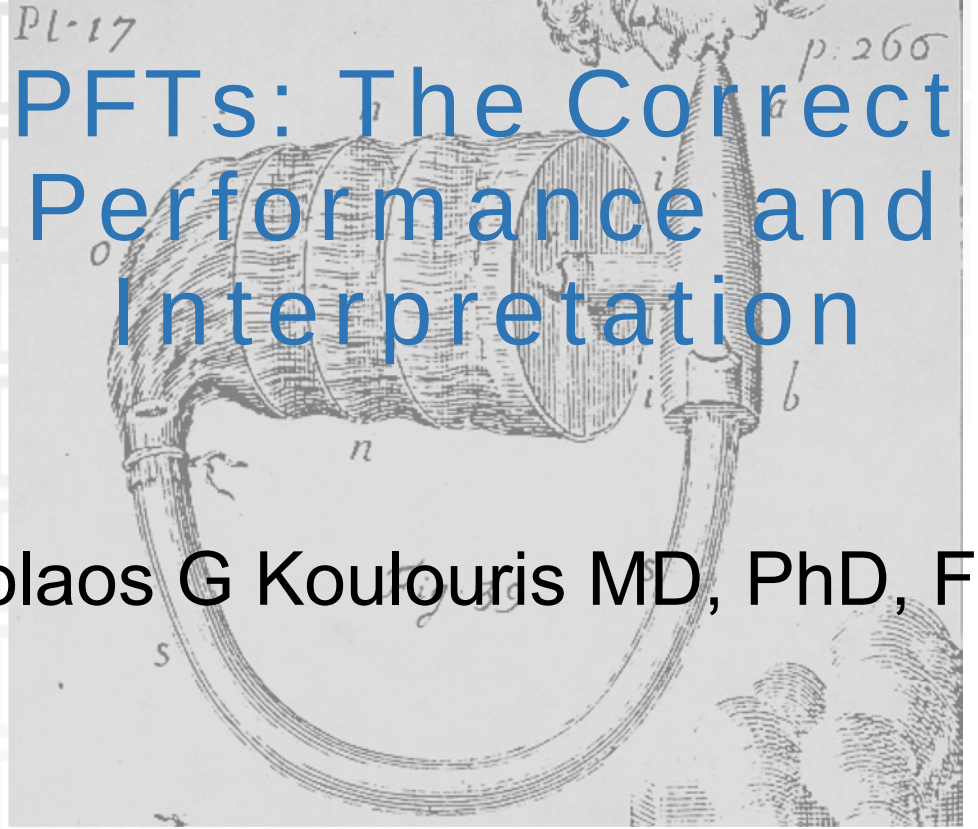
CHEST Regional Congress | ATHENS 2019 | Greece | 27-29 June | HELLENIC THORACIC SOCIETY

Megaron Athens International Conference Centre (MAICC)

Conflict of interest disclosure

- ***I have no, real or perceived, direct or indirect conflicts of interest that relate to this presentation.***



PFTs: The Correct Performance and Interpretation

Nickolaos G Koulouris MD, PhD, FCCP

CHEST® Regional Congress

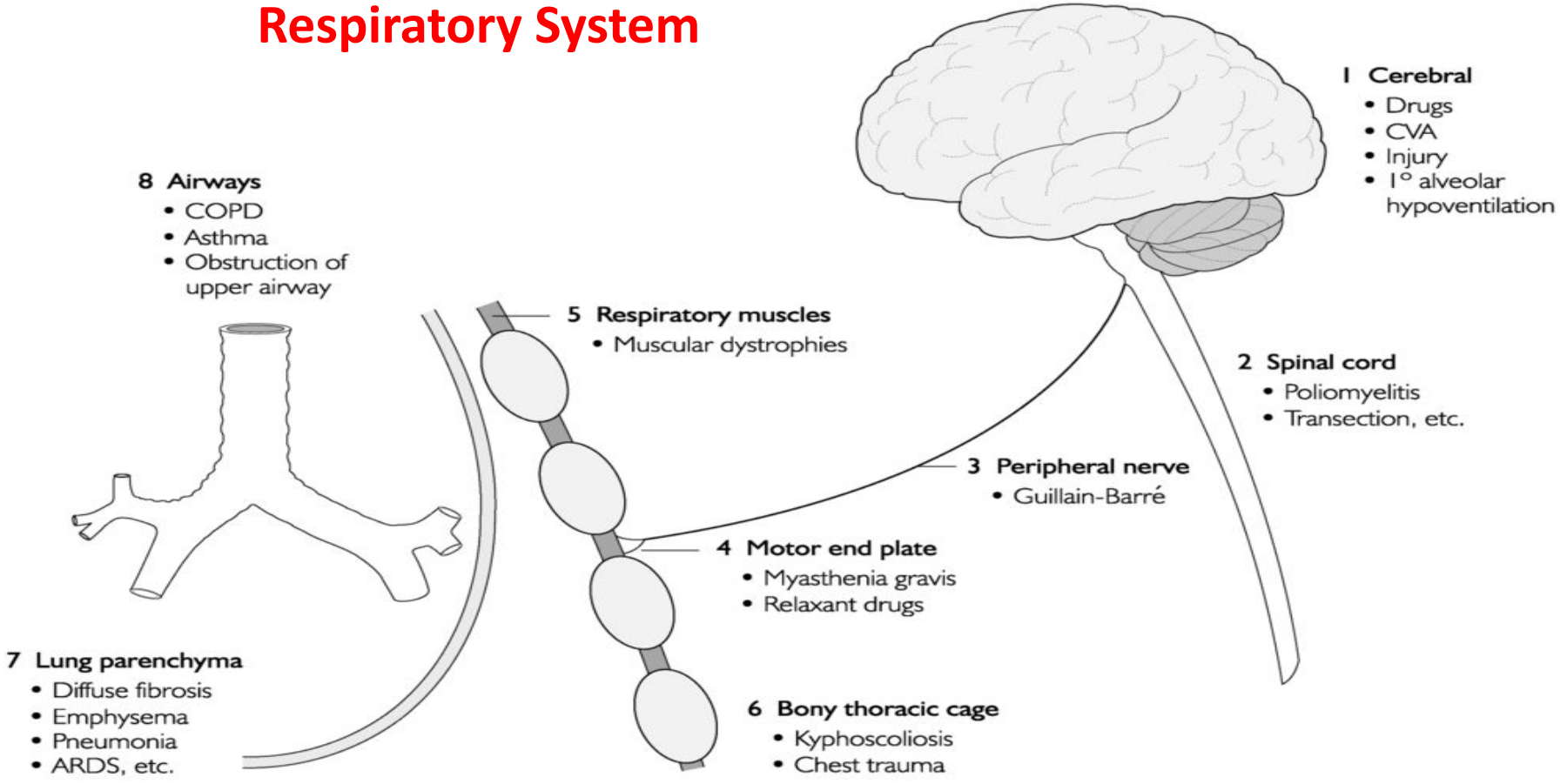
ATHENS 2019
GREECE | 27-29 JUNE

HELLENIC THORACIC SOCIETY

Learning Objectives:

- Explain how to perform spirometry testing.
- Learn how to detect airway obstruction.
- Be able to give a preoperative assessment.
- Describe the current algorithm for preoperative assessment.

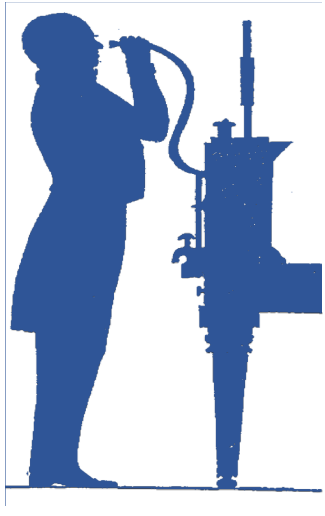
Respiratory System



Pulmonary lung function tests

Pulmonary lung function tests are designed to identify and quantify defects and abnormalities in the function of the respiratory system (ventilatory defects or functional syndromes) and answer several crucial questions, such as:

- Does a patient has a ventilatory limitation?
- If yes, on what basis?
- How severe it is?
- And many more questions……



How lung function testing helps us?

Measurements determine

↓

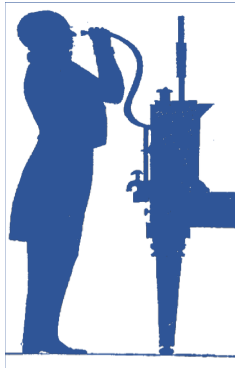
The Ventilatory Defect of a patient. Combining these data

↓

with History and Clinical Examination we make the correct

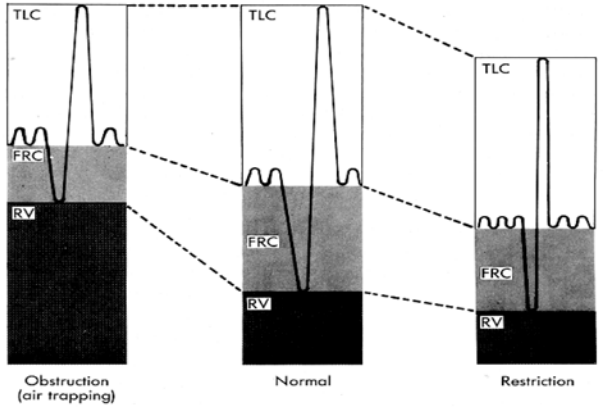
↓

Diagnosis



VENTILATORY DEFECTS

The ventilatory defects are: a) *obstructive* characterized by obstruction or narrowing of the airways, b) *restrictive* chararacterized by a reduction of Total Lung Capacity (TLC) due to i) pulmonary diseases per se (i.e., pulmonary fibrosis), ii) extrapulmonary diseases and disorders (i.e., chest wall deformities, neuromuscular diseases, etc),and c) *mixed* characterized by the presence of both, obstructive and restrictive ventilatory defects.



Routine Lung Function Tests

- **Simple spirometry and maximum flow-volume curve** before and after bronchodilation (PEF, FEVC, FEV1, MMEF), seated and supine

It is the best test to detect airways obstruction

- **Static Lung Volumes and Capacities** (TLC, FRC, RV)

TLC is the best measurement to detect restriction

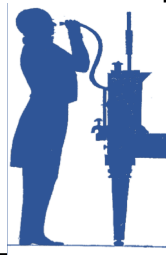
- **Diffusing Capacity or Transfer Factor and Carbon Monoxide Rate Constant** (DLCO ή TLCO, KCO)

Assesses the transfer of gas between the alveoli and pulmonary capillary blood flow

Maximum Static Mouth Pressures (Pimax, Pemax)

Assessment of Respiratory Muscle Strength

- **Blood Gases** (PaO_2, $PaCO_2$, pH), pulse oximetry



Possible order for undertaking lung function tests in a laboratory

Dynamic studies: spirometry, flow–volume loops, PEF

Static lung volumes

Inhalation of bronchodilator agent (if used)

Diffusing capacity

Repeat dynamic studies (if a bronchodilator was given)

PEF: peak expiratory flow.

Miller et al, Eur Respir J 2005; 26: 153–161

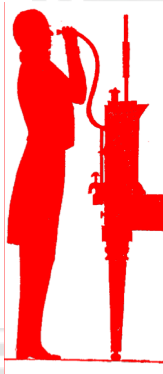
DEFINITION OF SPIROMETRY

Spirometry, Spirometer : Introduced in Oxford Dictionary in 1846

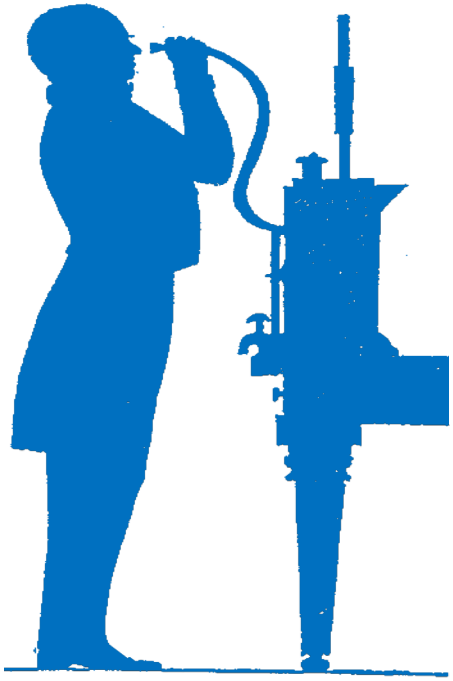
From the Latin Spiro, Respiro (breathing) and the Greek Μετρώ (measure)

Spirometry is a physiological test that measures how an individual inhales or exhales volumes of air as a function of time or flow.

In practice, **Spirometry** is the measurement of Forced Vital Capacity (FVC). FVC is the maximum volume of air expelled after a maximum inhalation.



John Hutchinson invented and presented the first spirometric device in 1846. (Spirometer is a device that measures air volumes exhaled from the lung). He also described in detail the measurement of the first spirometric test the so called **Slow Vital Capacity (SVC).**



BROMPTON HOSPITAL—North Building, Mid 19th Century

ON THE

CAPACITY OF THE LUNGS,

AND ON THE

RESPIRATORY FUNCTIONS,

WITH A VIEW OF ESTABLISHING A PRECISE AND EASY METHOD OF DETECTING DISEASE BY THE SPIROMETER.

By JOHN HUTCHINSON, Surgeon.

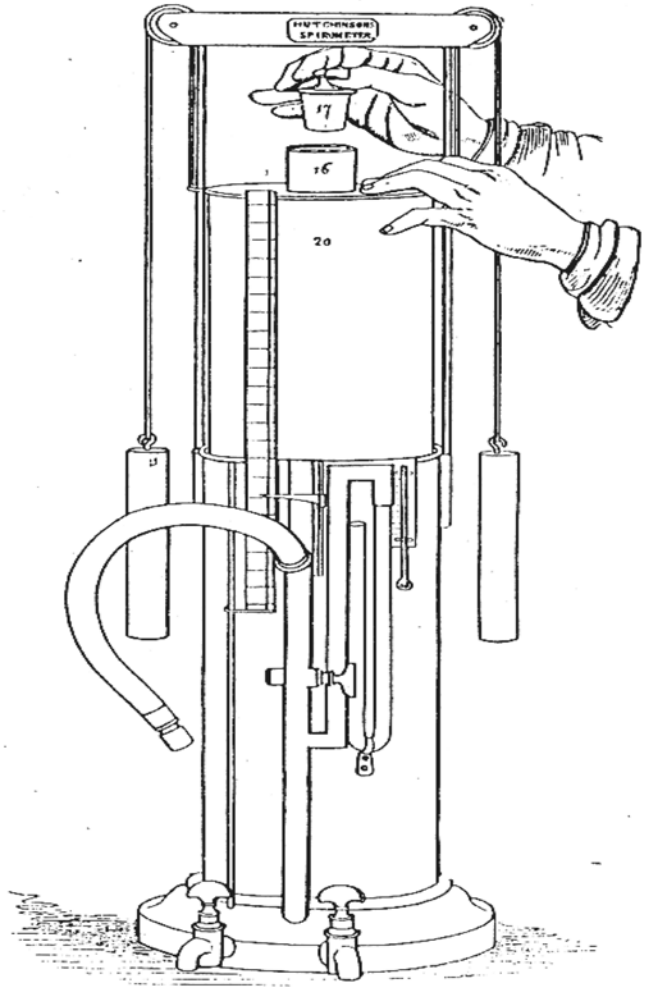
Communicated by GEORGE CURSHAM, M.D.,

one of the Secretaries of the Society.

Received January 22nd—Read April 28th, 1816.

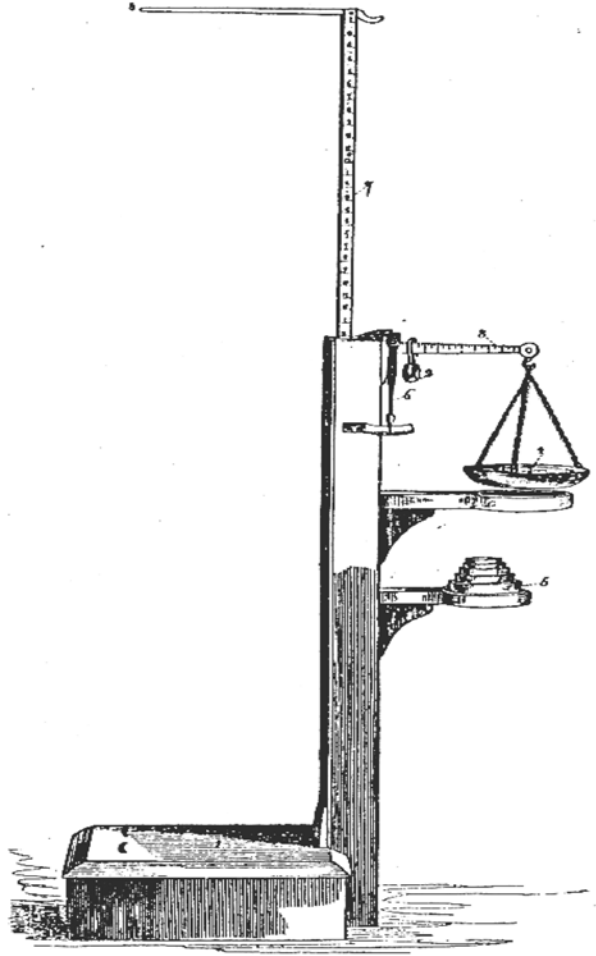
MR. HUTCHINSON

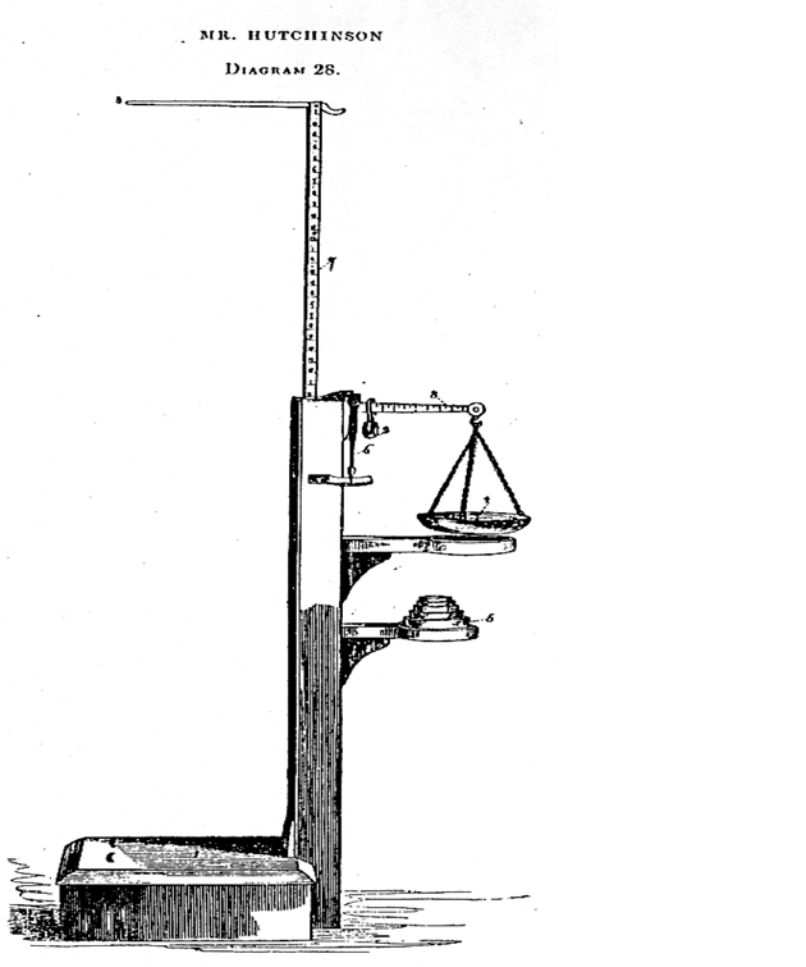
DIAGRAM 27.



MR. HUTCHINSON

DIAGRAM 28.





University Of Athens-'SOTIRIA' Hospital
Respiratory function Laboratory
Tel. 210 77 63 454
In Charge: Dr. N. G. Koulouris

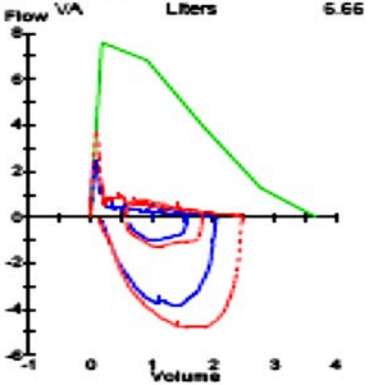
- Pulmonary Function Analysis -

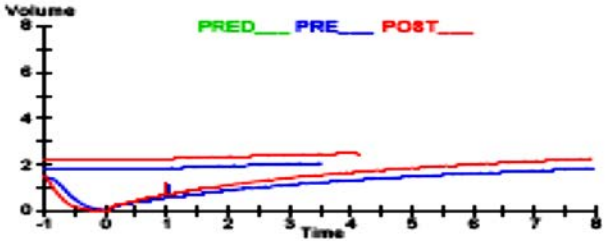
Gender: Male
Age: 72
Height(cm): 172
Weight(kg): 80.0

Id: 2075/03
Date: 05/02/10
Race: Caucasian
PBar: 742 Temp: 23

			PRE-RX		POST-RX		
Spirometry	(BTPS)	PRED	BEST	%PRED	BEST	%PRED	%Chg
FVC	Liters	3.70	2.06	56	2.48	67	20
FEV1	Liters	2.82	0.58	21	0.72	25	24
FEV1/FVC	%	74	28		29		
FEF25-75%	L/sec	2.94	0.22	8	0.29	10	32
FEF75%	L/sec	1.28	0.13	10	0.18	14	35
FEF50%	L/sec	3.94	0.22	6	0.33	8	50
FEF25%	L/sec	6.83	0.47	7	0.45	7	-3
PEF	L/sec	7.61	2.50	33	3.70	49	48
FIVC	Liters	3.70	1.89	51	2.32	63	23
FEF/FIF50		<1.00	0.06		0.07		19
Lung Volumes							
TLC	Liters	6.66	8.21	123			
RV	Liters	2.61	5.09	195			
RV/TLC	%	42	62				
FRC N2	Liters	3.58	6.45	180			
VC	Liters	3.83	3.12	82			
ERV	Liters	1.36	1.36	100			
IC	Liters	2.73	1.76	65			
Wash Time	Min		3.1				
Diffusion							
DLCO	mmol/kPa.min	8.3	5.6	67			
DL Adj	mmol/kPa.min	8.3	5.2	63			
DLCO/VA	DLCO/L	1.25	1.68	134			
DL/VA Adj	DLCO/L	1.25	1.57	126			
VA	Liters	6.66	3.33	50			

Hb: 10.7 mmol/L

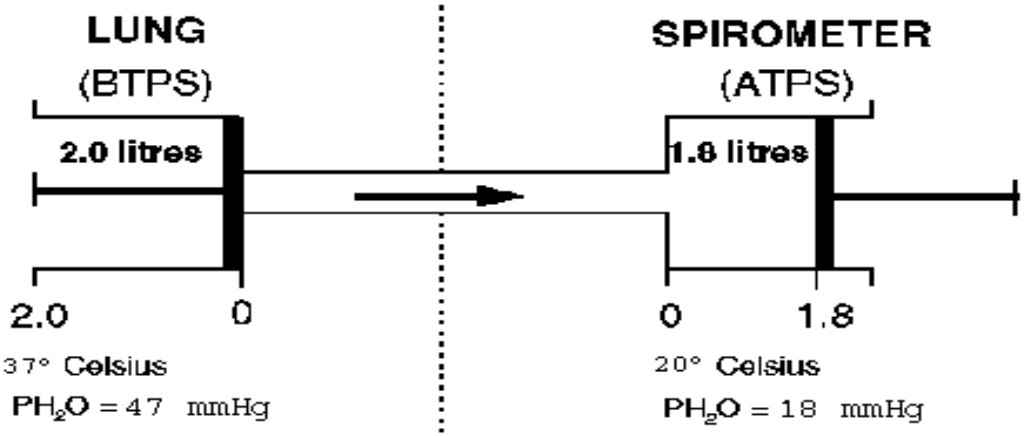




BTPS CORRECTION

Body Conditions: Body Temperature, Ambient Pressure, and Saturation with water vapor

- ✓Charles Law states that the volume occupied by any given quantity of gas is directly related to temperature. As the exhaled air travels from a patient (BTPS conditions) to a spirometer it cools (ATPS conditions). Therefore, the volume of air exhaled is reduced and its water saturation changes.



Indications for spirometry

Diagnostic

- To evaluate symptoms, signs or abnormal laboratory tests
- To measure the effect of disease on pulmonary function
- To screen individuals at risk of having pulmonary disease
- To assess pre-operative risk
- To assess prognosis
- To assess health status before beginning strenuous physical activity programmes

Monitoring

- To assess therapeutic intervention
- To describe the course of diseases that affect lung function
- To monitor people exposed to injurious agents
- To monitor for adverse reactions to drugs with known pulmonary toxicity

Disability/impairment evaluations

- To assess patients as part of a rehabilitation programme
- To assess risks as part of an insurance evaluation
- To assess individuals for legal reasons

Public health

- Epidemiological surveys
- Derivation of reference equations
- Clinical research

Miller et al, Eur Respir J 2005; 26: 319–338

TABLE 1 Conditions where suboptimal lung function results are likely

Chest or abdominal pain of any cause

Oral or facial pain exacerbated by a mouthpiece

Stress incontinence

Dementia or confusional state

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

Miller et al, Eur Respir J 2005; 26: 153–161

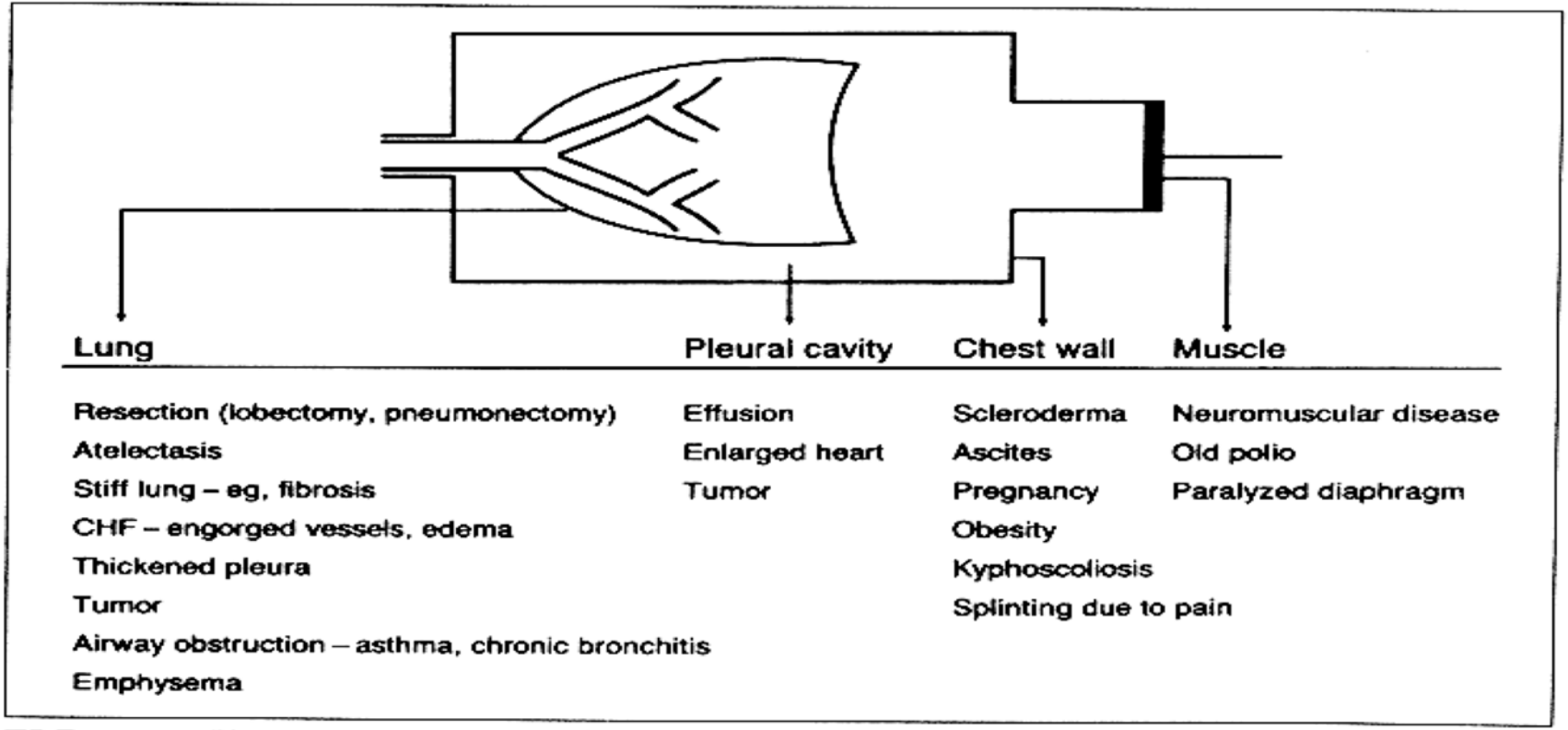
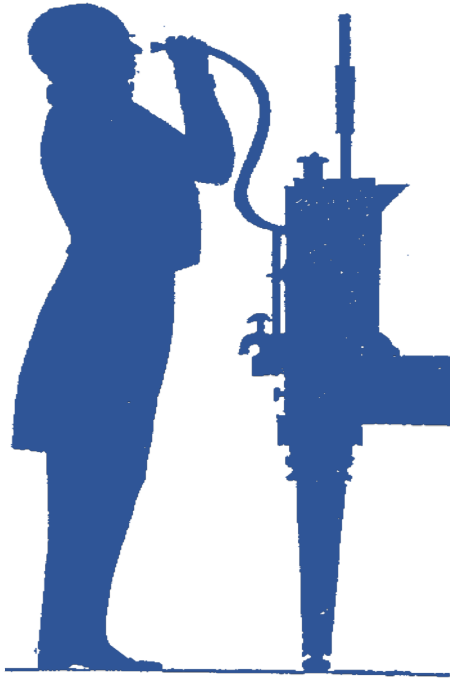


FIG. 2-3. Various conditions that can restrict the forced vital capacity. CHF, congestive heart failure.

Slow Vital Capacity (SVC), used as the sole lung function test for 101 years, it was not capable of detecting the commonest lung defect, i.e., the obstructive lung defect. Most lung diseases cause obstructive lung defect (~70%).

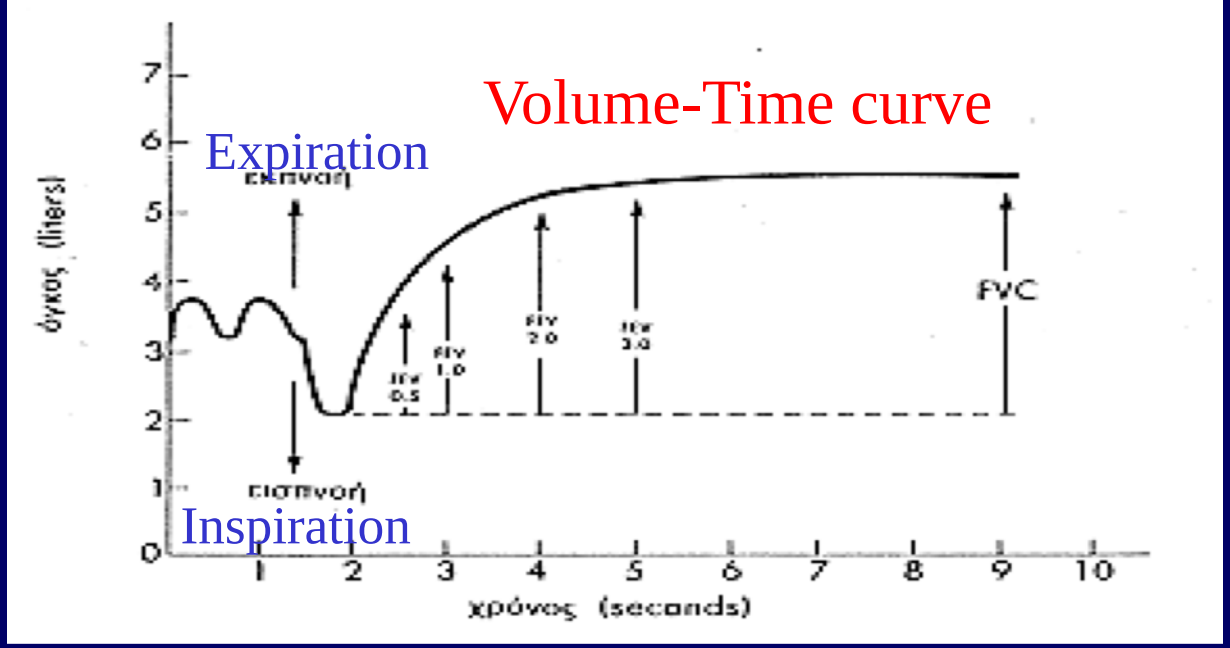


27 Décembre 1947

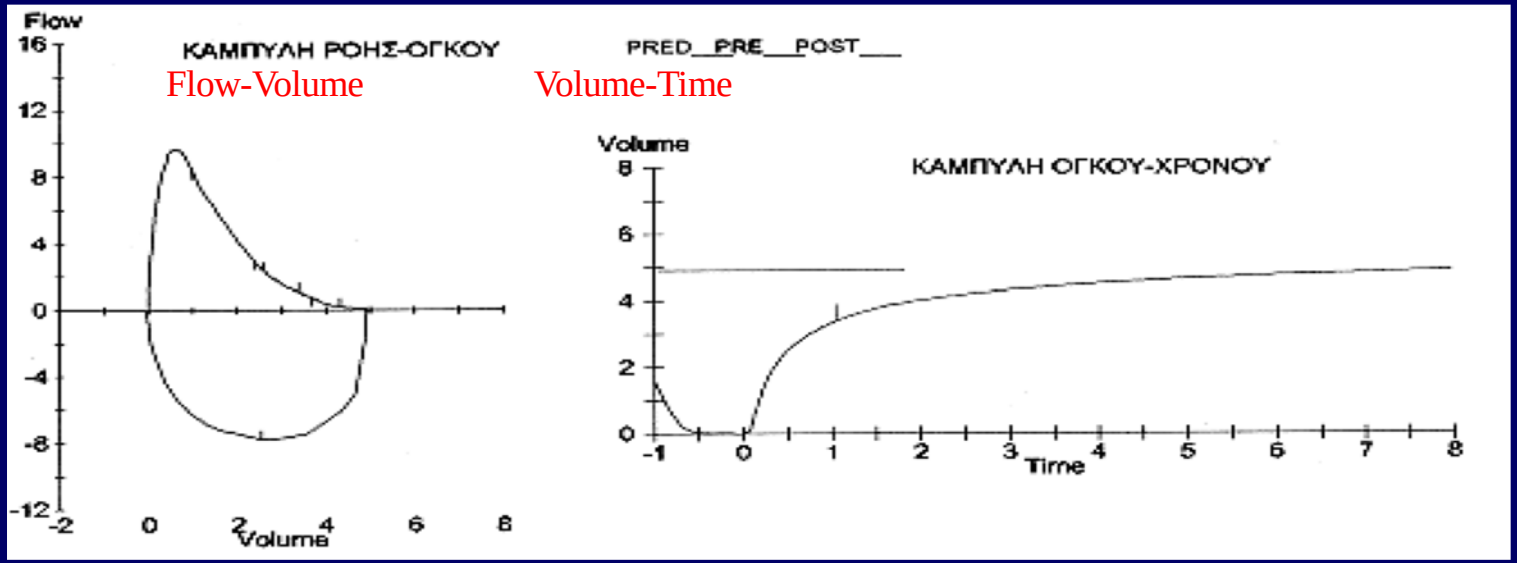
AIR CIRCULANT ET AIR CAPTIF DANS L'EXPLORATION DE LA FONCTION VENTILATRICE PULMONAIRE

PAR

Robert TIFFENEAU et PINELLI



In 1947, the detection of the “obstructive lung defect” was made possible only when two French investigators **Tiffeneau & Pinelli** proposed the measurement of two new parameters derived from the Forced Spirogram. a) **Forced Expired Volume in the 1st second (FEV_1),** and b) **FEV_1/FVC, % ratio** (also known as Tiffeneau’s ratio).



In 1958, Hyatt presented the Maximum Expiratory Flow Volume (MEFV) curve as an alternative expression of the classical Volume-Time curve (FVC-*t*).

Pulmonary mechanics

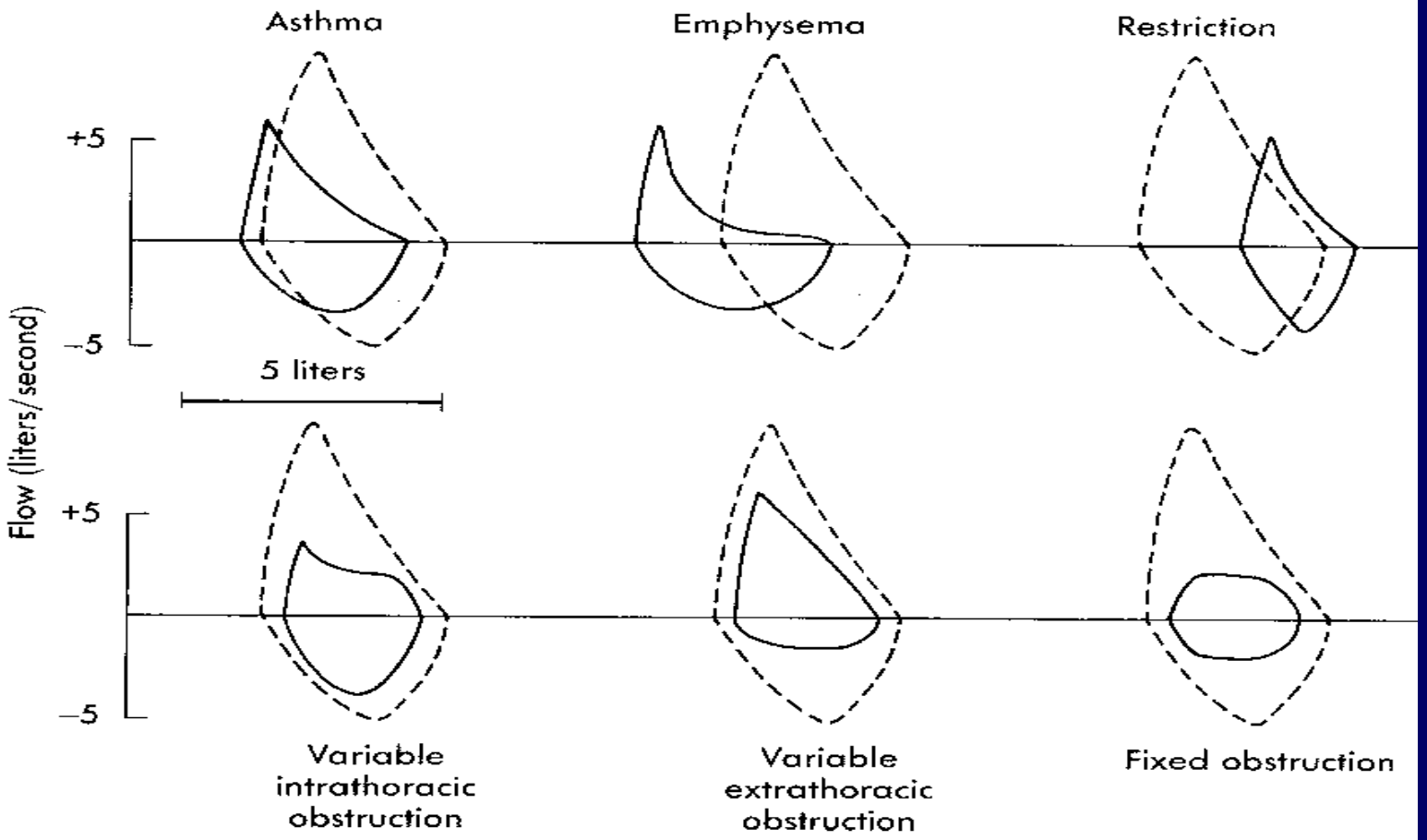


Figure 1.7 Effect of pharyngeal collapse on MIFV curve.

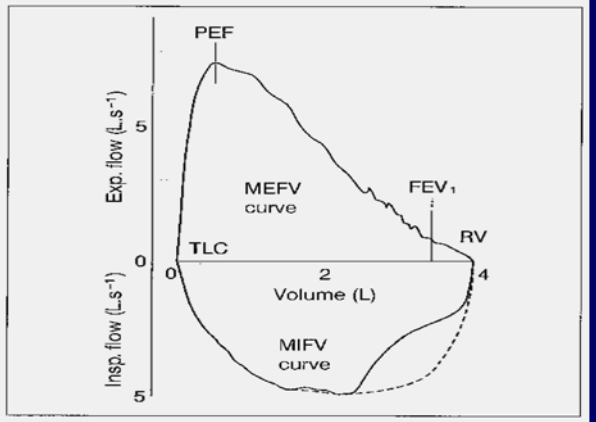
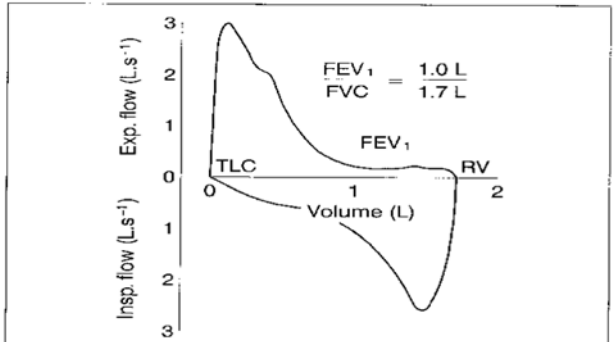
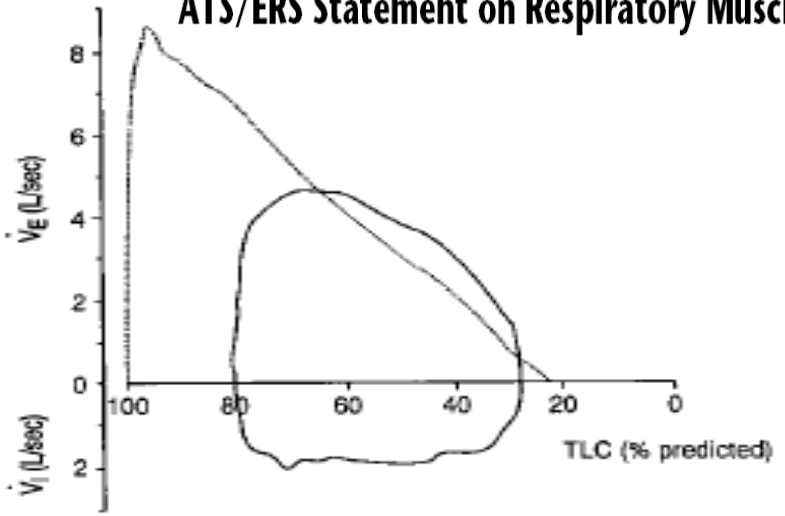


Figure 1.9 Two compartment filling and emptying



(Reproduced from Gascoigne et al. Thorax 1990; 45:637–8, with permission)[9]

ATS/ERS Statement on Respiratory Muscle Testing



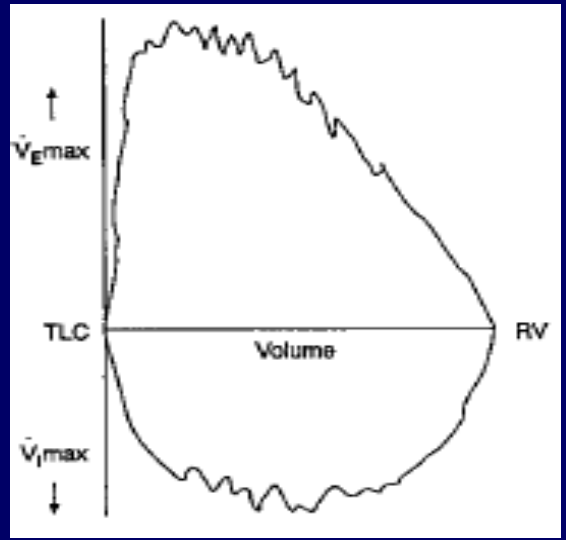


TABLE 4 Procedures for recording forced vital capacity

Check the spirometer calibration

Explain the test

Prepare the subject

- Ask about smoking, recent illness, medication use, *etc.*
- Measure weight and height without shoes

Wash hands

Instruct and demonstrate the test to the subject, to include

- Correct posture with head slightly elevated
- Inhale rapidly and completely
- Position of the mouthpiece (open circuit)
- Exhale with maximal force

Perform manoeuvre (closed circuit method)

- Have subject assume the correct posture
- Attach nose clip, place mouthpiece in mouth and close lips around the mouthpiece
- Inhale completely and rapidly with a pause of <1 s at TLC
- Exhale maximally until no more air can be expelled while maintaining an upright posture
- Repeat instructions as necessary, coaching vigorously
- Repeat for a minimum of three manoeuvres; no more than eight are usually required
- Check test repeatability and perform more manoeuvres as necessary

Miller et al, Eur Respir J 2005; 26: 319–338

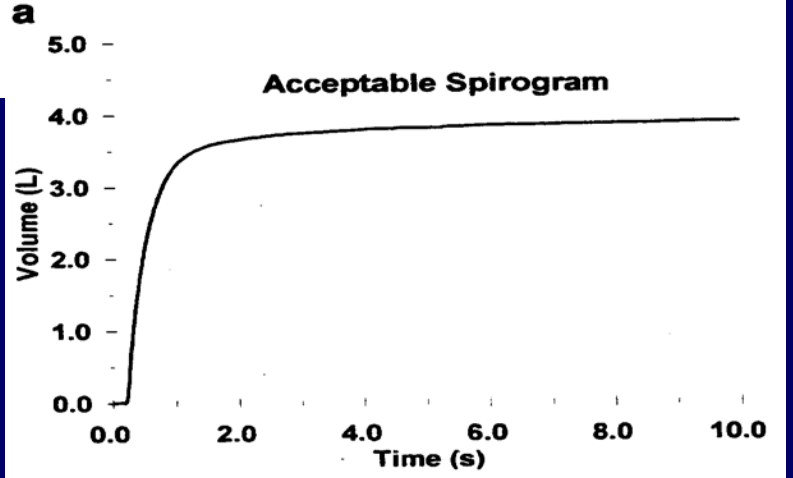


Figure A1a. Acceptable volume–time spirogram.

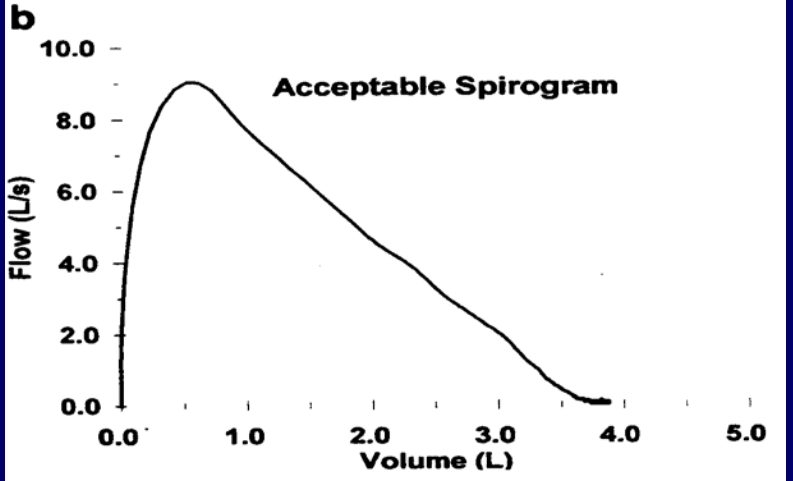
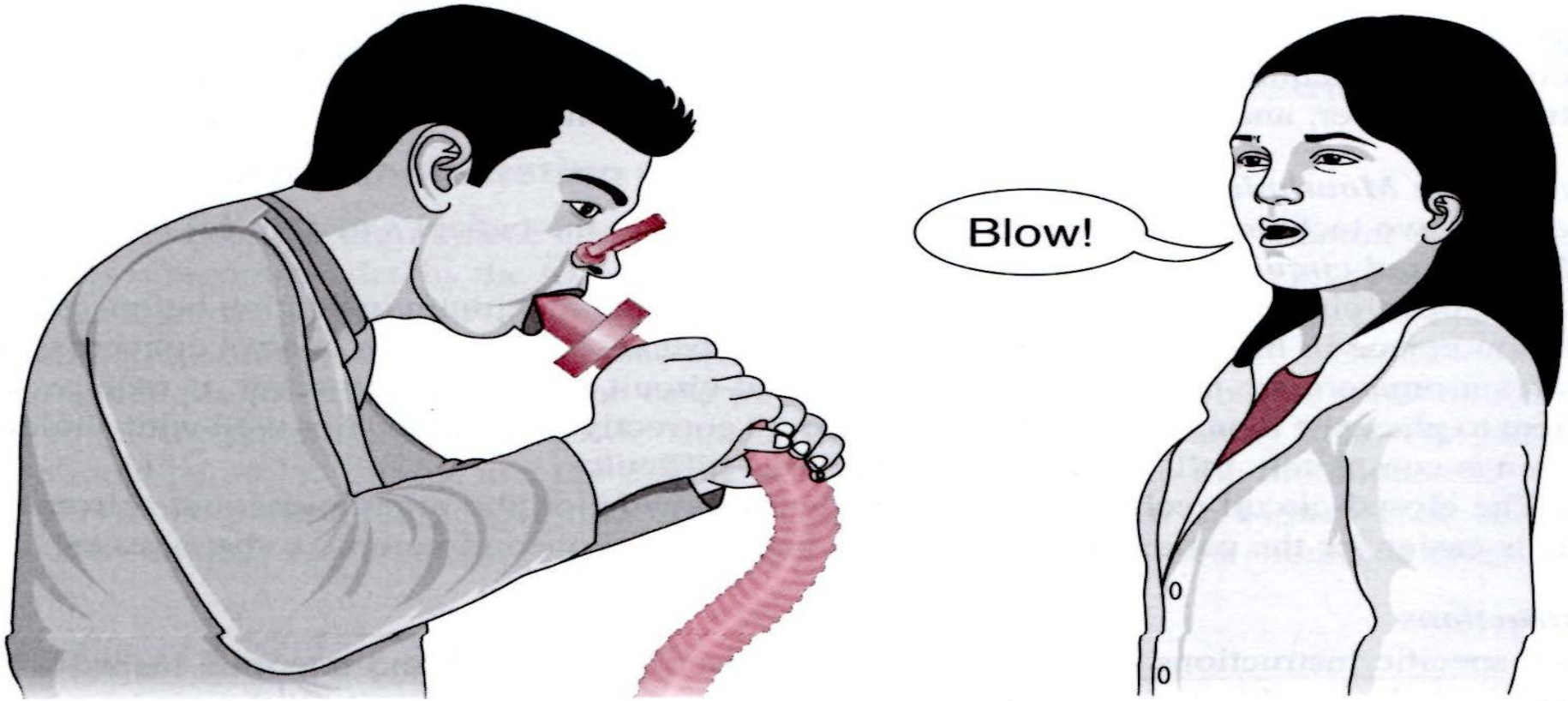


Figure A1b. Acceptable flow–volume spirogram.

Time to reach PEF is 100ms.

The volume–time curve shows no change in volume (0.025 L) for ≥1 s, and the subject has tried to exhale for ≥ 3 s in children aged ≤10 yrs and for ≥ 6 s in subjects aged ≥ than10 yrs. For patients with airways obstruction or older subjects, exhalation times of ≥ 6 s are frequently needed. However, exhalation times of ≥15 s will rarely change clinical decisions.

Use good coaching during forced spirometry.



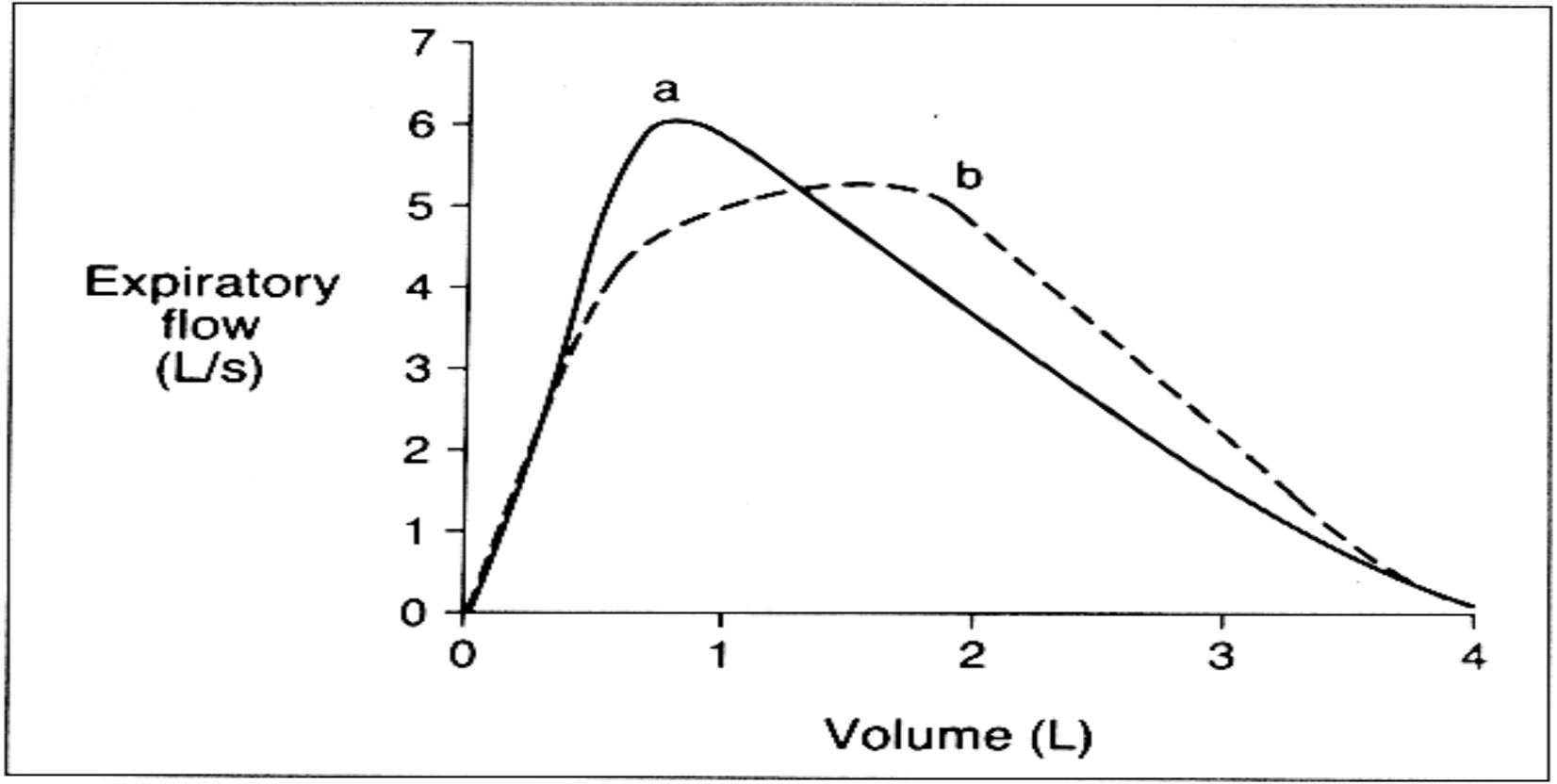


FIG. 5-4. Two consecutive flow-volume curves during which the subject exerted maximal effort (curve a) and then slightly submaximal effort (curve b). Note the slightly lower and delayed peak flow but higher flows over the lower volumes of curve b.

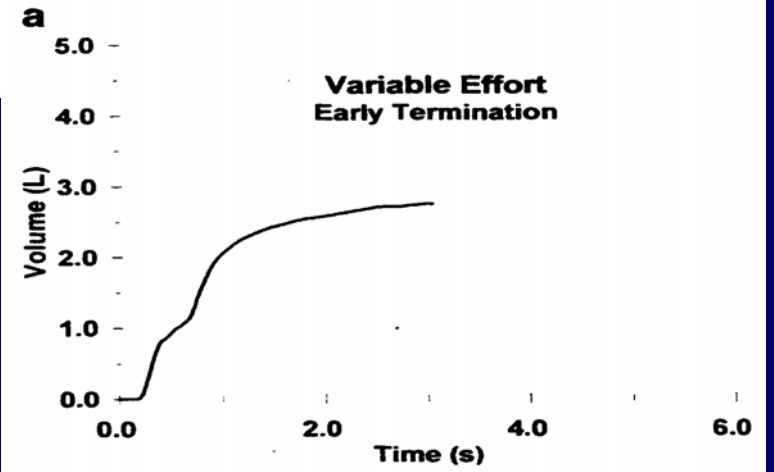


Figure A3a. Unacceptable volume–time spirogram due to variable effort and early termination.

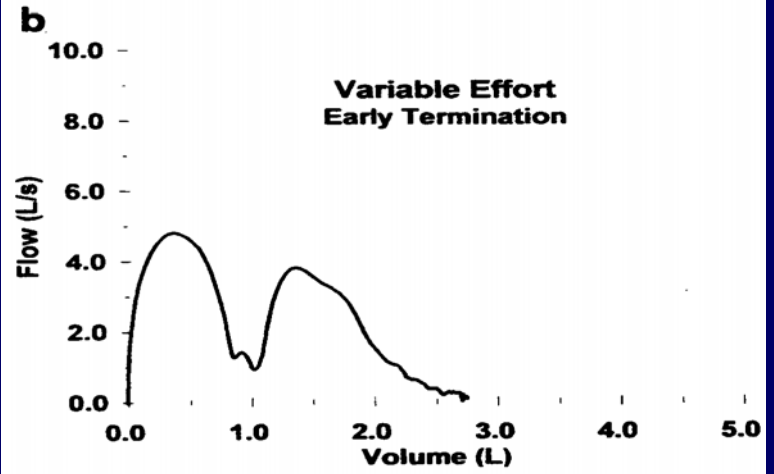


Figure A3b. Unacceptable flow–volume spirogram due to variable effort and early termination.

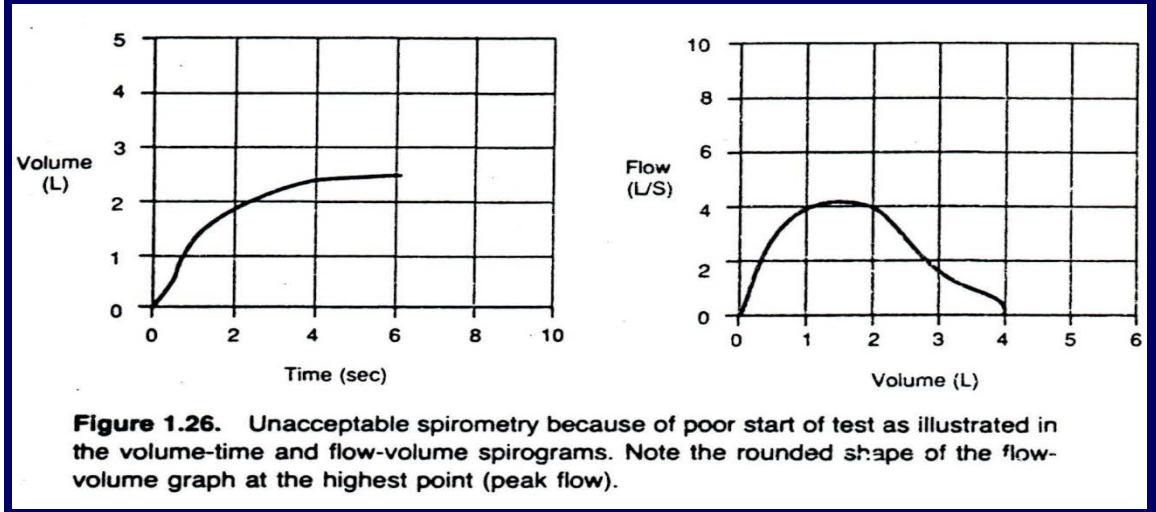
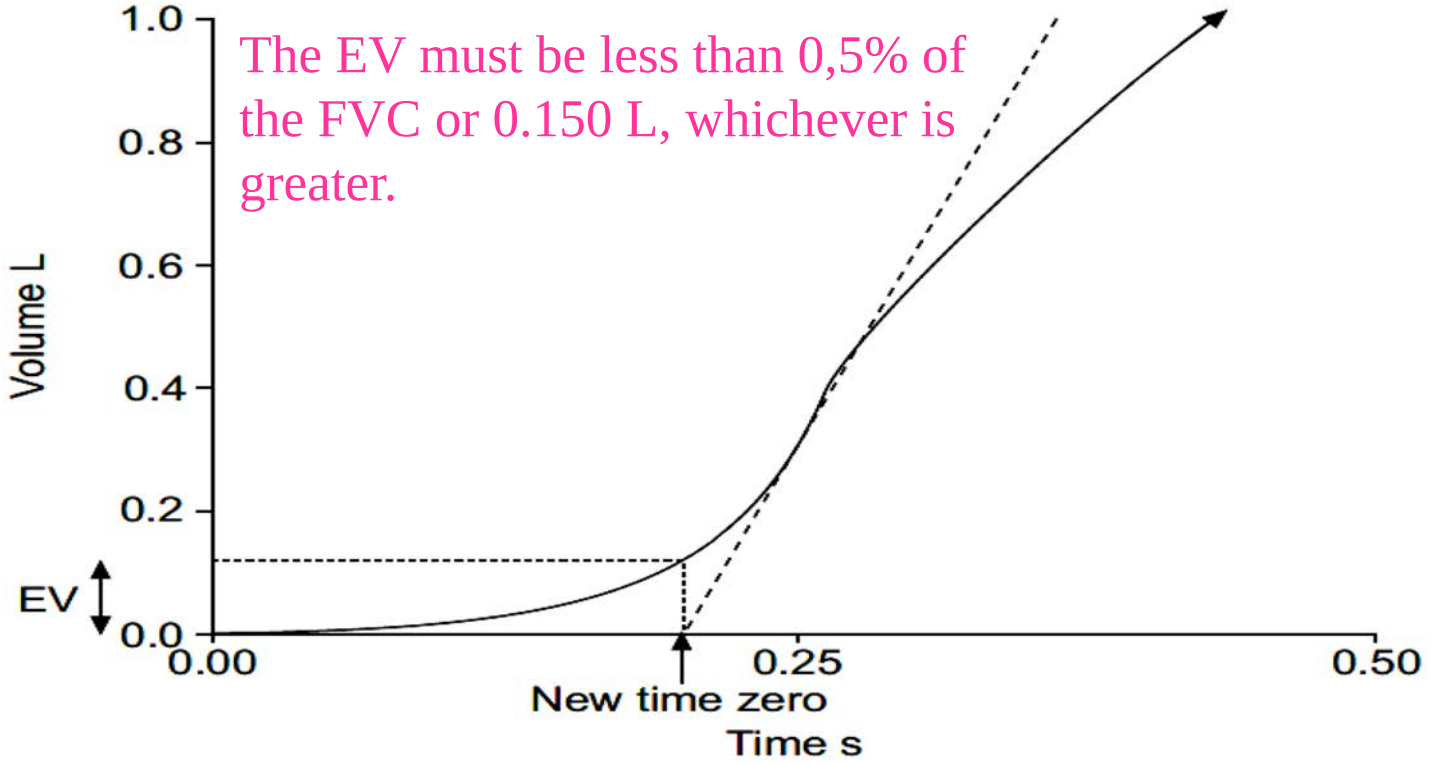


Figure 1.26. Unacceptable spirometry because of poor start of test as illustrated in the volume-time and flow-volume spirograms. Note the rounded shape of the flow-volume graph at the highest point (peak flow).

The EV must be less than 0,5% of the FVC or 0.150 L, whichever is greater.



Expanded version of the early part of a subject's volume–time spirogram, illustrating back extrapolation through the steepest part of the curve, where flow is peak expiratory flow (PEF), to determine the new "time zero". Forced vital capacity (FVC)=4.291 L; back extrapolated volume (EV)=0.123 L (2.9% FVC). -----: back extrapolation line through PEF.

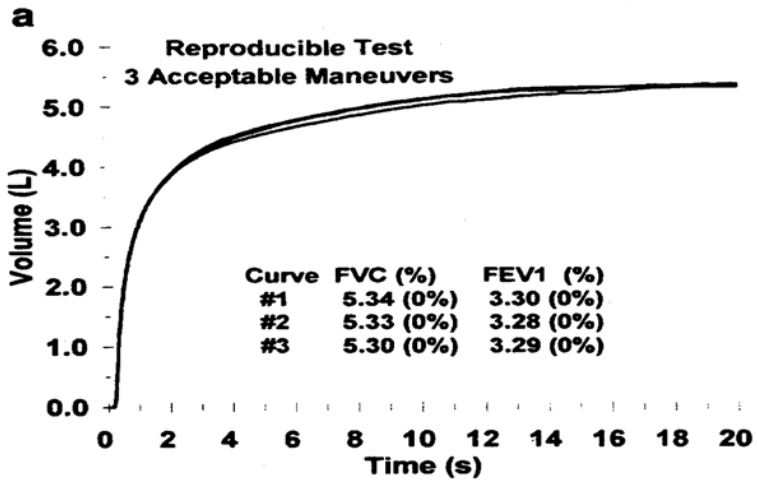


Figure A8a. Reproducible test with three acceptable volume–time curves. Percents are difference from largest value.

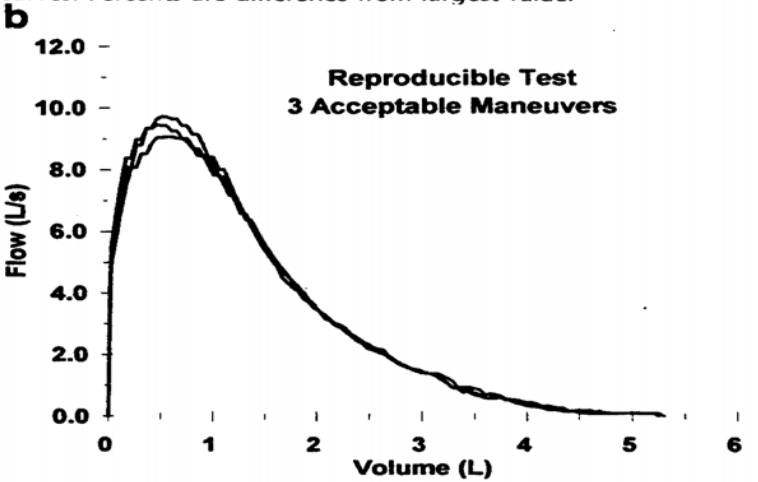


Figure A8b. Reproducible test with three acceptable flow–volume curves.

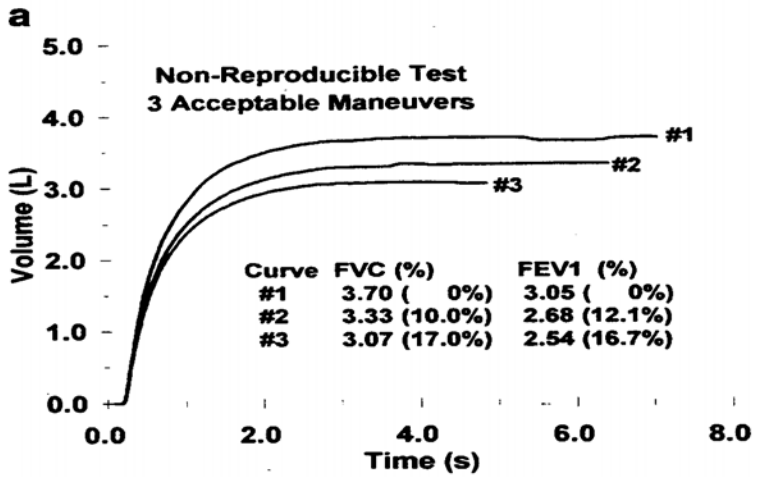


Figure A7a. Nonreproducible test with three acceptable volume–time curves. Percents are difference from largest value.

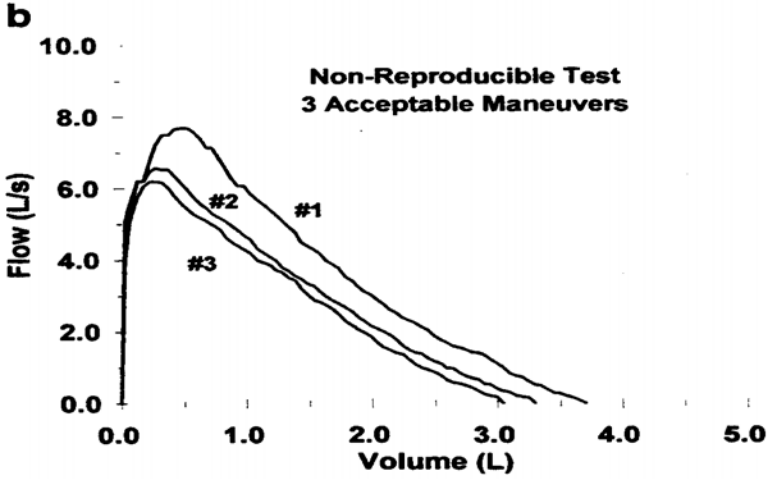


Figure A7b. Nonreproducible test with three acceptable flow–volume curves.

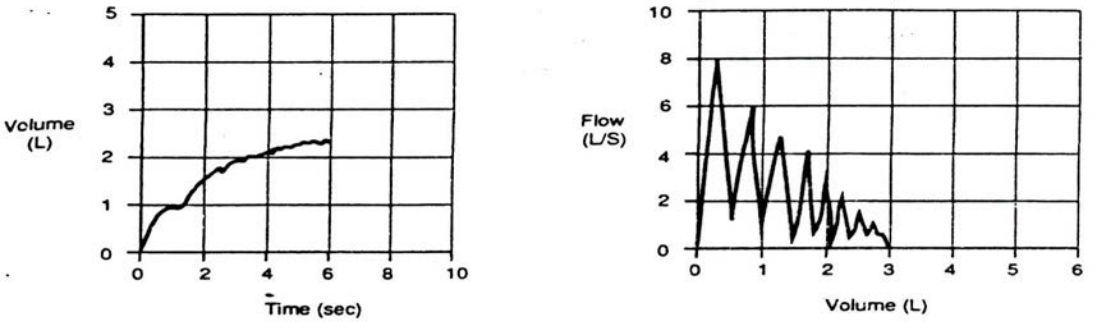


Figure 1.25. Unacceptable spirometry because of significant coughing as illustrated in the volume-time and flow-volume spirograms.

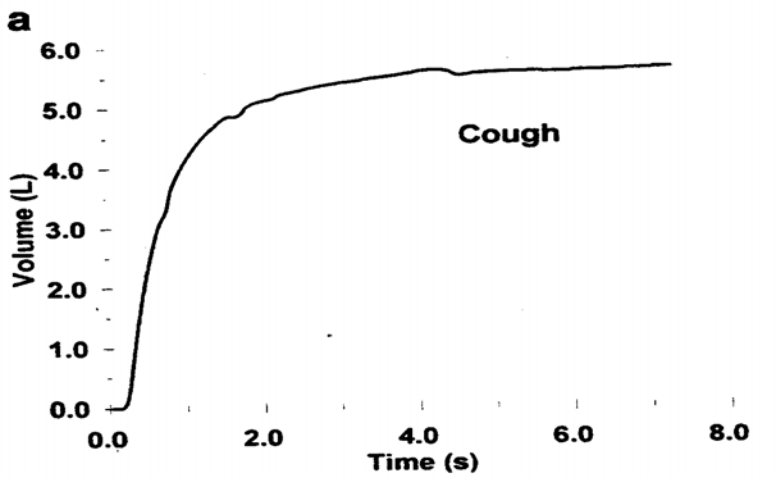


Figure A2a. Volume–time spirogram with a cough during the first second of exhalation.

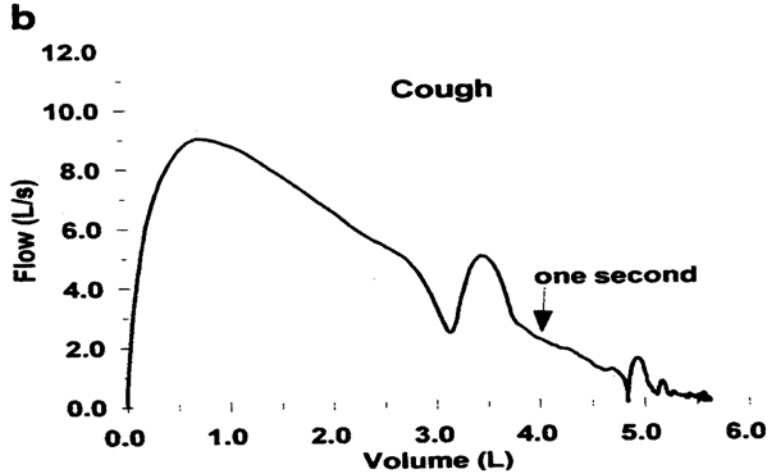


Figure A2b. Flow–volume spirogram with a cough during the first second of exhalation.

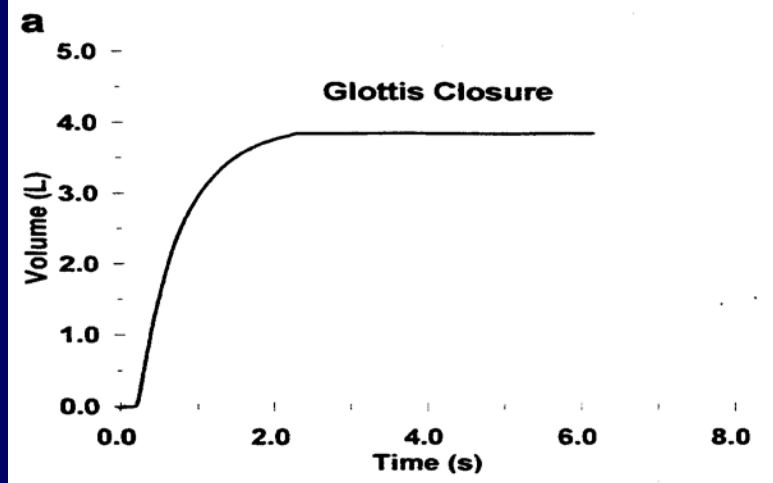


Figure A4a. Unacceptable volume–time spirogram due to possible glottis closure.

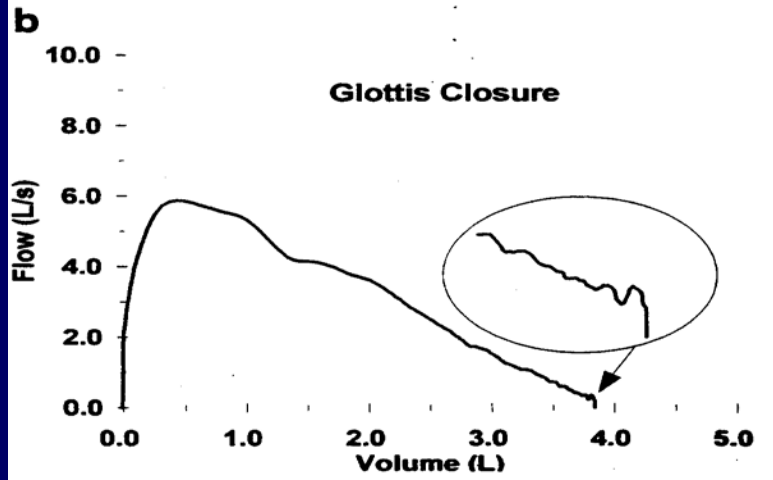


Figure A4b. Unacceptable flow–volume spirogram due to possible glottis closure.

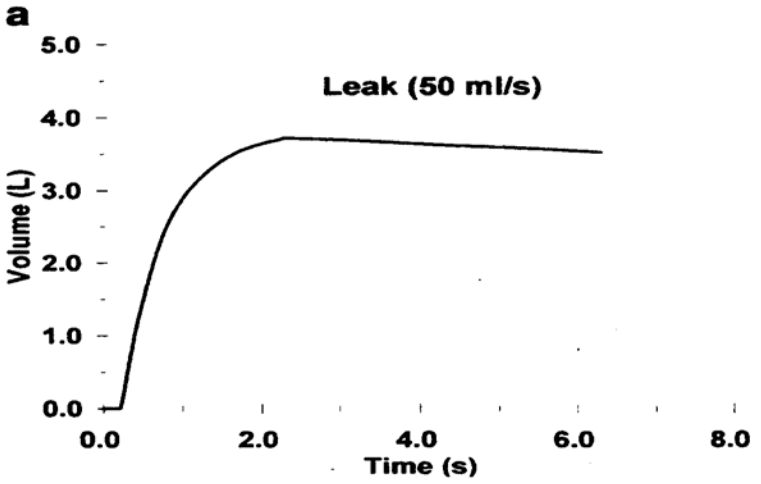


Figure A5a. Unacceptable volume–time spirogram due to a leak.

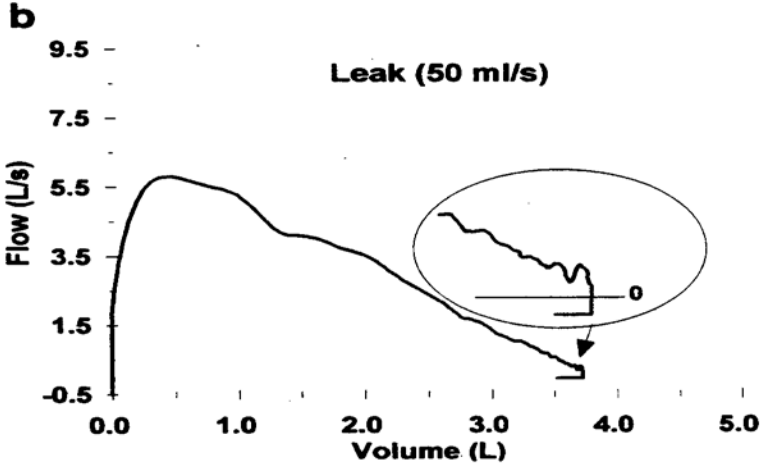


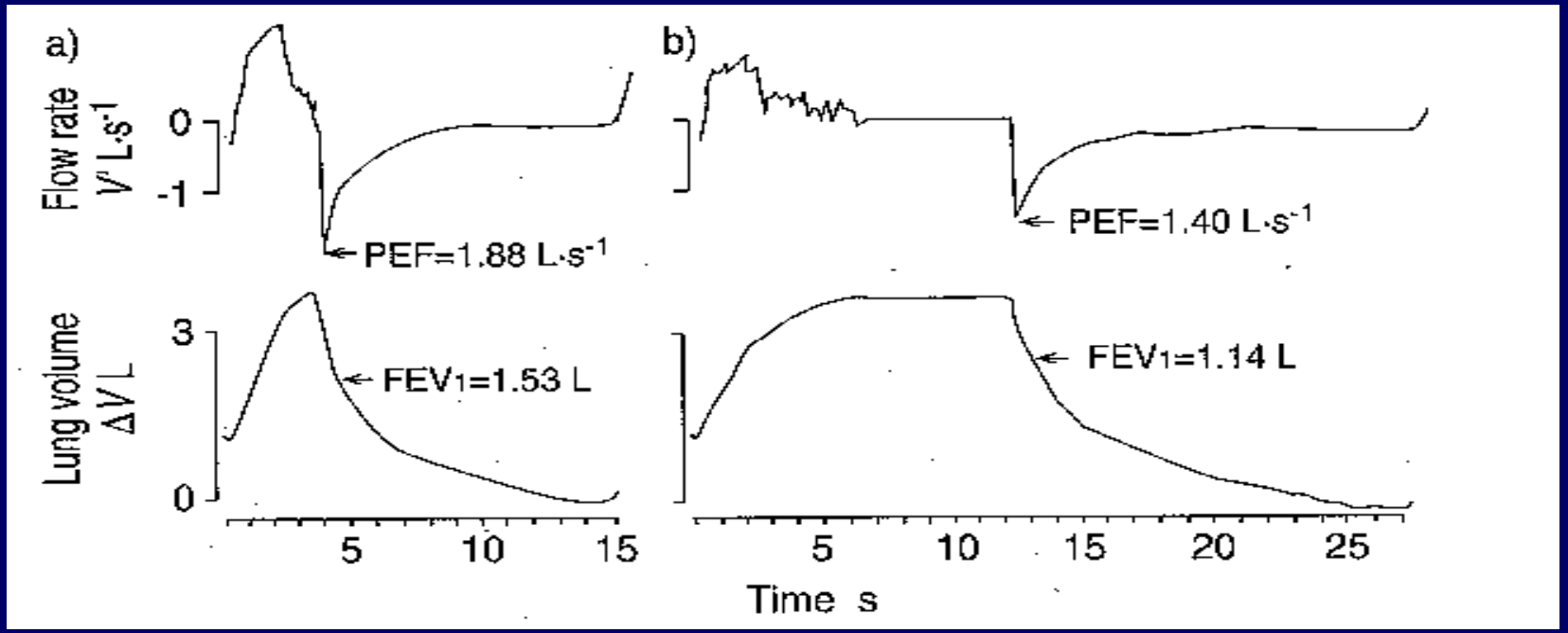
Figure A5b. Unacceptable flow–volume spirogram due to a leak.

Time dependence of Forced Vital Capacity (FVC)

Extensive guidelines have been provided for the measurement procedure of FVC. In the early guidelines , however, the inspiratory manoeuvre preceding the expiratory effort was not standardized. In practice, the FVC was preceded by

1) maximal inspirations made at different speeds, and
2) variable pauses at full inspiration

The time course of inspiration preceding the FVC has a marked effect on PEF, FEV1, and MEFV curves both in normal subjects and patients with obstructive and restrictive lung disease.



Tracings showing the time course of changes in lung volume (ΔV) obtained in a COPD patient during an FVC manoeuvre preceded by a) a rapid inspiration without breathhold at end inspiration, and b) a slow inspiration with a 5s breathhold. With the slow manoeuvre the PEF and FEV1 were 23% lower than the fast one, whilst FVC did not change. D'Angelo et al, *Am J Respir Crit care Med 1994; 150: 1581-1586*

TABLE 5 Summary of within- and between-manoeuvre acceptability criteria

Within-manoeuvre criteria

Individual spirograms are "acceptable" if

- They are free from artefacts [3]
  - Cough during the first second of exhalation
  - Glottis closure that influences the measurement
  - Early termination or cut-off
  - Effort that is not maximal throughout
  - Leak
  - Obstructed mouthpiece
- They have good starts
  - Extrapolated volume <5% of FVC or 0.15 L, whichever is greater
- They show satisfactory exhalation
  - Duration of ⩾6 s (3 s for children) or a plateau in the volume–time curve or
    - If the subject cannot or should not continue to exhale

Between-manoeuvre criteria

After three acceptable spirograms have been obtained, apply the following tests

- The two largest values of FVC must be within 0.150 L of each other
- The two largest values of FEV_1 must be within 0.150 L of each other

If both of these criteria are met, the test session may be concluded

If both of these criteria are not met, continue testing until

- Both of the criteria are met with analysis of additional acceptable spirograms
  - or
- A total of eight tests have been performed (optional) or
- The patient/subject cannot or should not continue

Save, as a minimum, the three satisfactory manoeuvres

Miller et al, Eur Respir J 2005; 26: 319–338

Table 11-2 Comparison of spirometry efforts

Test	Trial 1	Trial 2	Trial 3	"Best" test
FVC	5.20	5.30	5.35*	5.35
$FEV_{1.0}$	4.41*	4.35	4.36*	4.41
$FEV_{1.0}/FVC$	85	82	82	82
$FEF_{25\%-75\%}$	3.87	3.92	3.94	3.94
$\dot{V}_{max\ 50}$	3.99	3.95	3.41	3.41
$\dot{V}_{max\ 25}$	1.97	1.95	1.89	189
PEFR	8.39	9.44	9.89	9.89

*These values are keys to selecting the "best" test results. The $FEV_{1.0}$ is taken from Trial 1, even though the largest sum of FVC and $FEV_{1.0}$ occurs in Trial 3. All FVC-dependent flows (average and instantaneous flows) come from Trial 3. It should be noted that the $FEV_{1\%}$ ($FEV_{1.0}/FVC$) is calculated from the $FEV_{1.0}$ of Trial 1 and the FVC of Trial 3. The MEFV curve, if reported, would be the curve from Trial 3 as well.

Lung Volumes

1. Tidal volume (Vt) is the volume of air that is inspired and expired with each breath during normal breathing.

2. Residual Volume (RV) is the volume of air remaining in the lungs at the end of a maximum expiration.

3. Inspiratory Reserve Volume (IRV) is the maximum amount of air that can be inhaled beyond the tidal volume end-inspiratory level.

4. Expiratory Reserve Volume (ERV) is the maximum amount of air that can be exhaled below the tidal volume end-expiratory level.

Lung Capacities

1. Functional Residual Capacity (FRC) is the volume remaining in the lungs at the tidal volume end-expiratory level.

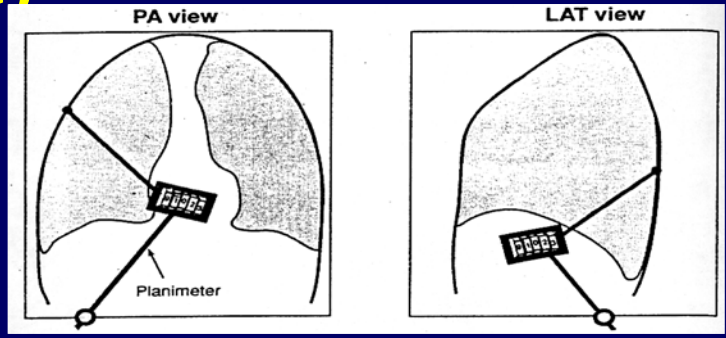
2. Total Lung Capacity (TLC) is the volume of air in the lungs after a maximum inspiration.

3. Vital Capacity (VC) is the volume of air that can be exhaled from the lungs after a maximum inhalation.

4. Inspiratory Capacity (IC) is the maximum amount of air that can be inhaled from the tidal volume end-expiratory level.

Techniques for measuring Static Lung Volumes (essentially FRC)

1) Body Plethysmography
2) Nitrogen Washout
3) Helium Dilution
4) Imaging (CXR, CT, MRI)



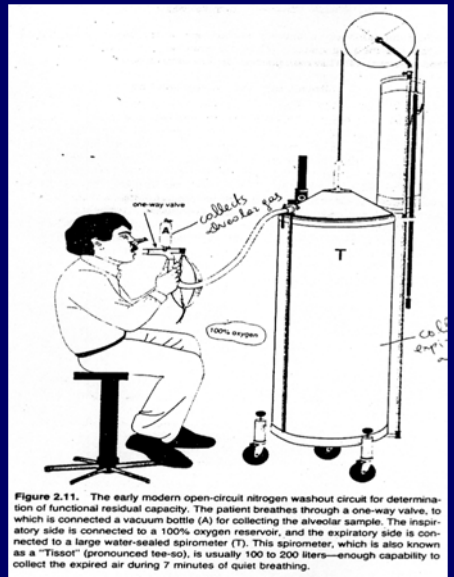
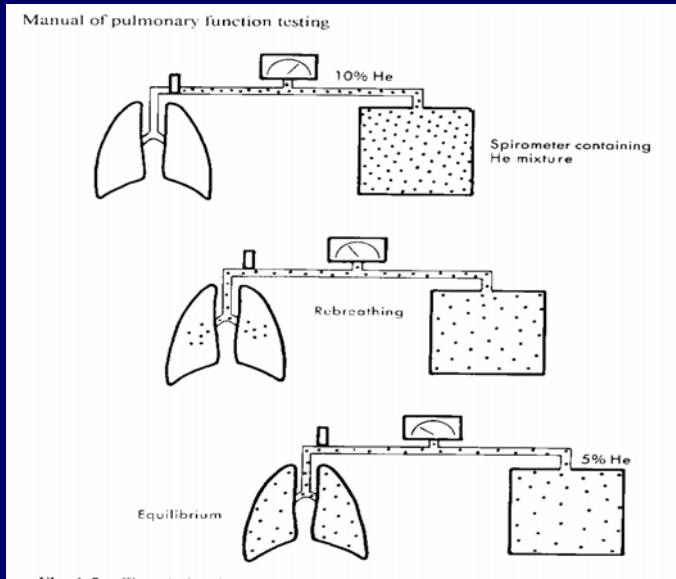


Figure 2.11. The early modern open-circuit nitrogen washout circuit for determination of functional residual capacity. The patient breathes through a one-way valve, to which is connected a vacuum bottle (A) for collecting the alveolar sample. The inspiratory side is connected to a 100% oxygen reservoir, and the expiratory side is connected to a large water-sealed spirometer (T). This spirometer, which is also known as a "Tissot" (pronounced tee-so), is usually 100 to 200 liters—enough capability to collect the expired air during 7 minutes of quiet breathing.



Definition of Diffusion Capacity (USA) or Transfer Factor (Europe)

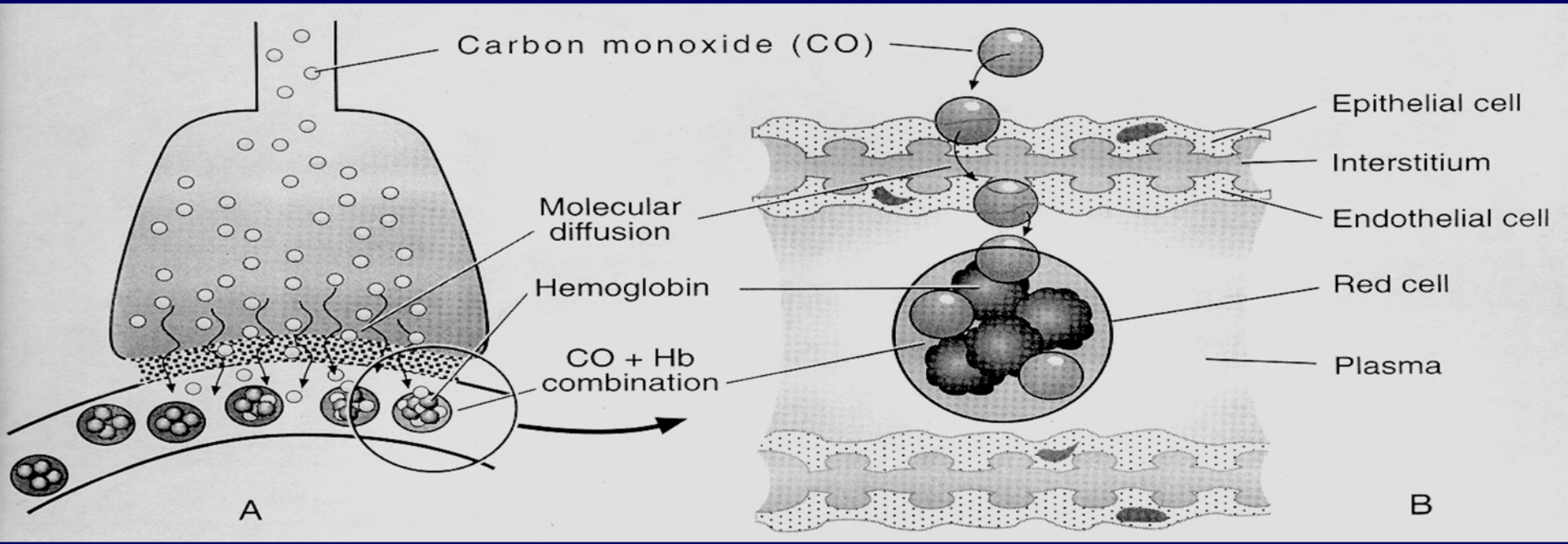
$$DL_{CO} * 0.33 = TL_{CO}$$

DL_{CO} is actually the diffusive conductance, meaning the “ease of transfer” for CO molecules passing from alveolar gas to pulmonary capillary hemoglobin. It reflects the surface area of the lung available for gas exchange.

1. Membrane Conductance
2. Reactive Conductance

1/DLCO=1/Dm+1/ θ.Qc

Roughton FJW, Forster RE. JAP 1957;11: 290-302



Hughes & Pride (eds). Lung Function Tests. London WB Saunders, 1999.

Factors that reduce DL_{CO}

Extrapulmonary reduction in lung inflation (reduced V_A) producing changes in D_M or θV_c that reduce $D_{L,CO}$

- Reduced effort or respiratory muscle weakness
- Thoracic deformity preventing full inflation

Diseases that reduce θV_c and thus reduce $D_{L,CO}$

- Anaemia
- Pulmonary emboli

Other conditions that reduce θV_c and thus reduce $D_{L,CO}$

- Hb binding changes (*e.g.* HbCO, increased F_{I,O_2})
- Valsalva manoeuvre (increased intrathoracic pressure)

Diseases that reduce (in varying degrees) D_M and θV_c and thus reduce $D_{L,CO}$

- Lung resection (however, compensatory recruitment of θV_c also exists)
- Emphysema
- Interstitial lung disease (*e.g.* IPF, sarcoidosis)
- Pulmonary oedema
- Pulmonary vasculitis
- Pulmonary hypertension

Factors that increase D_{LCO}

Diseases that increase θV_c and thus increase $D_{L,CO}$

- Polycythaemia
- Left-to-right shunt
- Pulmonary haemorrhage (not strictly an increase in θV_c, but effectively an increase in lung Hb)
- Asthma

Other conditions that increase θV_c and thus increase $D_{L,CO}$

- Hb binding changes (*e.g.* reduced F_{I,O_2})
- Muller manoeuvre (decreased intrathoracic pressure as in asthma, resistance breathing)
- Exercise (in addition, a possible D_M component)
- Supine position (in addition, possibly a slight increase in D_M)
- Obesity (in addition, a possible D_M component)

Surgery remains the best treatment option for non-small cell lung cancer, but only 20–25% of lung cancer patients are operable. Therefore, offering surgery to patients deemed to be inoperable remains highly relevant.

In order to construct a reasonable algorithm it seems necessary to use FEV_1, Diffusion Capacity, and exercise testing.

FEV1

Spirometry is widely available, well standardized, and cheap. Among the multiple parameters measured, FEV1 has stood the test of time and has been included in all the published functional algorithms. However, its predictive value for postoperative complications is not very high, even if the extent of resection is taken into account through the calculation of a ppoFEV1. For these reasons, the decision to operate or not should not be based on ppoFEV1 alone.

Licker M, Schnyder JM, Frey JG, et al. Impact of aerobic exercice capacity and procedure-related factors in lung cancer surgery. Eur Respir J 2010 DOI: 10.1183/09031936.00069910

Usefulness of DL,CO for lung resection

DL,CO is an independent predictor of post-operative mortality and morbidity after lung resection. Patients with normal FEV_1 may present with decreased DL,CO.

Liptay MJ, Basu S, Hoaglin MC, *et al.* Diffusion lung capacity for carbon monoxide (DLCO) is an independent prognostic factor for long-term survival after curative lung resection for cancer. *J Surg Oncol* 2009; 100: 703–707.

For these reasons, DL,CO combined with FEV_1, comprises the first step of pulmonary assessment in the BTS and ERS/ESTS algorithms. The ACCP recommends measuring this parameter in patients with FEV_1 <80% pred, or with dyspnoea or diffuse parenchymal disease on chest radiography.

Exercise tests

Koulouris et al, JAP 1997; 82: 723-31

In the literature, V´O2,max appears to be 1) an independent risk factor of both Cardiovascular and Pulmonary Complications, and 2) a very strong predictor of Postoperative Complications, as well as a good predictor of long-term post-operative exercise capacity.

Therefore, the most used and best validated exercise parameter is V´O2, max (*ml per Kg per min*).

Licker M, Schnyder JM, Frey JG, *et al.* Impact of aerobic exercice capacity and procedure-related factors in lung cancer surgery. *Eur Respir J* 2010 [Epub ahead of print DOI: 10.1183/09031936.00069910]

Table 1 Cut-off values for lung function and exercise tests

Cut-off value	Recommendation
Lung function and $V'O_{2,max}$	
FEV_1 and $D_{L,CO}$ >80% pred	Resection up to pneumonectomy
$V'O_{2,max}$ >75% pred or >20 mL per kg per min	Resection up to pneumonectomy
$V'O_{2,max}$ <35% pred or <10 mL per min per kg	High risk of complications A pneumonectomy or a lobectomy are usually not recommended
$V'O_{2,max}$ 35–75% pred	Calculate ppo values
ppo values	
ppoFEV_1 and ppo$D_{L,CO}$ >30% pred and $V'O_{2,max}$ >35% pred	Resection up to pneumonectomy
ppoFEV_1 or ppo $V'O_{2,max}$ <30% pred	Calculate ppo$V'O_{2,max}$
ppo$V'O_{2,max}$ >35% pred or >10 mL per kg per min	Resection up to pneumonectomy
ppo$V'O_{2,max}$ <35% pred or <10 mL per kg per min	High risk of complications A pneumonectomy or a lobectomy are usually not recommended

Modified from the European Respiratory Society/European Society of Thoracic Surgeons guidelines [4]. $V'O_{2,max}$: maximal oxygen uptake; FEV_1: forced expiratory volume in 1 s; $D_{L,CO}$: diffusing capacity of the lung for carbon dioxide; % pred: % predicted value; ppo: predicted post-operative value.

Low-technology exercise tests

Formal CPET with V´O2,max (*ml per Kg per min*) measurements may not be readily available in all centres. Therefore, low-technology tests have been used to evaluate fitness before lung resection

- The 6MWT is not recommended to select patients for lung resection because does not correlate with V´O2,max.
- In contrast, there is a good correlation between the distance walked during a shuttle test and V´O2,max. Chronic obstructive pulmonary disease patients walking 420 m have a mean V´O2,max of 21 mL per kg per min and those walking 120 m of 11 mL per kg per min.
- The stair climbing test has also been used as a screening test. The height of ascent correlates with V´O2,max, 98% of patients climbing>22 m demonstrating V´O2,max >15 mL per min per kg. The speed of ascent also correlates with V´O2,max, a speed >15 m per min corresponding to V´O2,max >20 mL per kg per min.

Cardiological assessment

A cardiological assessment has been intergrated in all guidelines

A cardiological evaluation is justified, as 10% of major complications and 50% of minor complications after lung resection have a cardiovascular cause.

The guidelines published by the BTS, ACCP and ERS/ESTS recommend using the American College of Cardiology and American Heart Association guidelines.

Lee TH, Marcantonio ER, Mangione CM, et al. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. Circulation 1999; 100: 1043–1049.
9. Poldermans D, Bax JJ, Boersma E, et al. Guidelines for pre-operative cardiac risk assessment and perioperative cardiac management in non-cardiac surgery: Eur Heart J 2009; 30: 2769–2812.

Box 1 Calculating the revised cardiac risk index (RCRI) based on history, physical examination, baseline ECG and serum creatinine

Each item is assigned 1 point

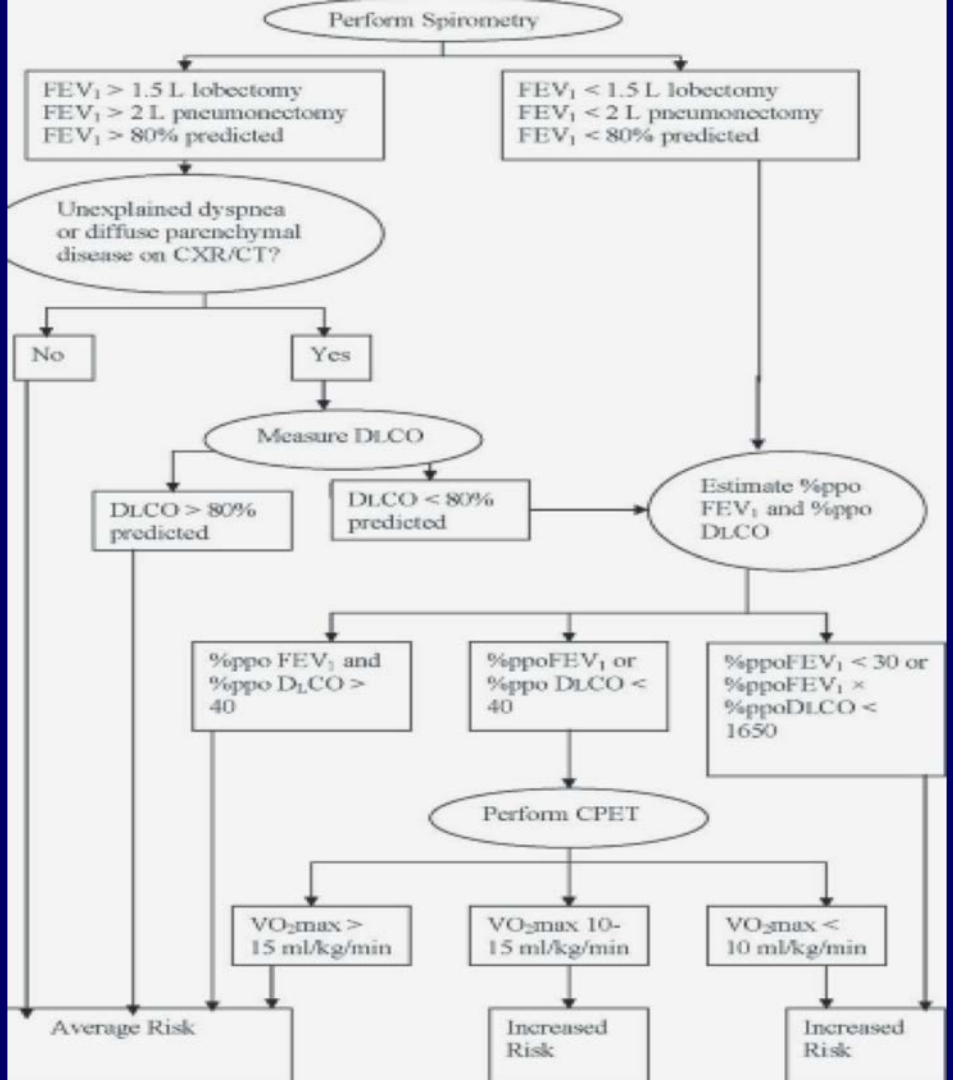
- High-risk surgery (including lobectomy or pneumenectomy)
- Ischaemic heart disease (prior myocardial infarction or angina pectoris)
- History of heart failure
- Insulin-dependent diabetes
- Previous stroke or transient ischemic attack
- Pre-operative serum creatinine >2.0 mg per dL

If

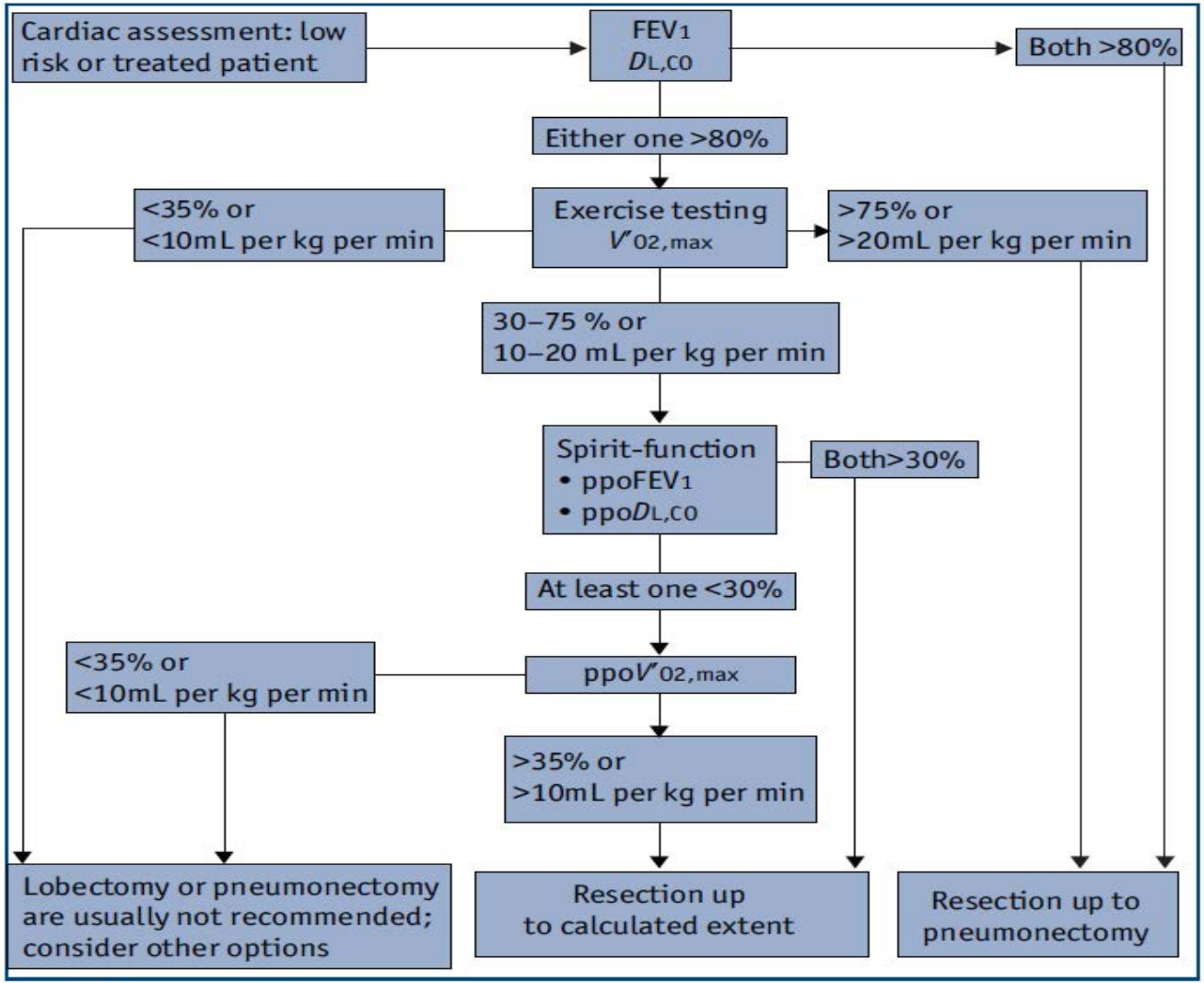
- RCRI ⩾2,
- the patient has any cardiac condition requiring medications,
- the patient has a newly suspected cardiac condition, or
- the patient is unable to climb two flights of stairs,

a cardiological consultation is needed

It is recommended to express FEV1 as % predicted rather than an absolute value.



Algorithm for assessment of pulmonary reserve before major lung resection



Brunelli A. Algorithm for functional evaluation of lung resection candidates: time for reappraisal? Respiration 2009;78: 117–118.

Brunelli A, Charloux A, Bolliger CT, et al. ERS/ESTS clinical guidelines on fitness for radical therapy in lung cancer patients (surgery and chemo-radiotherapy). Eur Respir J 2009; 34: 17–41.

Calculation of predictive post operative (ppo) forced expiratory volume in 1 s (FEV_1), diffusing capacity of the lung for carbon dioxide (DL,CO) or maximal oxygen uptake ($V´O2,max$), ppoFEV1 is taken as a model.

Similar equations are used for the calculation of $ppoDL,CO$ or ppo $V´O2,max$, and include preoperative DL,CO or $V´O2,max$, respectively. For $ppoFEV_1$ before lobectomy, the calculation is based on the segment counting method, as follows. Number of functional segments: 19

Right lung:	Left lung:
Upper lobe: 3	Upper lobe: 3
Middle lobe: 2	Lingula: 2
Lower lobe: 5	Lower lobe: 4

$ppoFEV_1$=pre-operative $FEV_1X(1 - a/b)$

where a is the number of unobstructed segments to be resected and b is the total number of unobstructed segments. An unobstructive segment is defined as one where the patency of the bronchus and the segment structure are preserved, according to bronchoscopy and computed tomography (CT) scan.

For ppoFEV1 before pneumonectomy, the calculation is based on scintigraphy or quantitative CT scan, as follows.

$ppoFEV_1$=pre-operative $FEV_1X(1 - FP)$

where FP is the fraction of total perfusion for the lung to be resected.

Respiratory Function Tests, represent the most powerful tools we have available for the diagnosis of many respiratory diseases. Just as one cannot make a diagnosis of hypertension without measuring blood pressure, so one cannot diagnose COPD, asthma, restrictive disorders, respiratory muscle weakness, and many other chest diseases without respiratory function tests. To understand the natural history of many lung diseases and to determine how they respond to therapy also requires function tests. Sadly, this seem to have been forgotten in recent years.

Peter T Macklem

Thanks for your attention

Questions

1) **What is the best respiratory function parameter to define a "Restrictive Ventilatory Defect" ?**

a) Functional Residual Capacity (FRC)
b) Airway Resistance (Raw)
c) Residual Volume (RV)
d) Total Lung Capacity (TLC)
e) Forced Vital Capacity (FVC)

2) **What test is best for detecting "Obstructive Ventilatory Defect"?**

a) Measurement of Lung Volumes
b) DLCO
c) Spirometry
d) Respiratory Muscle Testing
e) Specific airway Conductance (SGaw)

3) If you like construct an algorithm for preoperative assessment for lung resection, which test(s) you choose?

1) Formal CPET including V´O2,max (*ml per Kg per min*) measurement
2) Spirometry
3) Diffusion Capacity
4) Static Lung Volumes
5) A combination of 1, 2, 3 tests