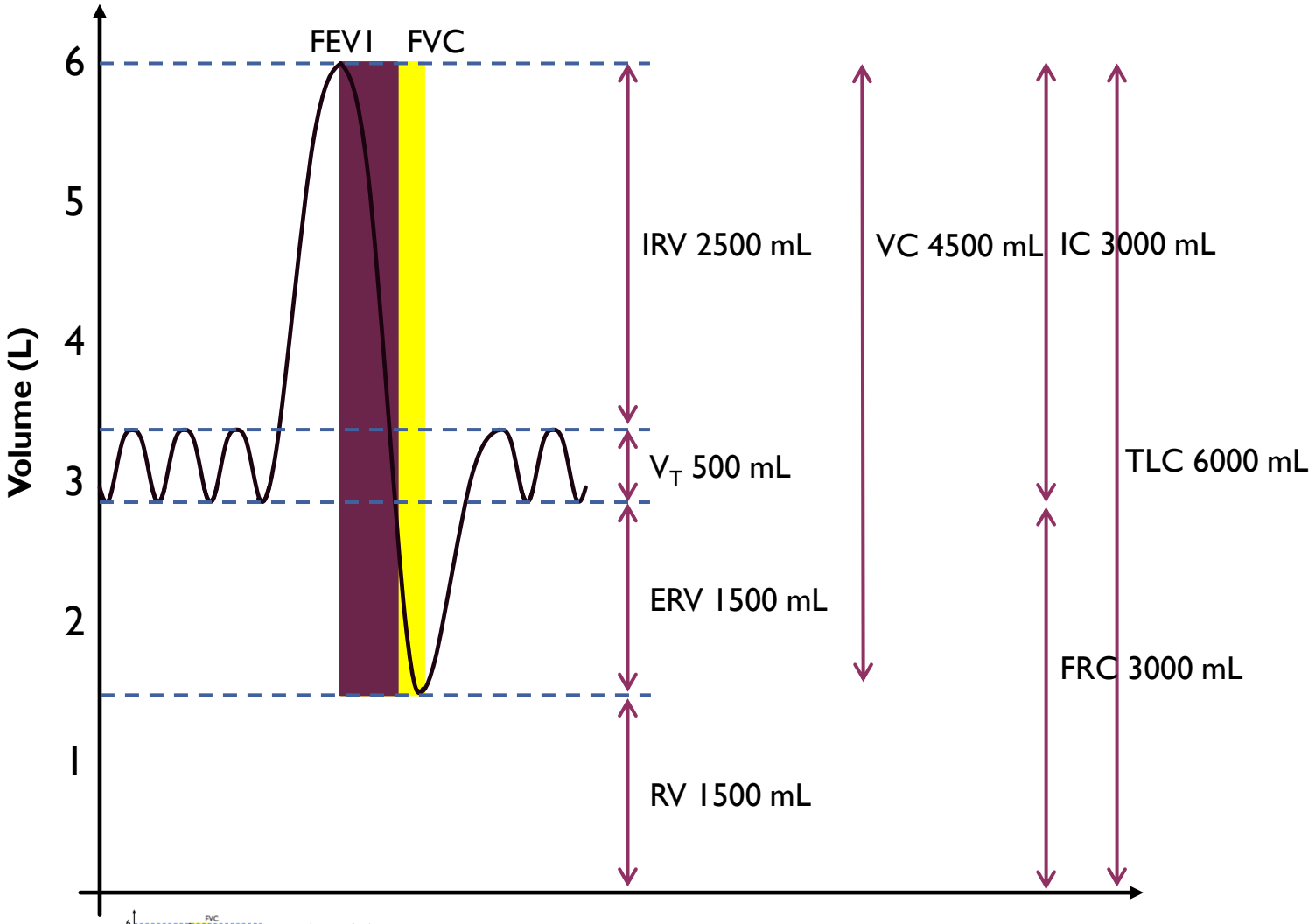
- Measurements that quantify the specific amount of air present in the lungs at various stages of the respiratory cycle.
- **Volumes** are primary measurements; **Capacities** are the sum of two or more volumes.

Diffusing Capacity of the Lung for Carbon Monoxide

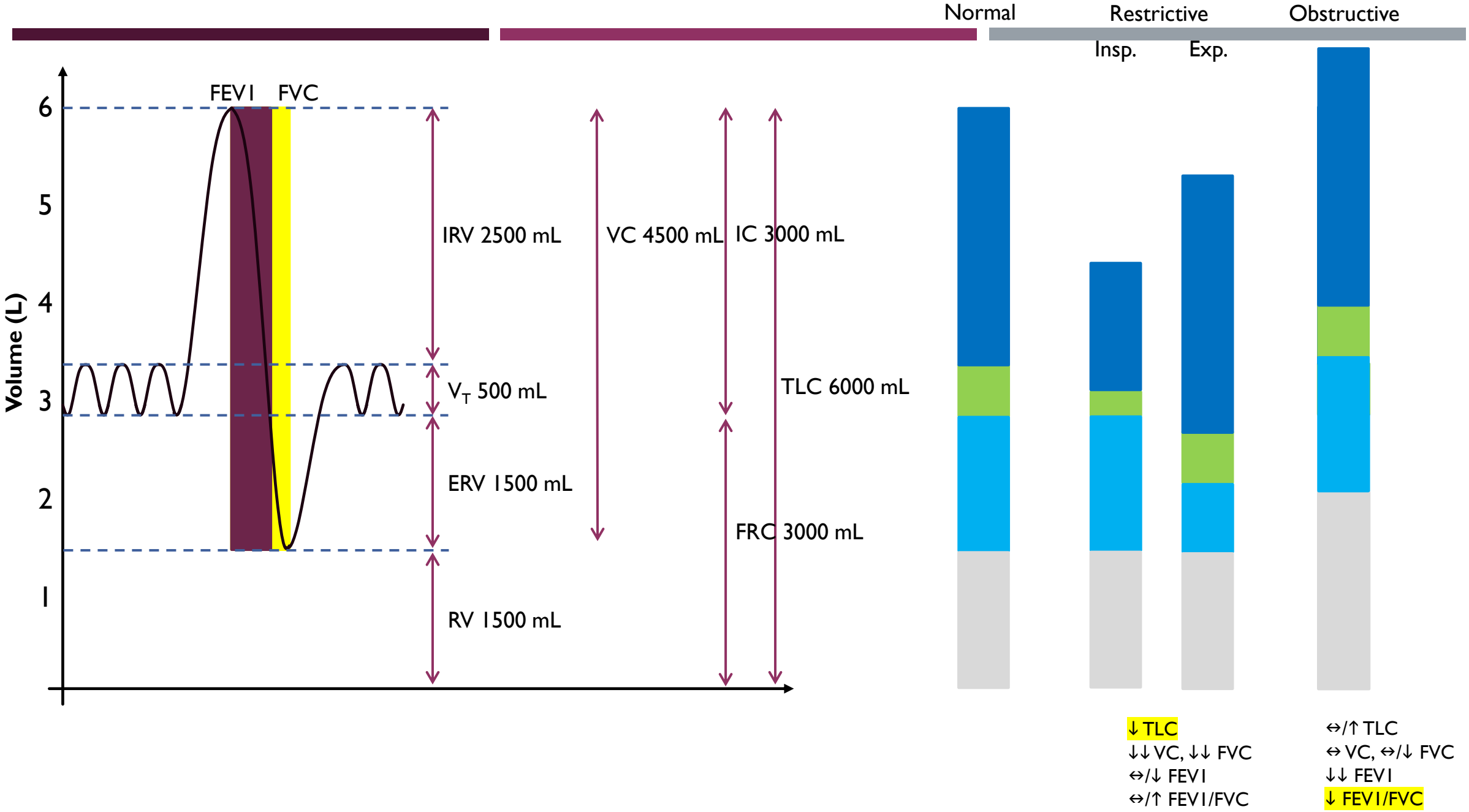
- A test measuring the ability of the lungs to transfer gas from the inhaled air to the red blood cells in pulmonary capillaries.
- It serves as a direct marker for the integrity of the **alveolar-capillary membrane**.

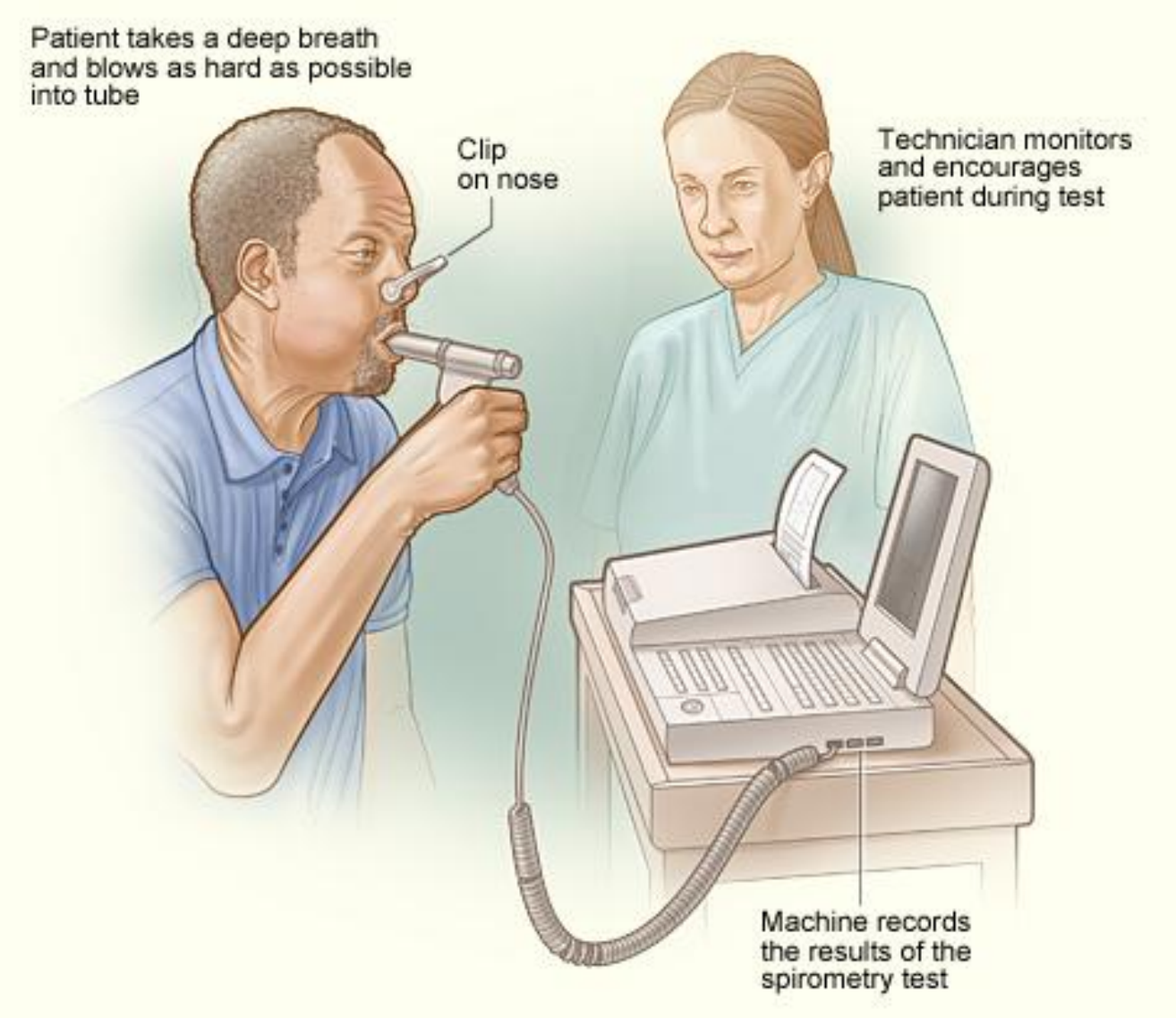


LUNG VOLUMES



	Name	Definition
V_T	**Tidal Volume**	The volume of air inspired **or** expired during a single normal breath.
IRV	**Inspiratory Reserve Volume**	The maximum volume of air that can be inspired after a normal tidal inspiration.
ERV	**Expiratory Reserve Volume**	The maximum volume of air that can be exhaled after a normal tidal expiration.
RV	**Residual Volume**	The volume of air remaining in the lungs after a maximal forced expiration.
FRC	**Functional Residual Capacity**	The volume of air remaining in the lungs after a normal tidal expiration (ERV + RV).
IC	**Inspiratory Capacity**	The maximum volume of air that can be inspired from the resting expiratory level (V_T + IRV).
VC	**Vital Capacity**	The maximum volume of air that can be expired after a maximal inspiration (V_T + IRV + ERV).
TLC	**Total Lung Capacity**	The total volume of air contained in the lungs at the end of a maximal inspiration (VC + RV).


Normal
Restrictive
Obstructive
Insp.
Exp.
FEV1
FVC
Volume (L)
6
5
4
3
2
1
IRV 2500 mL
VC 4500 mL
IC 3000 mL
V_T 500 mL
TLC 6000 mL
ERV 1500 mL
FRC 3000 mL
RV 1500 mL
↓ TLC
↓↓ VC, ↓↓ FVC
↔/↓ FEV1
↔/↑ FEV1/FVC
↔/↑ TLC
↔ VC, ↔/↓ FVC
↓↓ FEV1
↓ FEV1/FVC



SPIROMETRY

LET'S PUFF!

PRECAUTIONS .. PREPARATION .. EXECUTION

Precautions

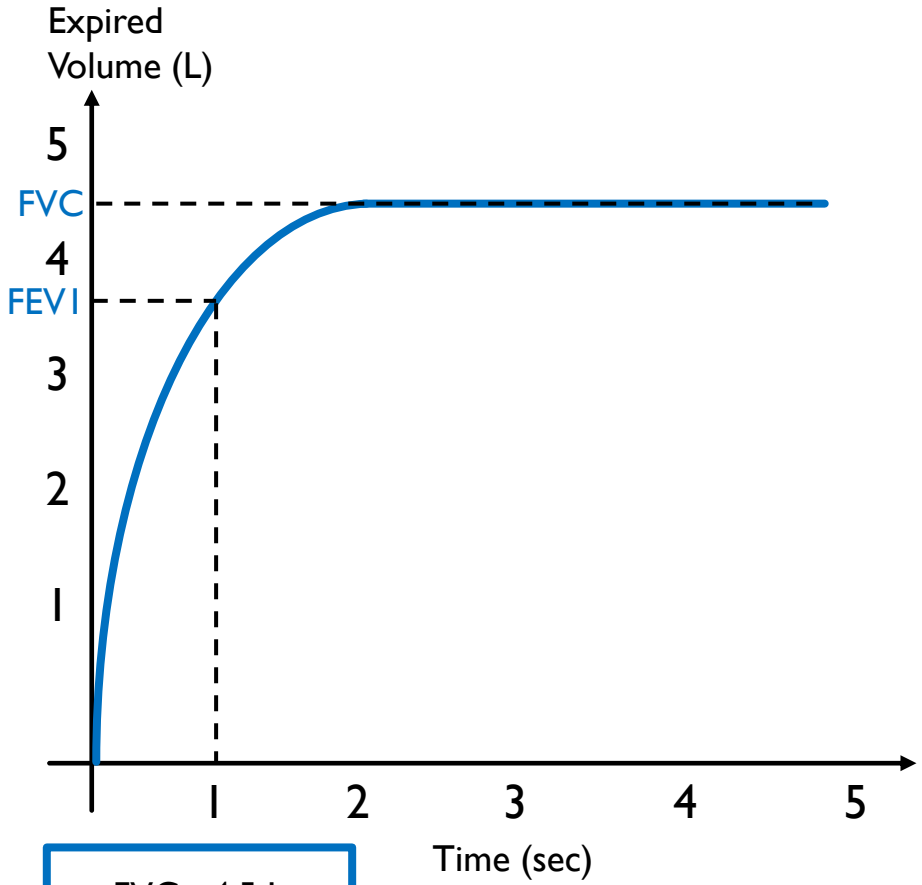
- No smoking within 2 hours of the test
- No vigorous exercising
- Do not eat a heavy meal before the test
- Do not take a short-acting bronchodilator within 4 to 6 hours
- Do not take a long-acting inhaled bronchodilator within 12 hours
- Do not wear restrictive clothing during the test

Preparation

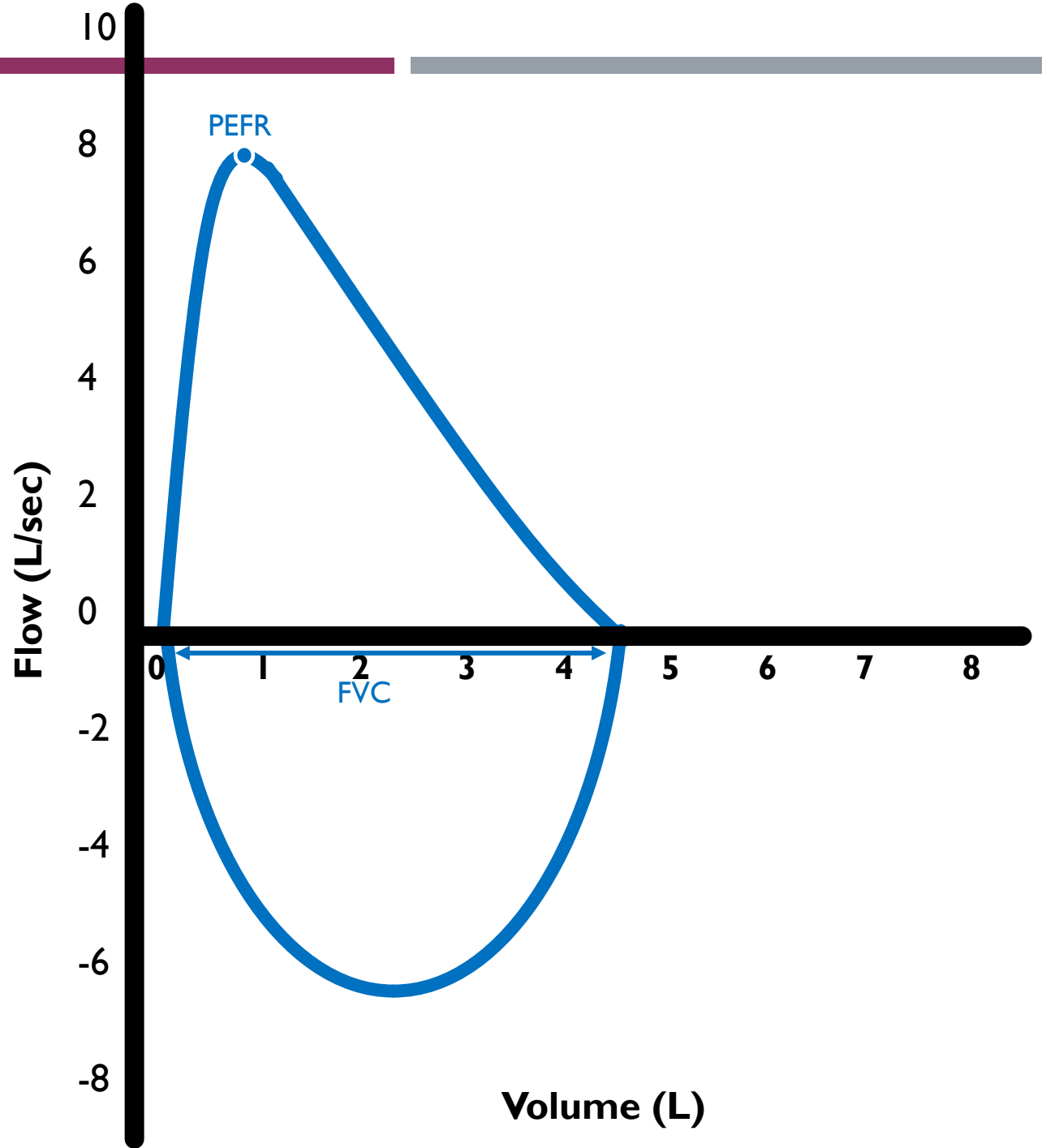
- Record the patients name, age, gender , ethnicity, smoking history, weight and height on the spirometer
- Make sure the patient is sitting upright, feet flat on the floor (legs not crossed
- Give clear instructions about the test procedure
- Teach the patient how to make a good seal with the mouthpiece
- Apply a nose clip

Execution

- Give the patient the following instructions:
  - Take a few normal breaths
  - Take the deepest breath you can take
  - Exhale the air as strong and as fast as possible (continue for approximately 6 seconds)
  - Then take a deep breath back in
- Repeat the process three times; give the patient a chance to rest between trials
- The highest value among three close test results is used as the final result.



FVC= 4.5 L
FEV1= 3.6 L
FEV1/FVC= 80%
Normal is >70%



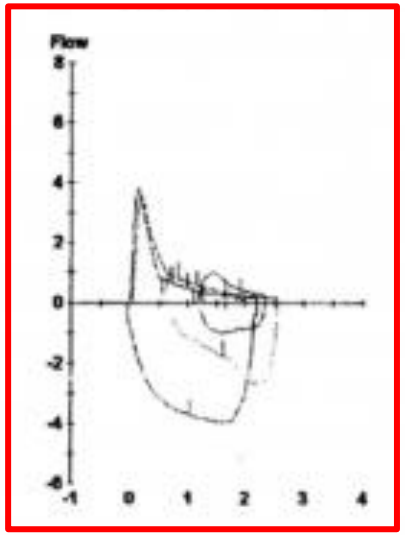
Height(in): 73 Weight(lb): 277 Age: 60 Gender: Male
Date: 05/19/99 Race: Caucasian Physician: GMC

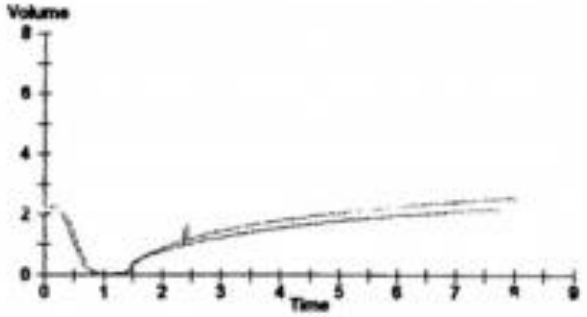
SPIROMETRY

		Ref	Pre Meas	Pre % Ref	Post Meas	Post % Ref	Post % Chg
FVC	Liters	5.04	2.19	43			
FEV1	Liters	4.04	1.01	25			
FEV1/FVC	%	79	46				
FEF25-75%	L/sec	4.02	0.49	12			
FEF50%	L/sec	4.92	(0.41)	(8)			
FEF75%	L/sec	1.87	(0.27)	(14)			
PEF	L/sec	9.33	4.09	44			
MVV	L/min	150	(42)	(28)			
MVV Length			12				

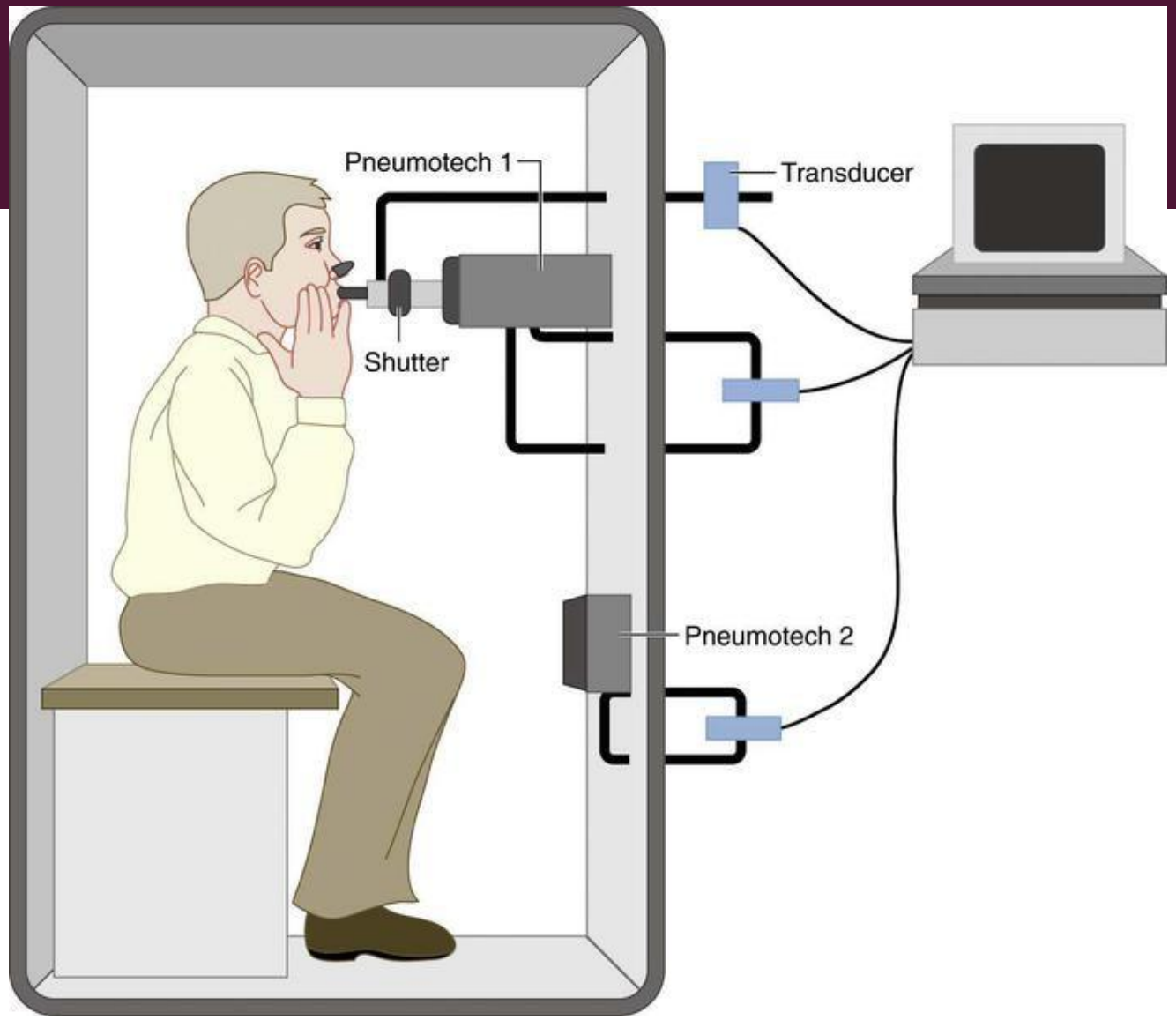
Values are reported as a % of that predicted (% Ref)

"Normal" is generally considered within ~80 120% predicted



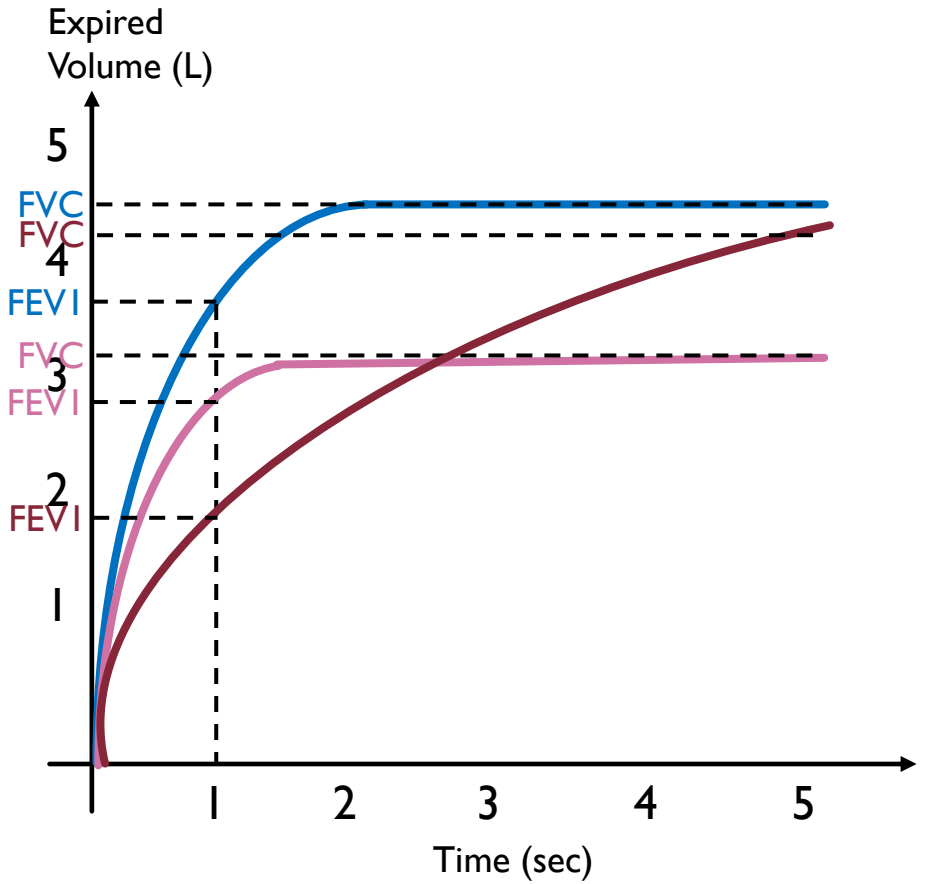


Parameter	Definition
FVC	The total volume of air that can be forcibly exhaled from the lungs after taking the deepest breath possible.
FEV1	The volume of air exhaled during the first second of the FVC maneuver.
FEV1/FVC	The fraction of the total air capacity that can be exhaled in one second.
PEFR	The maximum speed of expiration, reflecting large airway patency and expiratory muscle strength.
FEF	The flow rate of expired air at a specific cutoff point of the total FVC, for example, **FEF 25%** is the flow rate at the moment where 25% of the FVC is expired.
FEF 25-75%	The average flow rate during the middle half of the FVC maneuver; often used as an indicator of **small airway** function.
MVV	The maximum volume of air that can be breathed in and out in one minute (usually measured over 12 seconds and extrapolated), reflecting the overall endurance of the respiratory system.

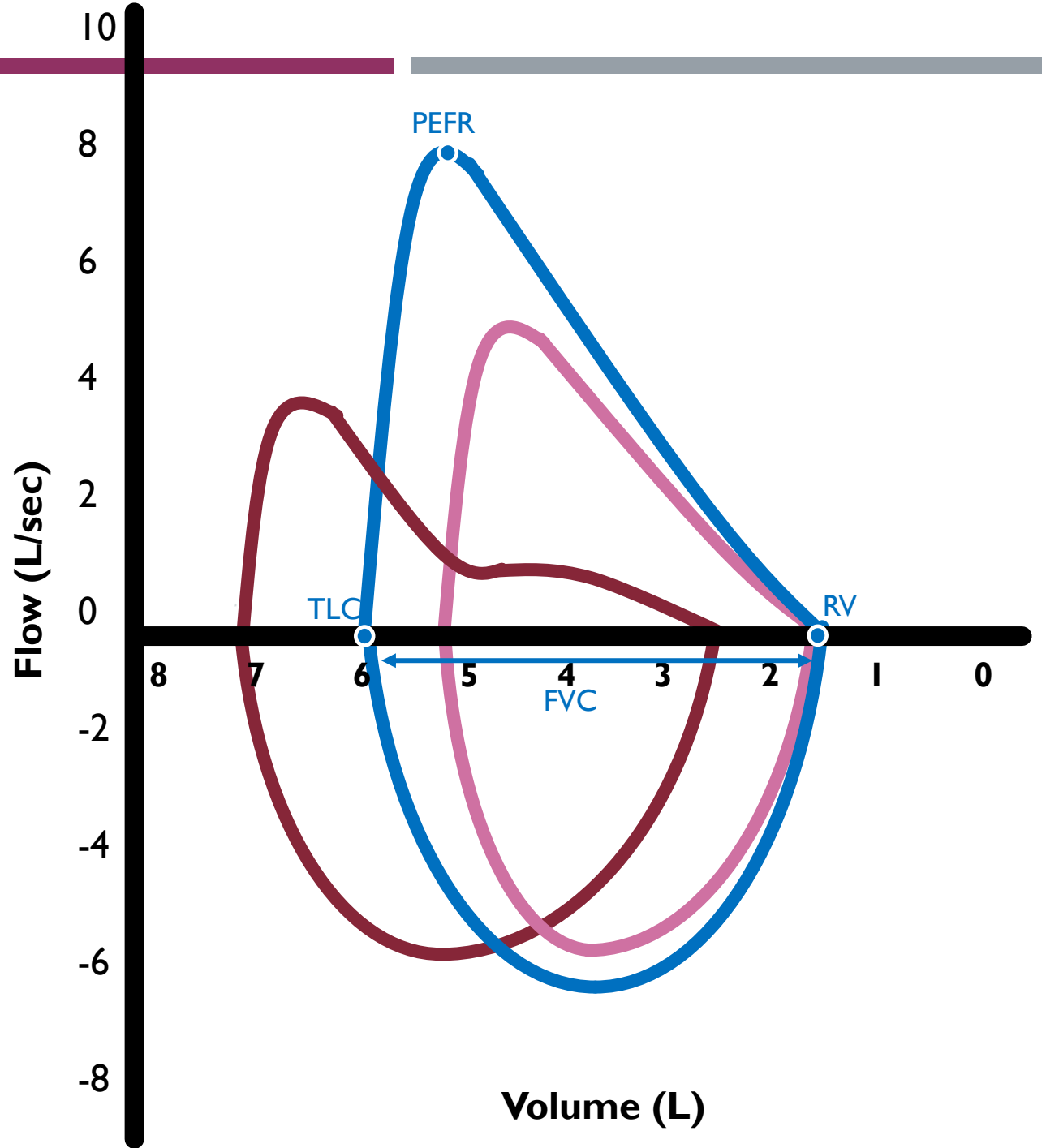


LET'S PUFF AGAIN

BUT THIS TIME .. IN A BOX



FVC= 4.5 L FEV1= 3.6 L FEV1/FVC= 80%	FVC= 3.2 L FEV1= 2.8 L FEV1/FVC= 88%	FVC= 4.2 L FEV1= 1.8 L FEV1/FVC= 43%



HOW DOES THE REPORT LOOK LIKE

APPROACH TO INTERPRETATION

FULL STANDARD PFT

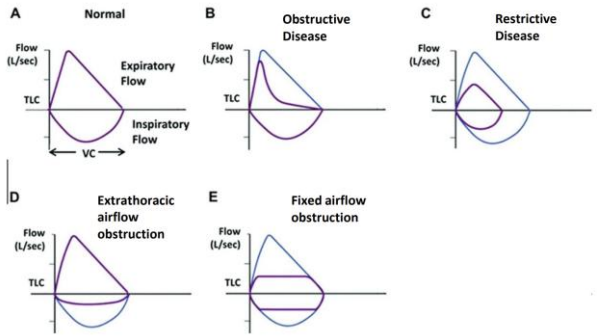
Step 1 — Confirm Patient's Demographic Data

- **Age, Sex**, Ethnicity, Height

Step 2 — Is the Test of Adequate Quality?

- **Acceptability**: Free from artifacts, Free from leaks, Good start, Good effort; appreciated by:
  - Rapid increase in airflow at the start of exhalation on **Flow-Volume curve**
  - Exhalation continued for ~6 seconds on **Volume-Time curve**
- **Reproducibility**: 3 acceptable maneuvers in which the difference between the two largest FVC measurements and between the two largest FEV1 measurements is within 200 ml

Step 3 — Flow-Volume Loop Interpretation



Step 4

NOTE I: A reduction in FEF25-75% of less than 60% of that predicted confirms airway obstruction
NOTE II: PEF decreases with obstructive diseases and shows great diurnal variation

Height(in): 73 Weight(lb): 277 Age: 60 Gender: Male
Date: 05/19/99 Race: Caucasian Physician: GMC

SPIROMETRY

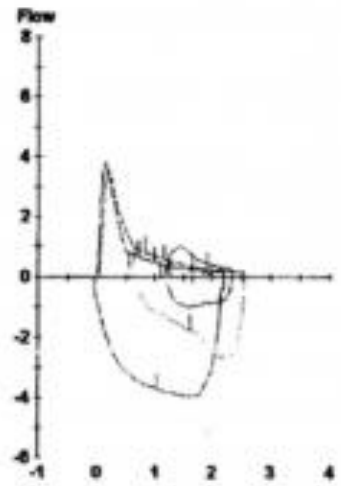
		Ref	Pre Meas	Pre % Ref	Post Meas	Post % Ref	Post % Chg
FVC	Liters	5.04	2.19	43	2.55	51	16
FEV1	Liters	4.04	1.01	25	1.18	29	17
FEV1/FVC	%	79	46		46		
FEF25-75%	L/sec	4.02	0.49	12	0.56	14	13
FEF50%	L/sec	4.92	(0.41)	(8)	(0.52)	(10)	25
FEF75%	L/sec	1.87	(0.27)	(14)	(0.25)	(13)	-7
PEF	L/sec	9.33	4.09	44	3.92	42	-4
MVV	L/min	150	(42)	(28)			
MVV Length			12				

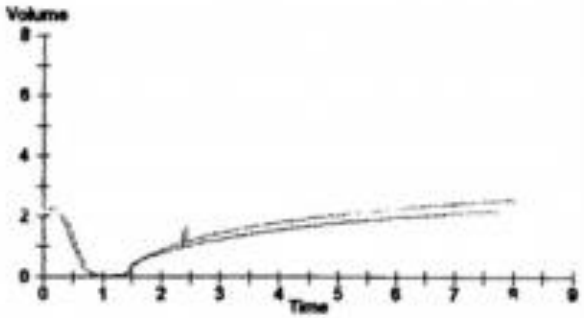
PLETHYSMOGRAPH LUNG VOLUMES

		Pre Meas	Ref	Pre % Ref
TLC	Liters	(8.62)	7.38	(120)
Vtg	Liters	6.65		
RV	Liters	(5.36)	2.58	(208)
FRC PL	Liters	(6.09)	3.51	(174)
VC	Liters	3.47	5.04	69
IC	Liters	2.74		
ERV	Liters	0.73		
Raw	cmH2O/L/sec	3.65	1.29	284
RV/TLC	%	(61)	37	

DIFFUSING CAPACITY

		Pre Meas	Ref	Pre % Ref
DLCO	mL/min/mmHg	(12.5)	30.8	(41)
VA	Liters	6.19		
DLCO/VA	1/min/mmHg	2.03	3.83	53





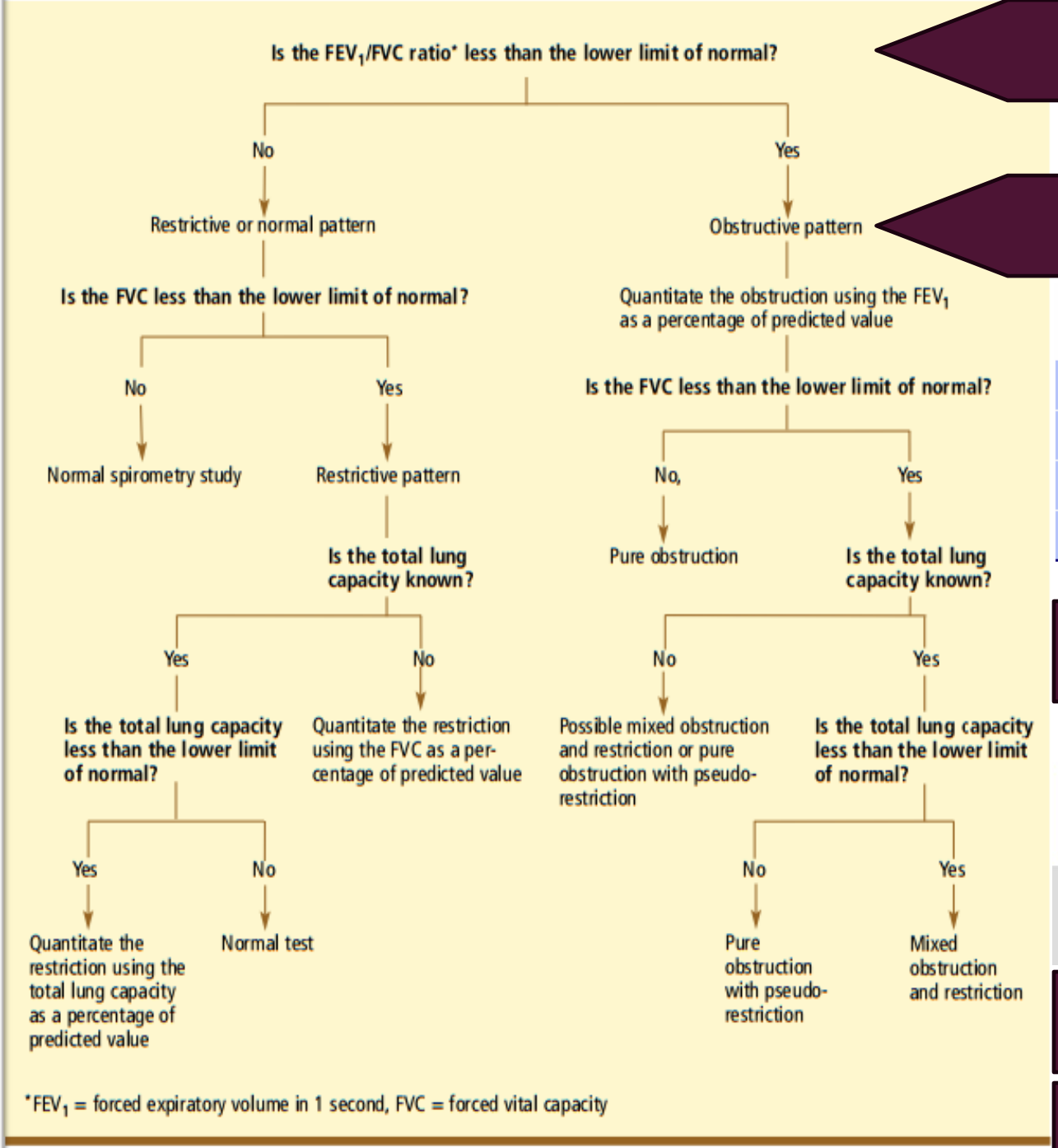


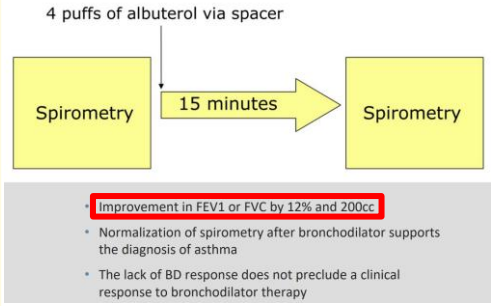
FIGURE 3. Flow chart for rapid interpretation of pulmonary function tests

1- Is there an obstruction?

2- How severe is the obstruction?

	FEV_1 compared to predicted for age/gender/height
GOLD Stage I	$FEV_1 \geq 80\%$
GOLD Stage II	$50\% \leq FEV_1 < 80\%$
GOLD Stage III	$30\% \leq FEV_1 < 50\%$
GOLD Stage IV	$FEV_1 < 30\%$

3- Is there response to bronchodilation?

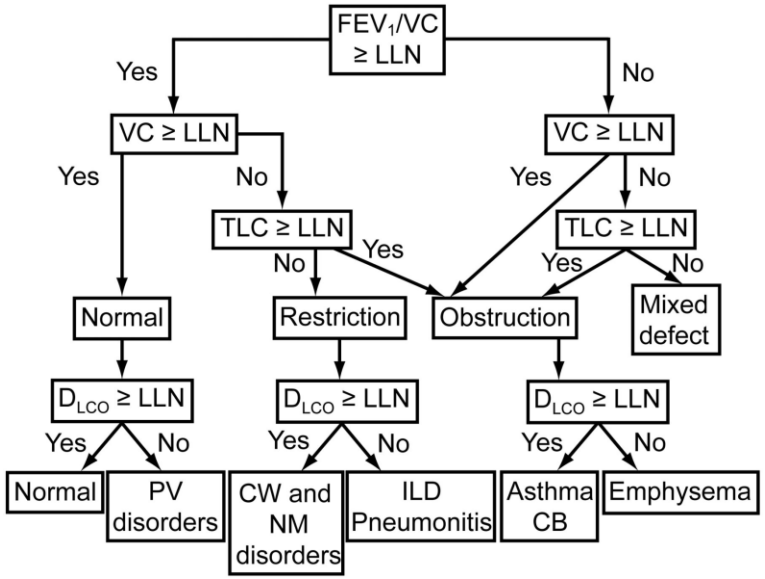


METHACHOLINE CHALLENGE TEST

- Methacholine: a direct stimulant that acts directly on acetylcholine receptors on smooth muscle, causing contraction and airway narrowing
- This test might be performed when the test results are normal, but the history strongly suggests the presence of asthma .
- Dose used between 4 and 16 mg per mL.
- During the test progressively larger doses of inhaled methacholine are given by a nebulizer. The test stops once the FEV1 drops by 20% or more from baseline or the maximum dose of methacholine is reached with no change in FEV1.

4- Full PFT interpretation

5- Supplemental (DL_{CO}, bronchoprovocation)



Parameter	**Obstructive Pattern**	**Restrictive Pattern**	**Pulmonary Vascular**
Primary Defect	Increased airway resistance (Air can't get *out*)	Decreased lung/wall compliance (Air can't get *in*)	Impaired gas exchange (Blood can't pick up O_2)
FEV_1/FVC	**Decreased** (< LLN / 0.70)	Normal to Increased	Normal
TLC	Normal or **Increased**	**Decreased** (< 80% pred)	Normal
RV	**Increased** (Air trapping)	**Decreased** (Parenchymal) or **Increased** (Bellows)	Normal
DLCO	**Decreased** or Normal	**Decreased** or Normal	**Decreased** (Isolated)

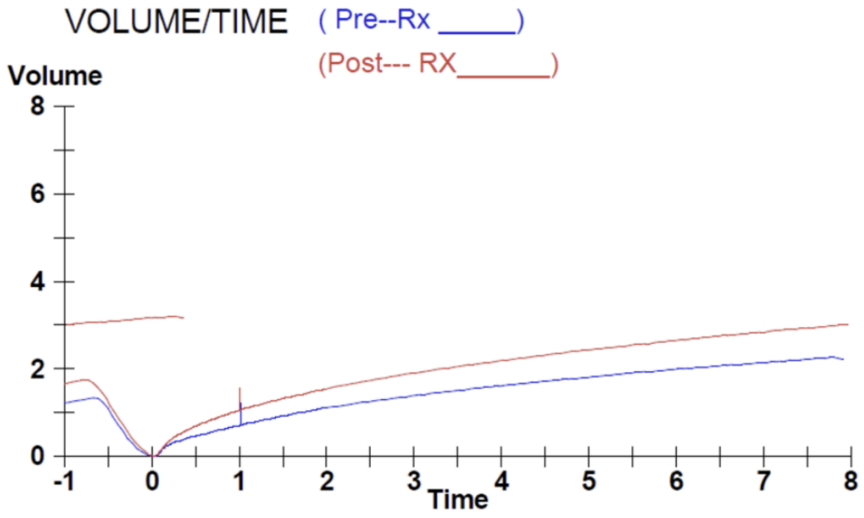
INTERPRETATION PRACTICE

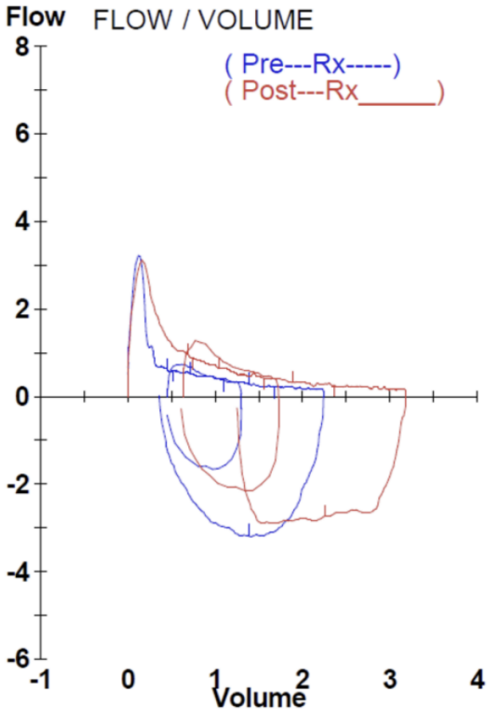
CHALLENGE THE PULMONOLOGIST INSIDE YOU ☺

		PRED	BEST	%PRED	BEST	%PRED	% Chg
Spirometry			*Values in Parentheses or Asterisks are outside the normal range*				
FVC	Liters	3.88	(2.25)	(58)	3.19	82	42
FEV1	Liters	2.95	(0.73)	(25)	(1.08)	(37)	47
FEV1/FVC	%	77	(33)		(34)		
FEF25-75%	L/sec	2.64	(0.31)	(12)	(0.38)	(15)	25
FEF25%	L/sec		0.53		0.80		50
FEF50%	L/sec		0.32		0.39		23
FEF75%	L/sec		0.19		0.24		28
PEF	L/sec		3.22		3.10		-4
FEF/FIF50			0.10		0.14		43
Lung Volumes							
VC	Liters	3.88	(2.70)	(70)			
TLC	Liters	6.43	(8.74)	(136)			
RV	Liters	2.44	(6.04)	(247)			
RV/TLC	%	38	(69)				
FRC PL	Liters	3.44	(7.51)	(219)			
FRC N2	Liters	3.44					
ERV	Liters	1.28	1.63	127			
Diffusion							
DLCO	mL/mmHg/min	27.3	(6.1)	(22)			
DL Adj	mL/mmHg/min	27.3	(6.1)	(22)			
DLCO/VA	mL/mHg/min/L	4.43	(1.34)	(30)			
DL/VA Adj	mL/mHg/min/L		1.34				

INTERPRETATION:
1- FEV1/FVC ratio is 33% [<70%], so this patient has an obstructive disease
2- FEV1 is 25%, so the obstruction severity is GOLD stage IV
3- Post vs. Pre, bronchodilator response, FVC_{post} 3.19- FVC_{pre} 2.25= 0.94 (940 mL improvement [>200]) AND % change is 42% [>12%]; results are significant, so obstruction is reversible
4- FVC is 58%, so *maybe* restrictive, needs TLC to decide
5- TLC is 136%, no restriction
6- DL_{CO} is 22%, suggestive of alveolar pathology (e.g., emphysema) and/or pulmonary vascular disease

COMMENT: Patient has an obstructive lung disease.





Age: 73 Race: African-American
Height(in): 76 192 cm
Weight(lb): 158 71.8 kg

Temp: 19 PBar: 631 FIN: 1030500541
Physician: ROBERTSON MD
Technician: DANELE ADAMS RRT

(BTPS)

			PRE-RX		POST-RX		
		PRED	BEST	%PRED	BEST	%PRED	% Chg
Spirometry		*Values in Parentheses or Asterisks are outside the normal range*					
FVC	Liters	5.30	(3.05)	(58)	(3.08)	(58)	1
FEV1	Liters	3.97	(1.65)	(42)	(1.61)	(40)	-3
FEV1/FVC	%	74	(54)		(52)		
FEF25-75%	L/sec	3.26	(0.74)	(23)	(0.62)	(19)	-16
FEF25%	L/sec		2.17		1.79		-18
FEF50%	L/sec		0.92		0.78		-15
FEF75%	L/sec		0.32		0.29		-9
PEF	L/sec	9.31	(6.59)	(71)	(5.08)	(55)	-23
FEF/FIF50			0.19		0.38		99
PIF	L/sec		5.07		2.22		-56
Lung Volumes							
VC	Liters	5.30	(3.19)	(60)			
TLC	Liters	8.17	(5.95)	(73)			
RV	Liters	2.83	2.76	97			
RV/TLC	%	37	(46)				
FRC PL	Liters	4.43	5.02	113			
FRC N2	Liters	4.43					
ERV	Liters	1.75	2.00	114			
Diffusion							
DLCO	mL/mmHg/min	37.4	(7.8)	(21)			
DL Adj	mL/mmHg/min	37.4	(7.1)	(19)			
DLCO/VA	mL/mHg/min/L	4.58	(2.20)	(48)			
DL/VA Adj	mL/mHg/min/L	3.78	2.01	53			

INTERPRETATION:
1- FEV1/FVC ratio is 54% [<70%], so this patient has an obstructive disease
2- FEV1 is 42%, so the obstruction severity is GOLD stage III
3- Post vs. Pre, bronchodilator response, FVC_{post} 3.08- FVC_{pre} 3.05= 0.03 (30 mL improvement [<200]) and % change is 1% [<12%]; results are insignificant, so obstruction is irreversible
4- FVC is 58%, so *maybe* restrictive, needs TLC to decide
5- TLC is 73%, so the patient has a restrictive disease
6- DL_{CO} is 21%, suggestive of alveolar pathology (e.g., emphysema or fibrosis) and/or pulmonary vascular disease

COMMENT: Patient has a mixed obstructive AND restrictive lung diseases.

Sex: Male
Age: 56 Race: Black
Height(in): 67 169 cm
Weight(lb): 118 53.6 kg

ID#: 1218299 Room: Out-Pt
Temp: 22 PBar: 641 FIN: 1029728145
Physician: GOEL
Technician: KIMBERLEY RAY RT

(BTPS)

Values in Parentheses or Asterisks are outside the normal range

		PRE-RX			POST-RX		
		PRED	BEST	%PRED	BEST	%PRED	% Chg
Spirometry							
FVC	Liters	3.96	(2.21)	(56)	(2.16)	(55)	-2
FEV1	Liters	3.16	(1.86)	(59)	(1.82)	(57)	-2
FEV1/FVC	%	80	84		84		
FEF25-75%	L/sec	3.45	2.23	65	2.18	63	-2
FEF25%	L/sec		7.11		7.09		-0
FEF50%	L/sec		3.11		3.65		17
FEF75%	L/sec		0.82		0.72		-13
PEF	L/sec	8.73	7.75	89	8.60	98	11
FEF/FIF50			0.68		0.69		2
Lung Volumes							
VC	Liters	4.29	(2.26)	(53)			
TLC	Liters	6.28	(3.71)	(59)			
RV	Liters	1.97	1.45	74			
RV/TLC	%	31	39				
FRC PL	Liters	3.19	2.76	86			
FRC N2	Liters	3.19					
ERV	Liters	1.42	1.20	85			

INTERPRETATION:
1- FEV1/FVC ratio is 84% [>70%], so this patient doesn't have an obstructive disease
2- FVC is 56%, so *maybe* restrictive, needs TLC to decide
3- TLC is 59%, so the patient has a restrictive disease
4- DL_{CO} is not provided

COMMENT: Patient has a restrictive lung disease, needs further testing to determine specific pathology.

THANK YOU

DR. ABDULLAH AL-JAOUNI, MD

DEC 2025