Pulmonary Function Testing – A Case Based Approach

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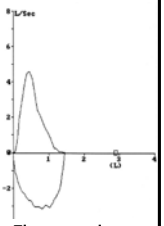
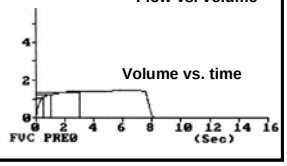
Interpretation

- **Acceptability**
  - ✓ **Smooth continuous curve**
  - ✓ **Good start**
  - ✓ **Good finish (plateau for 1 sec or 6 seconds total)**
- **Reproducibility**
  - ✓ **After 3 maneuvers the two largest FVC and FEV_1 are within 150 ml of each other.**



Flow vs. volume

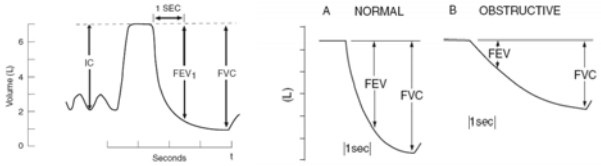


*** * Look at technicians comments if test is acceptable, reproducible, and if patient gave good effort.**

Interpretation

- **Is test acceptable and reproducible?**
- **Look at flow volume loop**
- **Examine FEV_1/FVC ratio**
- **Look at FVC**
- **If obstruction – is there a post-bronchodilator response**
- **Classify severity**
- **Look at lung volumes (specifically TLC)**
- **Examine DLCO**

Patterns of Disease

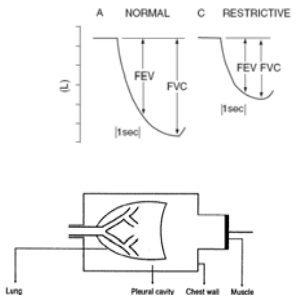


- **Obstructive Pattern**
  - **Decreased FEV_1/FVC ratio**
  - **Asthma, COPD/Emphysema, CF, Bronchiectasis**

Respirology (2005) 10, S1-S19

Patterns of Disease

- Restrictive Pattern
  - ✓ FEV_1/FVC ratio preserved but values decreased
  - ✓ Parenchymal disease
    - Idiopathic pulmonary fibrosis (IPF),
    - Pneumoconiosis
    - Interstitial lung diseases
  - ✓ Restrictive bellows
    - Neuromuscular disease (ALS, MD)
    - Chest wall abnormalities (obesity, kyphoscoliosis)

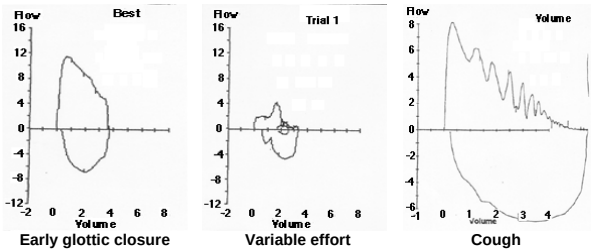


Respirology (2005) 10, S1-S19

Bronchodilator Challenge

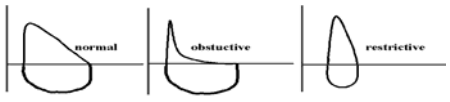
- Assess lung function at baseline
- Administer bronchodilator through a spacer
- Re-assess lung function after 15 min
- Positive bronchodilator response
  - An increase in FEV1 and/or FVC by 12% of control and by > 200 mL
- In the lack of a bronchodilator response in the laboratory does not preclude a clinical response to bronchodilator therapy

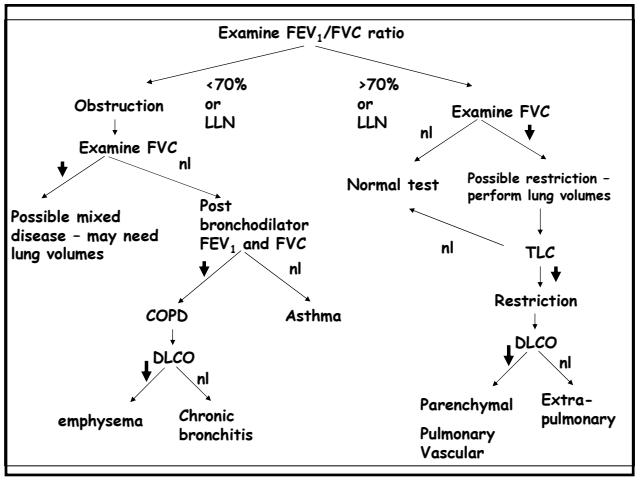
Flow Volume Loop



Early glottic closure | Variable effort

Cough





Case 1

PT:
PT#:
DIAGNOSIS: ASTHMA
RACE: B
SMK HX: NEVER

OCC:

RM#:
SEX: F

DATE: 10/02/2003
AGE: 31
WT: 188.0 lb
HT: 64.0 in

Spirometry		Pre-Drug* PREDICTED	PRE	%PRED	Post-Drug* M ALBUTEROL POST	%PRED	%CHG
FVC	(L)	3.16	2.62	83	3.72	118	42
FEV1	(L)	2.71	1.21	44	1.97	73	63
FEV1/FVC	(%)	86	46		53	62	14
FEF25-75%	(L/S)	3.76	0.48	13	0.85	22	77
FEFmax	(L/S)	6.42	3.07	48	5.01	78	63
FIVC	(L)	3.16	2.57	81	3.45	109	34

- **31 y/o female with 3 ½ month history of cough usually non-productive. Associated wheezing and mild dyspnea. Started after a viral illness.**
- **No PMH, ROS negative.**
- **Lungs – scattered bilateral expiratory wheezes.**
- **CXR - negative**

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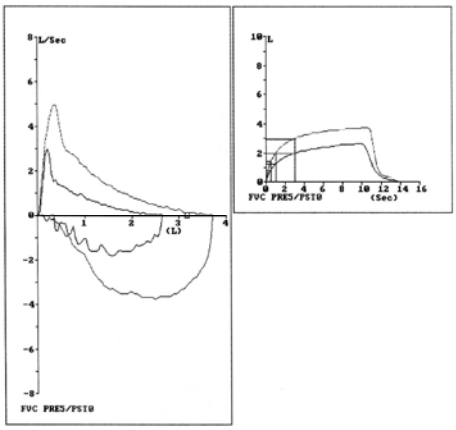
- **Obstruction with bronchodilator response**
- **Started on inhaled corticosteroid, as needed B2 agonist, and given peak flow meter.**
- **Return in 3 weeks revealed cough has almost totally resolved, peak flow has increased from 460 to 600.**
- **Dx – asthma**



Case 2

DIAGNOSIS: DYSPNEA
RACE: W
SMK HX: SMOKES CIGARETTES 45Y 1.0P/DAY 45PACK/YRS

OCC:

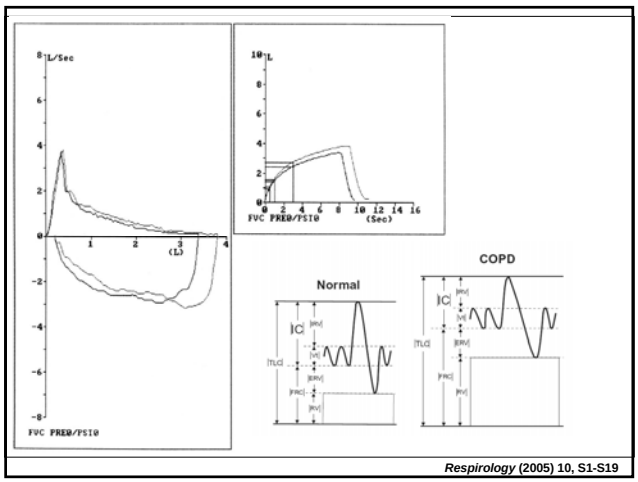
SEX: M

WT: 215.0 lb
HT: 69.0 in

Spirometry		Pre-Drug* M PREDICTED	PRE	%PRED	Post-Drug* M ALBUTEROL POST	%PRED	%CHG
FVC	(L)	4.60	3.35	73	3.81	83	13
FEV1	(L)	3.63	1.41	39	1.55	43	9
FEV1/FVC	(%)	79	42	54	41	52	-3
FEF25-75%	(L/S)	3.47	0.55	16	0.59	17	7
FEFmax	(L/S)	8.74	3.71	42	3.82	44	2
FIVC	(L)	4.60	3.17	69	3.61	78	13

Lung Volumes		Pre-Drug* Avg PREDICTED	PRE	%PRED
TLC	(L)	6.79	7.85	116
FRC	(L)	3.51	5.04	143
RV	(L)	2.17	4.08	188
ERV	(L)	1.35	0.95	71
RV/TLC	(%)	32	52	161
VC	(L)	4.60	3.76	82
IC	(L)	3.28	2.81	86

Diffusion	Pre-Drug* Avg PREDICTED	PRE	%PRED
Dmb ml/min/mmHg	33.16	11.30	34
Dmb(adj) ml/min/mmHg	33.16	11.30	34
D/VA		2.37	
Hb (gm/100ml)		14.60	
COHb (%)		0.00	
VA(sb) (L)		4.77	



Respirology (2005) 10, S1-S19

DIAGNOSIS: DYSPNEA SEX: M WT: 215.0 lb
RACE: W OCC: HT: 69.0 in
SMK HX: SMOKES CIGARETTES 45Y 1.0P/DAY 45PACK/YRS

Spirometry		Pre-Drug* M PREDICTED	PRE	%PRED	Post-Drug* M ALBUTEROL POST	%PRED	%CHG
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FEV1	(L)	3.63	1.41	39	1.55	43	9
FEV1/FVC	(%)	79	42	54	41	52	-3
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PEFmax	(L/S)	8.74	3.71	42	3.82	44	2
FIVC	(L)	4.60	3.17	69	3.61	78	13

Lung Volumes		Pre-Drug* Avg PREDICTED	PRE	%PRED	
TLC	(L)	6.79	7.85	116	← hyperinflation
FRC	(L)	3.51	5.04	143	← Air trapping
RV	(L)	2.17	4.08	188	
ERV	(L)	1.35	0.95	71	
RV/TLC	(%)	32	52	161	
VC	(L)	4.60	3.76	82	
IC	(L)	3.28	2.81	86	

Diffusion	Pre-Drug* Avg PREDICTED	PRE	%PRED
Dsb ml/min/mmHg	33.16	11.30	34
Dsb(adj) ml/min/mmHg	33.16	11.30	34
D/VA		2.37	
Hb (gm/100ml)		14.60	
COHb (%)		0.00	
VA(sb) (L)		4.77	

- **Severe airflow obstruction with air trapping and hyperinflation.**
- **Low DLCO**
- **Dx - COPD**

TABLE 6 Severity of any spirometric abnormality based on the forced expiratory volume in one second (FEV_1)

Degree of severity	FEV_1 % pred
Mild	>70
Moderate	60–69
Moderately severe	50–59
Severe	35–49
Very severe	<35

% pred: % predicted.

Interpretative strategies for lung function tests. SERIES ''ATS/ERS TASK FORCE: STANDARDISATION OF LUNGFUNCTION TESTING'' Eur Respir J 2005

Case 3

Test Date:10-25-2005 Age:83 Ht:60.0 in Wt:129 lbs
Gender: female Race:Caucasian Hb: None BMI:28.2 kg/m2
Adm.#:310272406 Smoke Hx (Pk Yrs): 70.0

	PRED	ACTUAL	%PRED	
*SPIROMETRY				
Forced Vital Capacity (FVC;L)	2.12	.75	35*	
Forced Exp. Vol. 1 (FEV1;L)	1.54	.59	38*	
% FEV1/FVC	85.5%	78.7%		
Mid Exp. Flow (FEF25-75;L/sec)	1.27	.48	38*	
Peak Flow (PF;L/sec)	4.74	1.76	37*	
*LUNG VOLUMES Plethysmography				
Slow Vital Capacity (SVC;L)	2.12	1.22	58*	
Exp. Reserve Volume (ERV;L)	.31	.22	71	
Thoracic Gas Volume (TGV;L)	2.56	3.46	135*	
Residual Volume (RV;L)	2.25	3.17	141*	
Total Lung Capacity (TLC;L)	4.45	4.39	99	
%RV/TLC	48.9	72.2*		
*ARTERIAL BLOOD GASES Predict.	7.35-7.45	Room Air		
pH		7.39		
PaO2 (mm Hg)	83	58*		
PaCO2 (mm Hg)	37-43	53*		
Bicarb.(meq/L)	23-26	31*		
SaO2%	>93%	90*		
Alv-art O2 Diff.(mm Hg)	29	21		

Test Date:10-25-2005 Age:83 Ht:60.0 in Wt:129 lbs
Gender: female Race:Caucasian Hb: None BMI:25.2 kg/m2
Smoke Hx (Pk Yrs): 70.0
Diagnosis:DOE/SOB/Wheezing

	PRED	ACTUAL	%PRED
*SPIROMETRY			
Forced Vital Capacity (FVC;L)	2.12	.75	35
Forced Exp. Vol. 1 (FEV1;L)	1.54	.59	38
% FEV1/FVC	85.5%	78.7%	
Mid Exp. Flow (FEF25-75;L/sec)	1.27	.48	38*
Peak Flow (PF;L/sec)	4.74	1.76	37*
*LUNG VOLUMES Plethysmography			
Slow Vital Capacity (SVC;L)	2.12	1.22	58*
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*ARTERIAL BLOOD GASES Predict.		Room Air	
pH	7.35-7.45	7.39	
PaO2 (mm Hg)	83	58*	
PaCO2 (mm Hg)	37-43	53*	
Bicarb.(meq/L)	23-26	31*	
SaO2%	>93%	90*	
Alv-art O2 Diff.(mm Hg)	29	21	

- Reduced FEV1 and FVC suggest restriction by spirometry
- No evidence of restriction by lung volumes.
- Low FVC – pseudorestriction
- If use SVC then the FEV1/VC ratio is 48%.

Dx - Severe oxygen-dependent chronic obstructive pulmonary disease

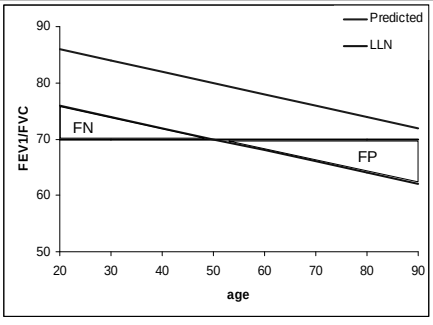
What's normal?

- **Reference Populations**
  - **Comparable to the patient population with regards to:**
    - **» Age**
    - **» Height**
    - **» Gender**
    - **» Ethnicity**
- **Spirometric reference values**
  - **Developed from National Health and Nutrition Examination Survey (NHANES III)**
  - **7,429 asymptomatic, lifelong nonsmoking subjects**
  - **Included Caucasians, African-Americans, and Hispanic-Americans**

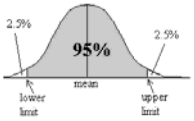
Case 4

Test Date:01-23-2004 Age:90 Ht:63.0 in Wt:123 lbs
Gender: female Race:Caucasian Hb: None BMI:21.8 kg/m2
Smoke Hx (Pk Yrs):
Diagnosis:Preoperative evaluation, respiratory Secondary:Lung Mass

	PRED	ACTUAL	%PRED
*SPIROMETRY			
Forced Vital Capacity (FVC;L)	2.16	2.42	112
Forced Exp. Vol. 1 (FEV1;L)	1.37	1.68	123
% FEV1/FVC	74.5%	69.4%	
Mid Exp. Flow (FEF25-75;L/sec)	.84	.99	118
Peak Flow (PF;L/sec)	4.89	4.56	93
*LUNG VOLUMES Plethysmography			
Slow Vital Capacity (SVC;L)	2.16	2.42	112
Exp. Reserve Volume (ERV;L)	.32	1.14	356
Thoracic Gas Volume (TGV;L)	2.86	3.15	110
Residual Volume (RV;L)	2.54	2.01	79
Total Lung Capacity (TLC;L)	4.90	4.43	90
%RV/TLC	51.8	45.4	
*ARTERIAL BLOOD GASES Predict.		Room Air	
pH	7.35-7.45	7.34*	
PaO2 (mm Hg)	83	80	
SaO2%	>93%	96	
PaCO2 (mm Hg)	37-43	43	
Bicarb.(meq/L)	23-26	24	
Alv-art O2 Diff.(mm Hg)	32	13	



- **FEV1/FVC is inversely proportional to age and height.**



Case 5

Test Date:03-12-2004 Age:58 Ht:64.0 in Wt:147 lbs
Gender: male Race:Caucasian Hb:13.2 g/dl BMI:25.2 kg/m2
Smoke Hx (Pk Yrs): 40.0

	PRED	ACTUAL	%PRED	
*SPIROMETRY				
Forced Vital Capacity (FVC;L)	3.26	2.92	90	
Forced Exp. Vol. 1 (FEV1;L)	2.44	1.50	61*	
% FEV1/FVC	80.4%	51.4%	*	
Mid Exp. Flow (FEF25-75;L/sec)	2.79	.47	17*	
Peak Flow (PF;L/sec)	8.23	6.61	80	
*INSPIRATORY LOOP				
FEF50%/FIF50% (normal<=1.0)	.24			
*LUNG VOLUMES Plethysmography				
Slow Vital Capacity (SVC;L)	3.26	2.92	90	
Exp. Reserve Volume (ERV;L)	1.03	.63	61	
Thoracic Gas Volume (TGV;L)	2.90	3.57	123	
Residual Volume (RV;L)	1.87	2.94	157*	
Total Lung Capacity (TLC;L)	5.78	5.86	101	
%RV/TLC	32.0	50.2*		
*DIFFUSING CAPACITY			Hb CORR/%PRED	
Diff. Cap. (DLCO;ml/min/mm Hg)	26.5	12.7	48*	14.7 55*
Single breath TLC (VA; L)	5.66	4.29	76	
DLCO/VA	4.65	2.96	64*	3.43 74*

- 58 yo AAM smoker with cough
- 40PY tob history
- Yearly history and physical exam– c/o mild dyspnea

Case 5

	PRED	ACTUAL	%PRED	
*SPIROMETRY				
Forced Vital Capacity (FVC;L)	3.26	2.92	90	
Forced Exp. Vol. 1 (FEV1;L)	2.44	1.50	61*	
% FEV1/FVC	80.4%	51.4%	*	
Mid Exp. Flow (FEF25-75;L/sec)	2.79	.47	17*	
Peak Flow (PF;L/sec)	8.23	6.61	80	
*INSPIRATORY LOOP				
FEF50%/FIF50% (normal<=1.0)	.24			
*LUNG VOLUMES Plethysmography				
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Total Lung Capacity (TLC;L)	5.78	5.86	101	
%RV/TLC	32.0	50.2*		
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Diff. Cap. (DLCO;ml/min/mm Hg)	26.5	12.7	48*	14.7 55*
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DLCO/VA	4.65	2.96	64*	3.43 74*

Lung age = 97 yo

Lung Age

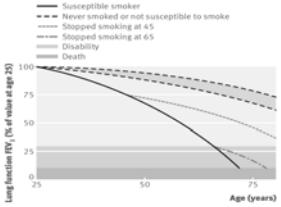

Fig 1 | Graph of lung function against age showing how smoking accelerates age related decline in lung function (adapted from Fletcher and Peto[1])

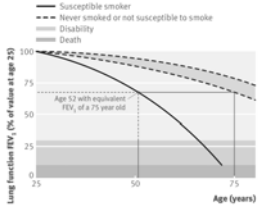

Fig 2 | Explaining lung age to participants (adapted from Fletcher and Peto[1])

Lung age calculation formula developed by Morris and Temple[3]

Men

Lung age=2.87×height (in inches)−(31.25×observed FEV_1 (litres))−39.375

Women

Lung age=3.56×height (in inches)−(40×observed FEV_1 (litres))−77.28

BMJ 2008;336:598-600

Case 6

	PRED	ACTUAL	%PRED	
*SPIROMETRY				
Forced Vital Capacity (FVC;L)	5.12	3.52	69*	
Forced Exp. Vol. 1 (FEV1;L)	3.93	3.01	77*	
% FEV1/VC	76.9%	85.5%		
Mid Exp. Flow (FEF25-75;L/sec)	3.37	4.40	131	
Peak Flow (PF;L/sec)	9.84	12.92	131	
*LUNG VOLUMES Plethysmography				
Slow Vital Capacity (SVC;L)	5.12	3.52	69*	
Exp. Reserve Volume (ERV;L)	1.54	1.30	84	
Thoracic Gas Volume (TGV;L)	3.71	2.90	78	
Residual Volume (RV;L)	2.17	1.60	74	
Total Lung Capacity (TLC;L)	7.18	5.12	71*	
%RV/TLC	30.7	31.3		
*DIFFUSING CAPACITY			Hb CORR/%PRED	
Diff. Cap. (DLCO;ml/min/mm Hg)	30.3	21.0	69*	
Single breath TLC (VA; L)	7.01	4.94	70*	
DLCO/VA	4.38	4.25	97	
*OXIMETRY/OTHER STUDIES Predict.	Actual			
%SaO2(Rest, room air) >93%	99			
%SaO2(6' walk, room air) >93%	94			
6' Walk Distance (ft) >1200	1476			
Dyspnea(Borg Scale 6'walk)	Rest: .5		Max: 2.0	
Heart rate (6' walk, b/min)	Rest: 86		Max: 112	

- 54 yo WM with cough
- Ht 71in, wt, 215 lbs
- BMI=30
- Hgb=14.3
- No tobacco hx
- Works as a welder, machinist in auto parts assembly

	PRED	ACTUAL	%PRED
*SPIROMETRY			
Forced Vital Capacity (FVC;L)	5.12	3.52	69*
Forced Exp. Vol. 1 (FEV1;L)	3.93	2.84	72*
% FEV1/VC	76.9	80.7	
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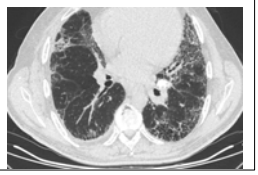
%RV/TLC	30.7	31.3	
*DIFFUSING CAPACITY			Hb CORR/%PRED
Diff. Cap. (DLCO;ml/min/mm Hg)	30.3	21.0	69*
Single breath TLC (VA; L)	7.01	4.94	70*
DLCO/VA	4.38	4.25	97
*OXIMETRY/OTHER STUDIES	Predict.	Actual	
%SaO2(Rest, room air)	>93%	90	
%SaO2(6' walk, room air) >93%		78	
6' Walk Distance (ft) >1200		1476	
Dyspnea(Borg Scale 6'walk)		Rest: .5	Max: 2.0
Heart rate (6' walk, b/min)		Rest: 86	Max: 112

- **No evidence of obstruction by spirometry**
- **Restriction by lung volumes**
- **Low diffusing capacity**
- **Some desaturation with 6 minute walk**
- **Chest CT: pulmonary fibrosis**



2/23/06

	PRED	ACTUAL	%PRED
*SPIROMETRY			
Forced Vital Capacity (FVC;L)	3.39	2.39	71*
Forced Exp. Vol. 1 (FEV1;L)	2.52	1.43	57*
% FEV1/VC	59.8%	59.8%	*
Mid Exp. Flow (FEF25-75;L/sec)	2.83	.42	15*
Peak Flow (PF;L/sec)	8.07	3.35	42*
*LUNG VOLUMES Plethysmography			
Slow Vital Capacity (SVC;L)	3.39	2.39	71*
Exp. Reserve Volume (ERV;L)	1.06	.08	8
Thoracic Gas Volume (TGV;L)	3.05	3.12	102
Residual Volume (RV;L)	1.99	3.04	153*
Total Lung Capacity (TLC;L)	5.99	5.43	91
%RV/TLC	32.9	56.0*	

Lung transplant in 2004.

5/03/06

*LUNG VOLUMES Gas Dilution			
Slow Vital Capacity (SVC;L)	3.39	2.41	71*
Exp. Reserve Volume (ERV;L)	1.06	.44	42
Functional Resid. Capac.(FRC;L)	3.05	.82	27*
Residual Volume (RV;L)	1.99	.38	19*
Total Lung Capacity (TLC;L)	5.99	2.79	47*
%RV/TLC	32.9	13.6*	

TECHNICIAN COMMENTS: Patient cooperation: good
Gas dilution done to obtain lung volumes due to IV in use.

Case 7

Test Date:05-03-2006
Last Test:02-24-0224 Age:61 Ht:65.0 in Wt:189 lbs
Gender: male Race:Caucasian Hb:10.1 g/dl BMI:31.4 kg/m2
Smoke Hx (Pk Yrs): 189.0
Diagnosis:Lung transplant

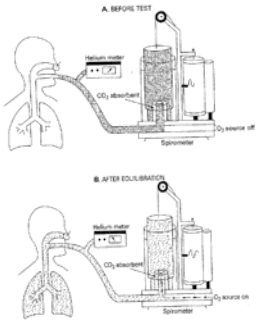
	PRED	ACTUAL	%PRED
*SPIROMETRY			
Forced Vital Capacity (FVC;L)	3.39	2.12	63*
Forced Exp. Vol. 1 (FEV1;L)	2.52	1.40	56*
% FEV1/VC	58.1%	58.1%	*
Mid Exp. Flow (FEF25-75;L/sec)	2.83	.89	31*
Peak Flow (PF;L/sec)	8.07	2.88	36*
*INSPIRATORY LOOP			
FEF50%/FIF50% (normal<=1.0)	.42		
*LUNG VOLUMES Gas Dilution			
Slow Vital Capacity (SVC;L)	3.39	2.41	71*
Exp. Reserve Volume (ERV;L)	1.06	.44	42
Functional Resid. Capac.(FRC;L)	3.05	.82	27*
Residual Volume (RV;L)	1.99	.38	19*
Total Lung Capacity (TLC;L)	5.99	2.79	47*
%RV/TLC	32.9	13.6*	
*DIFFUSING CAPACITY			Hb CORR/%PRED
Diff. Cap. (DLCO;ml/min/mm Hg)	26.2	15.9	61* 22.2 85
Single breath TLC (VA; L)	5.85	3.79	65*
DLCO/VA	4.51	4.20	93 5.86 130*

TECHNICIAN COMMENTS: Patient cooperation: good
Gas dilution done to obtain lung volumes due to IV in use.

Compare to old PFTs

Lung Volumes: Gas Dilution

- **Helium Dilution**
  - **Inert tracer gas (He) of known initial concentration contained in a circuit of known volume (C_1V_1)**
  - **Diluted by an unknown volume of gas from an additional source (patient)**
  - **Produced CO2 removed from system and absorbed oxygen replaced**
  - **Measure the new steady-state helium concentration (C2)**
  - **$C_1V_1=C_2V_2$**



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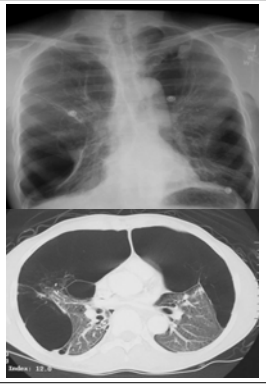
Lung Volumes

- **Limitation of gas dilution**
  - **Assumes all areas of lung equally ventilated**
  - **Underestimates lung volumes in obstructive disease**
  - **Communicating gas volumes**
  - **Leaks**



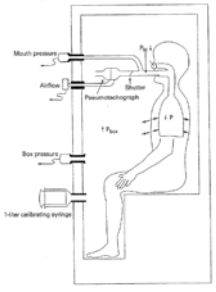
Case 8

Test Date:04-01-2008
Last Test:05-29-2007 Age:67 Ht:63.5 in Wt:104 lbs
Gender: male Race:Caucasian Hb: None BMI:18.1 kg/m2
Smoke Hx (Pk Yrs):
Diagnosis:Hypoxia

	PRED	ACTUAL	%PRED
*SPIROMETRY			
Forced Vital Capacity (FVC;L)	3.49	.54	15*
Forced Exp. Vol. 1 (FEV1;L)	2.58	.45	17*
% FEV1/VC	74.2%	68.2%	
Mid Exp. Flow (FEF25-75;L/sec)	2.05	.52	25*
Peak Flow (PF;L/sec)	7.25	2.15	30*
*INSPIRATORY LOOP			
FEF50%/FIF50% (normal<=1.0)			.56
*LUNG VOLUMES Plethysmography			
Slow Vital Capacity (SVC;L)	3.49	.66	19*
Exp. Reserve Volume (ERV;L)	.90	.10	11
Thoracic Gas Volume (TGV;L)	2.93	1.39	47*
Residual Volume (RV;L)	2.03	1.29	64*
Total Lung Capacity (TLC;L)	5.70	1.95	34*
%RV/TLC	34.8	66.2*	
*DIFFUSING CAPACITY			Hb CORR/%PRED
Diff. Cap. (DLCO;ml/min/mm Hg)	24.2	6.8	28*
Single breath TLC (VA; L)	5.57	1.33	24*
DLCO/VA	4.41	5.11	116

Lung Volumes: Body Plethysmography

- **Based on Boyle's Law: $P_1V_1=P_2V_2$**
- **Patient seated within a body box and breathes through a mouthpiece to outside atmosphere via a shutter**
- **Body box is a closed system and with inspiratory and expiratory efforts**
- **Pressure changes within the lung, measured at the mouth**
- **Resulting changes in the lung volume (thoracic gas volume)**
- **Changes in the lung volume result in opposite changes In the body box system pressure**



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	PRED	ACTUAL	%PRED
*SPIROMETRY			
Forced Vital Capacity (FVC;L)	3.49	.54	15*
Forced Exp. Vol. 1 (FEV1;L)	2.58	.45	17*
% FEV1/VC	74.2%	68.2%	
Mid Exp. Flow (FEF25-75;L/sec)	2.05	.52	25*
Peak Flow (PF;L/sec)	7.25	2.15	30*
*INSPIRATORY LOOP			
FEF50%/FIF50% (normal<=1.0)			
*LUNG VOLUMES Plethysmography			
Slow Vital Capacity (SVC;L)	3.49	.66	19*
Exp. Reserve Volume (ERV;L)	.90	.10	11
Thoracic Gas Volume (TGV;L)	2.93	1.39	47*
Residual Volume (RV;L)	2.03	1.29	64*
Total Lung Capacity (TLC;L)	5.70	1.95	34*
%RV/TLC	34.8	66.2*	
*DIFFUSING CAPACITY			
Diff. Cap. (DLCO;ml/min/mm Hg)	24.2	6.8	28*
Single breath TLC (VA; L)	5.57	1.33	24*
DLCO/VA	4.41	5.11	116

PFTS: **Severe restriction**
Reduced DLCO

Dx: **Kyphoscoliosis**

Case 9

	PRED	ACTUAL	%PRED
*SPIROMETRY			
Forced Vital Capacity (FVC;L)	3.38	3.28	97
Forced Exp. Vol. 1 (FEV1;L)	2.41	2.04	85
% FEV1/VC	78.9%	62.8%	*
Mid Exp. Flow (FEF25-75;L/sec)	2.58	.88	34*
Peak Flow (PF;L/sec)	7.43	6.83	92
*INSPIRATORY LOOP			
FEF50%/FIF50% (normal<=1.0)	.25		
*LUNG VOLUMES Plethysmography			
Slow Vital Capacity (SVC;L)	3.38	3.28	97
Exp. Reserve Volume (ERV;L)	1.02	1.39	136*
Thoracic Gas Volume (TGV;L)	3.43	3.11	91
Residual Volume (RV;L)	2.41	1.72	71*
Total Lung Capacity (TLC;L)	6.44	5.00	78*
%RV/TLC	37.5	34.4	
*DIFFUSING CAPACITY			Hb CORR/%PRED
Diff. Cap. (DLCO;ml/min/mm Hg)	23.6	6.7	28*
Single breath TLC (VA; L)	6.24	4.34	70*
DLCO/VA	3.93	1.54	39*

- **76yo WM with progressive SOB and cough**
- **50PY tob hx**
- **Mild obstruction by spirometry**
- **Mild restriction by lung volumes**
- **Severely reduced DLCO**
- **Increased ERV**

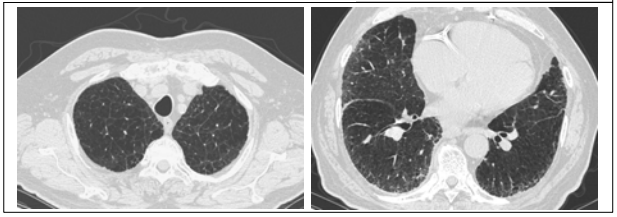
Case 10

Test Date:06-28-2005 Age:32 Ht:99.9 in Wt:140 lbs
Gender: male Race:Caucasian Hb:9.4 g/dl BMI:9.9 kg/m2
Smoke Hx (Pk Yrs): 17.0
Diagnosis:Hodgkin's Disease Secondary:Preoperative Evaluation

	PRED	ACTUAL	%PRED	
*SPIROMETRY				
Forced Vital Capacity (FVC;L)	11.71	2.87	25*	
Forced Exp. Vol. 1 (FEV1;L)	9.17	2.17	24*	
% FEV1/FVC	86.9%	75.6%		
Mid Exp. Flow (FEF25-75;L/sec)	9.01	1.76	20*	
Peak Flow (PF;L/sec)	15.27	5.08	33*	
*INSPIRATORY LOOP				
FEF50%/FIF50% (normal<=1.0)	1.26*			
*LUNG VOLUMES Plethysmography				
Slow Vital Capacity (SVC;L)	11.71	2.87	25*	
Exp. Reserve Volume (ERV;L)	3.68	.95	26	
Thoracic Gas Volume (TGV;L)	6.98	3.00	43*	
Residual Volume (RV;L)	3.30	2.05	62*	
Total Lung Capacity (TLC;L)	12.94	4.92	38*	
%RV/TLC	23.9	41.7*		
*DIFFUSING CAPACITY				Hb CORR/%PRED
Diff. Cap. (DLCO;ml/min/mm Hg)	47.5	18.2	38*	25.5 54*
Single breath TLC (VA; L)	12.59	4.23	34*	
DLCO/VA	3.42	4.30	126	6.03 176*

*OXIMETRY/OTHER STUDIES	Predict.	Actual	
%SaO2(Rest, room air)	>93%	94	
%SaO2(6' walk, room air)	>93%	59*	
6' Walk Distance (ft)	>1200	1807	
Dyspnea(Borg Scale 6'walk)		Rest: 0	Max: 3
Leg Fatique (Borg Scale 6' walk)		Rest: 0	Max: 2
Heart rate (6' walk, b/min)		Rest: 65	Max: 153

- Mixed obstruction and restriction pattern
- Decreased DLCO
- Dx: emphysema + pulmonary fibrosis

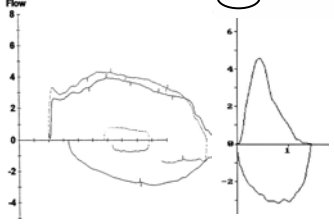


Case 11

	PRED	ACTUAL	%PRED
*SPIROMETRY			
Forced Vital Capacity (FVC;L)	4.78	4.63	97
Forced Exp. Vol. 1 (FEV1;L)	4.11	3.64	89
% FEV1/FVC	86.1%	78.6%	
Mid Exp. Flow (FEF25-75;L/sec)	4.63	3.50	76
Peak Flow (PF;L/sec)	9.59	5.07	53*

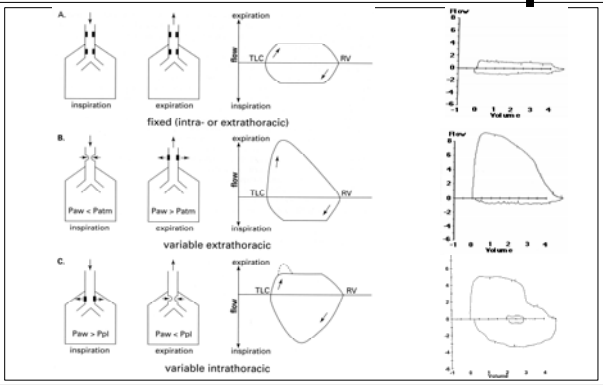
- **24yo WM admitted with SOB/DOE, wheezing, inspiratory stridor**
- **No PMHx, medications**
- **PSHx sig for exp lap 6 months prior after MVA**
- **2 PY Tob hx, occ EtOH**
- **Dx with asthma but no improvement with meds**

	PRED	ACTUAL	%PRED
*SPIROMETRY			
Forced Vital Capacity (FVC;L)	4.78	4.63	97
Forced Exp. Vol. 1 (FEV1;L)	4.11	3.64	89
% FEV1/FVC	86.1%	78.6%	
Mid Exp. Flow (FEF25-75;L/sec)	4.63	3.50	76
Peak Flow (PF;L/sec)	9.59	5.07	53*
*INSPIRATORY LOOP			
FEF50%/FIF50% (normal<=1.0)		1.38*	



- Normal spirometry
- Decreased peak flow
- Consistent with asthma
- No obstruction
- Tech notes: Patient with stridor during spirometry

Flow-Volume Loop



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*SPIROMETRY			
Forced Vital Capacity (FVC;L)	4.78	4.63	97
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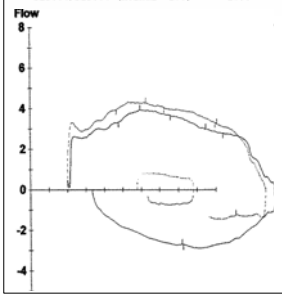
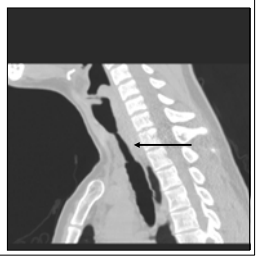
% FEV1/FVC	86.1%	78.6%	
Mid Exp. Flow (FEF25-75;L/sec)	4.63	3.50	76
Peak Flow (PF;L/sec)	9.59	5.07	53*
*INSPIRATORY LOOP			
FEF50%/FIF50% (normal<=1.0)		1.38*	



Fixed airway obstruction

Post-intubation tracheal stenosis/stricture

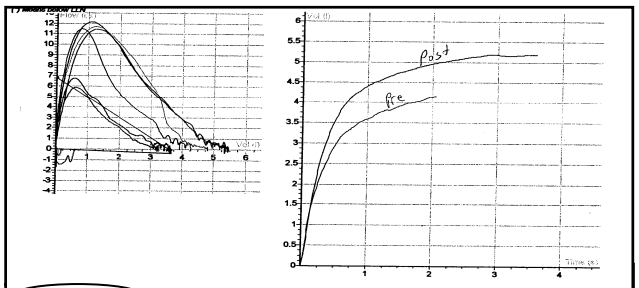


Case 12:

Parameter	Units	Pred	Best Effort 2. Pre	%Pred	1. Post	%Pred	%Change
FVC	(L)	3.58	4.26	119	5.46	152	128% (1.20)
FEV1	(L)	2.87	3.69	129	4.68	163	127% (0.99)
FEV1/FVC	(%)	81	87	107	86	106	99% (-1)
FEV6	(L)	3.50	4.26	122	5.46	156	128% (1.20)
PEF	(L/s)	6.82	11.49	169	11.46	168	100% (-0.03)
FEF25-75	(L/s)	2.90	4.47	154	5.48	189	123% (1.01)
ATS	-	-	No	-	No	-	-

Post Medication: Albuterol, 2.5mg/3ml

- 46 F with recent dx of asthma



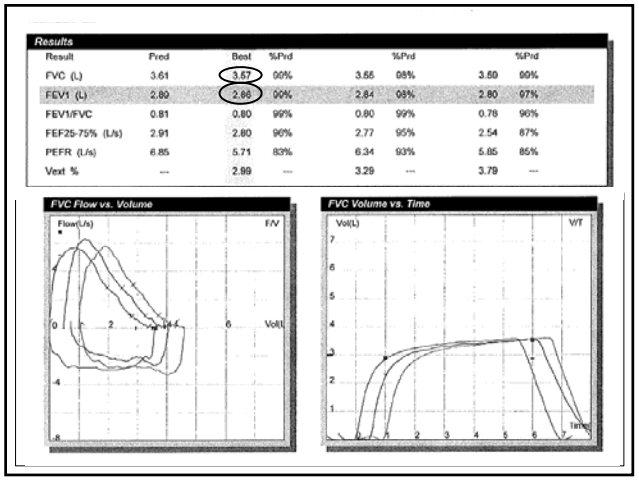
Quality Messages:
Pre: 3-Blow out longer, 2-Blow out longer, 1-Blow out longer, 3-Blow out longer,
Post: 2-Blow out longer, 1-Blow out longer,

FEV1 Pre / Post Var: 855 ml (23 %) / 38 ml (1 %)
FVC Pre / Post Var: 643 ml (15 %) / 107 ml (2 %)
ATS Reproducibility:
Pre: NOT MET (< 3 acceptable efforts)
Post: NOT MET (< 3 acceptable efforts)

Test Comment:

Calibrate Machine

- **Frequent checks with 3 liter syringe**
- **Biological control – no more than 5% variation in FVC and FEV1 per week.**



Results

Result	Pred	Best	%Pred		%Pred		%Pred
FVC (L)	3.61	3.67	90%	3.55	98%	3.60	99%
FEV1 (L)	2.80	2.86	90%	2.84	98%	2.80	97%
FEV1/FVC	0.81	0.80	99%	0.80	99%	0.78	96%
FEF25-75% (L/s)	2.91	2.80	96%	2.77	95%	2.54	87%
PEFR (L/s)	6.85	5.71	83%	6.34	93%	5.85	85%
Vext %	---	2.99	---	3.29	---	3.79	---

FVC Flow vs. Volume

FVC Volume vs. Time

TABLE 2 Activities that should preferably be avoided prior to lung function testing

Smoking within at least 1 h of testing
Consuming alcohol within 4 h of testing
Performing vigorous exercise within 30 min of testing
Wearing clothing that substantially restricts full chest and abdominal expansion
Eating a large meal within 2 h of testing

- **No use of short acting bronchodilators for 4 hours prior to testing.**
- **Long acting β agonists or aminophylline should be held for 12 hours.**

Interpretative strategies for lung function tests. SERIES ''ATS/ERS TASK FORCE: STANDARDISATION OF LUNGFUNCTION TESTING'' Eur Respir J 2005

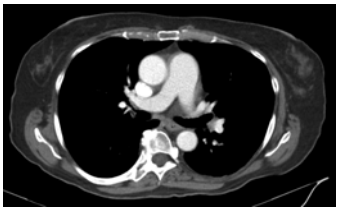
Case 13

	PRED	ACTUAL	%PRED
*SPIROMETRY			
Forced Vital Capacity (FVC;L)	3.25	2.93	90
Forced Exp. Vol. 1 (FEV1;L)	2.83	2.33	82
% FEV1/FVC	90.3%	79.5%	
Mid Exp. Flow (FEF25-75;L/sec)	3.44	2.26	66
Peak Flow (PF;L/sec)	6.79	4.87	72*
*INSPIRATORY LOOP			
FEF50%/FIF50% (normal<=1.0)	1.08*		
*LUNG VOLUMES Plethysmography			
Slow Vital Capacity (SVC;L)	3.25	2.93	90
Exp. Reserve Volume (ERV;L)	1.33	1.11	83
Thoracic Gas Volume (TGV;L)	2.48	2.40	97
Residual Volume (RV;L)	1.15	1.29	112
Total Lung Capacity (TLC;L)	4.60	4.22	92
%RV/TLC	25.2	30.6	
*DIFFUSING CAPACITY			Hb CORR/%PRED
Diff. Cap. (DLCO;ml/min/mm Hg)	24.3	13.5	56* 16.4 67*
Single breath TLC (VA; L)	4.57	3.81	83
DLCO/VA	5.12	3.54	69* 4.30 84
*OXIMETRY/OTHER STUDIES Predict.	Actual		
%SaO2(Rest, O2 = 2 L/min) >93%		96	
%SaO2(6' walk, room air) >93%		77*	
6' Walk Distance (ft) >1200		1459	
Dyspnea(Borg Scale 6'walk)		Rest: .0	Max: 3.0
Heart rate (6' walk, b/min)		Rest: 84	Max: 160

- 26yo AAF with progressive SOB/DOE
- Ht 61in, wt 100 lbs
- BMI=19
- Hgb=11.3
- 7 PY tob hx

Echocardiogram:

- **The right ventricular systolic pressure is calculated at 49 mmHg. There is evidence of moderate pulmonary**
- **Right Ventricle: The right ventricle is slightly dilated. The right ventricular global systolic function is mildly reduced.**



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*LUNG VOLUMES Plethysmography			
Slow Vital Capacity (SVC;L)	3.25	2.93	90
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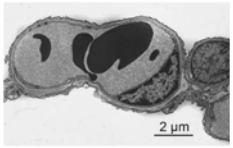
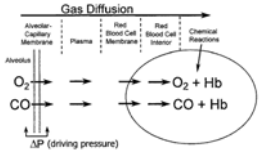
*DIFFUSING CAPACITY			Hb CORR/%PRED
Diff. Cap. (DLCO;ml/min/mm Hg)	24.3	13.5	56* 16.4 67*
Single breath TLC (VA; L)	4.57	3.81	83
DLCO/VA	5.12	3.54	69* 4.30 84
*OXIMETRY/OTHER STUDIES Predict.	Actual		
%SaO2(Rest, room air) >93%		96	
%SaO2(6' walk, room air) >93%		77*	
6' Walk Distance (ft) >1200		1459	
Dyspnea(Borg Scale 6'walk)		Rest: .0	Max: 3.0
Heart rate (6' walk, b/min)		Rest: 84	Max: 160

- Normal spirometry
- Normal lung volumes
- Low diffusing capacity
- Significant desaturation with normal walk distance
- DDx:
  - Pulm HTN
  - Early ILD

Diffusing Capacity

- Capacity of the lungs to exchange gas across the alveolar-capillary interface
- Most common technique based on CO uptake
- Function of
  - Flow delivery of CO to alveoli
  - Mixing and diffusion of CO to airways and alveoli
  - Transfer of CO across gas/liquid interface
  - Mixing and diffusion of CO in the lung parenchyma/capillary plasma
  - Diffusion across RBC membrane
  - Chemical reaction with Hgb





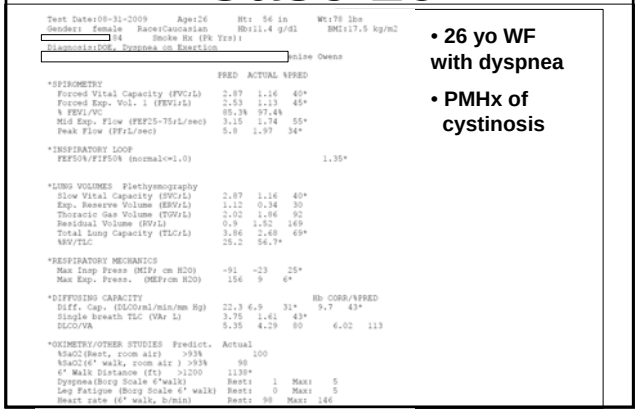
Swiss Med Wkly 2009;139(27–28):375–386
Respir Care 2003;48(8):777–782.

Case 15

Test Date:10-09-2008 Age:52 Ht:70.0 in Wt:176 lbs
Gender: male Race:Caucasian Hb:18.1 g/dl BMI:25.2 kg/m2
Smoke Hx (Pk Yrs):
Diagnosis:Multiple myeloma

	PRED	ACTUAL	%PRED		
*SPIROMETRY					
Forced Vital Capacity (FVC;L)	5.01	3.25	65*		
Forced Exp. Vol. 1 (FEV1;L)	3.87	2.08	54*		
% FEV1/VC	77.3%	62.3%	*		
Mid Exp. Flow (FEF25-75;L/sec)	3.37	1.13	34*		
Peak Flow (PF;L/sec)	9.73	5.06	52*		
*INSPIRATORY LOOP					
FEF50%/FIF50% (normal<=1.0)				.41	
*LUNG VOLUMES Plethysmography					
Slow Vital Capacity (SVC;L)	5.01	3.34	67*		
Exp. Reserve Volume (ERV;L)	1.49	1.05	70		
Thoracic Gas Volume (TGV;L)	3.57	3.53	99		
Residual Volume (RV;L)	2.08	2.49	120		
Total Lung Capacity (TLC;L)	6.97	5.83	84		
%RV/TLC	30.1	42.7*			
*DIFFUSING CAPACITY				Hb CORR	%PRED
Diff. Cap. (DLCO;ml/min/mm Hg)	30.3	12.5	41*	7.6	25*
Single breath TLC (VA; L)	6.82	4.78	70*		
DLCO/VA	4.50	2.62	58*	1.59	35*

Case 16

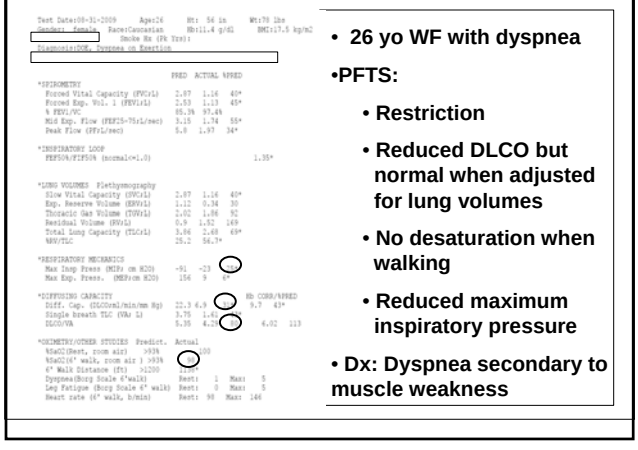


- 26 yo WF with dyspnea
- PMHx of cystinosis

Test Date:10-09-2008 Age:52 Height: 70.0 in Weight: 176 lbs
Gender: male Race: Caucasian Hb: 6.9 g/dl BMI: 25.2 kg/m2
Smoke Hx (Pk Yrs):
Diagnosis: Multiple myeloma

Predicted Values from NHANES III

	PRED	ACTUAL	%PRED		
SPIROMETRY					
Forced Vital Capacity (FVC; L)	5.01	3.25	65 *		
Forced Exp. Vol. 1 (FEV1; L)	3.87	2.08	54 *		
% FEV1 / VC	77.3 %	62.3 %	*		
Mid Exp. Flow (FEF25-75; L/sec)	3.37	1.13	34 *		
Peak Flow (PF; L/sec)	9.73	5.06	52 *		
INSPIRATORY LOOP					
FEF50% / FIF50%	<=1.0	.41			
LUNG VOLUMES *Plethysmography Method*					
Slow Vital Capacity (SVC; L)	5.01	3.34	67 *		
Exp. Reserve Volume (ERV; L)	1.49	1.05	70		
Thoracic Gas Volume (TGV; L)	3.57	3.53	99		
Residual Volume (RV; L)	2.08	2.49	120		
Total Lung Capacity (TLC; L)	6.97	5.83	84		
%RV/TLC	30.1	42.7	*		
DIFFUSING CAPACITY				Hb CORR	% PRED
Diffusing Capacity (DLCO; ml/min/mm Hg)	30.3	12.5	41 *	23.3	77
Single breath TLC (VA; L)	6.82	4.78	70 *		
DLCO/VA	4.50	2.62	58 *	4.87	108



- 26 yo WF with dyspnea
- PFTS:
  - Restriction
  - Reduced DLCO but normal when adjusted for lung volumes
  - No desaturation when walking
  - Reduced maximum inspiratory pressure
- Dx: Dyspnea secondary to muscle weakness

Case 17

Test Date:04-28-2008
Last Test:12-07-2007 Age:55 Ht:64.0 in Wt:182 lbs
Gender: male Race:Caucasian Hb: None BMI:31.2 kg/m2
Smoke Hx (Pk Yrs):
Diagnosis:DOE, Dyspnea on Exertion

	PRED	ACTUAL	%PRED
*SPIROMETRY			
Forced Vital Capacity (FVC;L)	3.95	3.39	86
Forced Exp. Vol. 1 (FEV1;L)	3.04	2.08	68*
% FEV1/VC	76.7%	56.8%	*
Mid Exp. Flow (FEF25-75;L/sec)	2.69	.80	30*
Peak Flow (PF;L/sec)	8.26	6.77	82
*LUNG VOLUMES Plethysmography			
Slow Vital Capacity (SVC;L)	3.95	3.66	93
Exp. Reserve Volume (ERV;L)	1.07	.06	6
Thoracic Gas Volume (TGV;L)	2.88	2.62	91
Residual Volume (RV;L)	1.81	2.56	141*
Total Lung Capacity (TLC;L)	5.77	6.22	108
%RV/TLC	31.1	41.2*	
*DIFFUSING CAPACITY			Hb CORR/%PRED
Diff. Cap. (DLCO;ml/min/mm Hg)	27.1	35.2	130*
Single breath TLC (VA; L)	5.66	5.56	98
DLCO/VA	4.75	6.33	133*

- **55yo WM with long standing asthma**

Test Date:04-28-2008
Last Test:12-07-2007 Age:55 Ht:64.0 in Wt:182 lbs
Gender: male Race:Caucasian Hb: None BMI:31.2 kg/m2
Smoke Hx (Pk Yrs):
Diagnosis:DOE, Dyspnea on Exertion

	PRED	ACTUAL	%PRED
*SPIROMETRY			
Forced Vital Capacity (FVC;L)	3.95	3.39	86
Forced Exp. Vol. 1 (FEV1;L)	3.04	2.08	68*
% FEV1/VC	76.7%	56.8%	*
Mid Exp. Flow (FEF25-75;L/sec)	2.69	.80	30*
Peak Flow (PF;L/sec)	8.26	6.77	82
*LUNG VOLUMES Plethysmography			
Slow Vital Capacity (SVC;L)	3.95	3.66	93
Exp. Reserve Volume (ERV;L)	1.07	.06	6
Thoracic Gas Volume (TGV;L)	2.88	2.62	91
Residual Volume (RV;L)	1.81	2.56	141*
Total Lung Capacity (TLC;L)	5.77	6.22	108
%RV/TLC	31.1	41.2*	
*DIFFUSING CAPACITY			Hb CORR/%PRED
Diff. Cap. (DLCO;ml/min/mm Hg)	27.1	35.2	130*
Single breath TLC (VA; L)	5.66	5.56	98
DLCO/VA	4.75	6.33	133*

- **PFTS:**
  - ✓ **Obstruction by spirometry**
  - ✓ **Increased RV c/w air trapping**
  - ✓ **Increased DLCO**
- **Asthma**
- **Obesity**
- **Polycythemia, cardiac shunts, alveolar hemorrhage**