Pulmonary Function Testing

Katharine Black, MD

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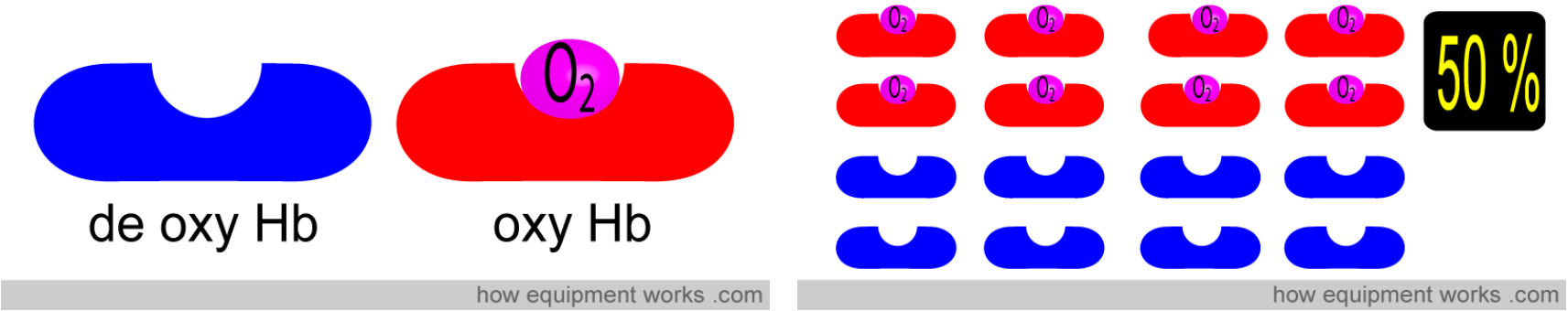
Outline

- Basics of measuring lung function
  - Oxygenation
  - Air movement
  - Exercise capacity
- Use of lung function tests
  - Diagnosis
  - Prognosis

Measuring lung function:
Pulse oximetry:



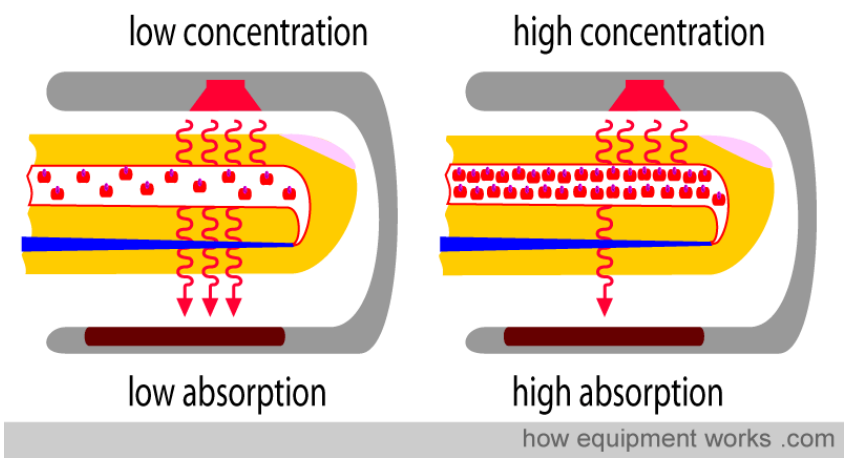
% saturation: <u>oxygenated hemoglobin</u>

oxygenated + deoxygenated hemoglobin

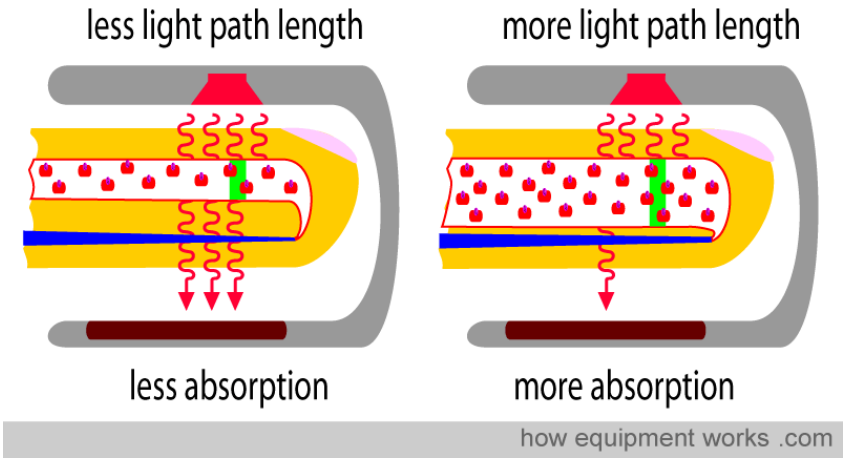
Arterial blood gas: measures actual concentration of oxygen and carbon dioxide in blood

http://www.howequipmentworks.com/pulse_oximeter/

Pulse oximeter: measures hemoglobin's absorption of light across the finger

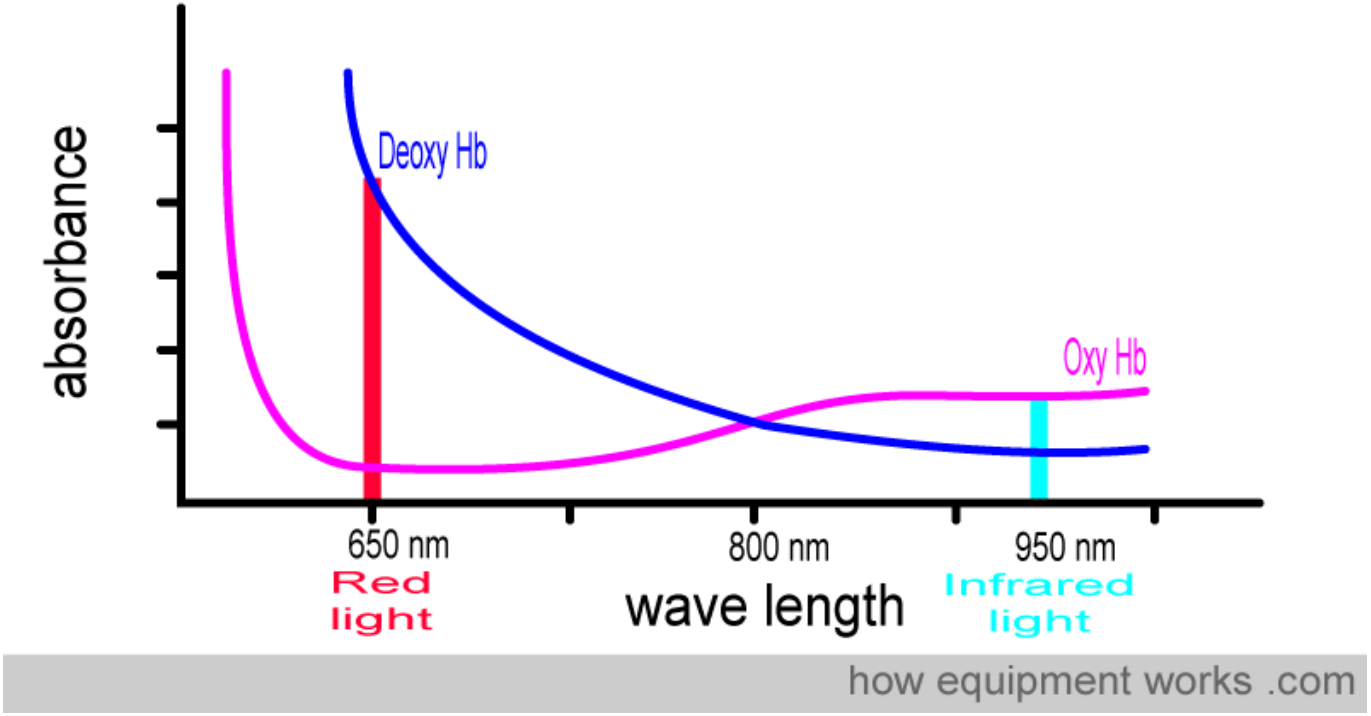


More hemoglobin, more absorption



Wider blood vessel , more absorption

Light sources for red and infrared distinguish oxygenated and deoxygenated hemoglobin

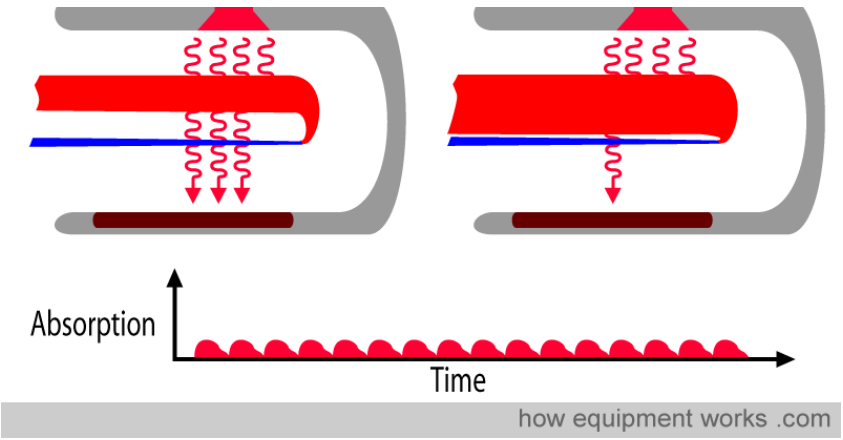


Deoxygenated hemoglobin absorbs red light

oxygenated hemoglobin absorbs infrared

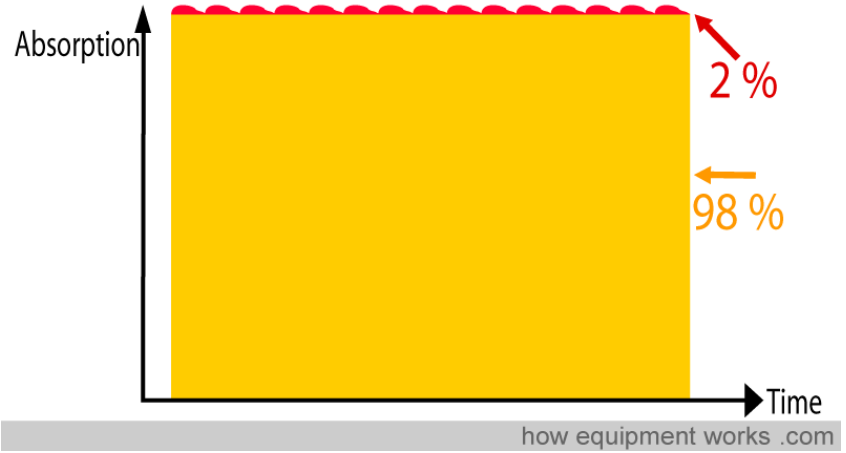
Pulsatile flow allows calculation of light absorption by artery only

Amount of blood varies over time in artery



Arterial absorption is pulsatile

Oximeter subtracts out the stable absorption



Reports only pulsatile absorption!

Measuring Lung Function: “PFTs”

- Spirometry: dynamic flow of air
- Lung volumes – plethysmography /helium dilution
- Diffusion capacity

Overall considerations for PFTs

- Values are compared to “normal” tables
  - huge data set of measurements taken in people thought not to have lung disease
- Based on age and height
  - Adjusted for race
  - Different torso/total height proportions
- May use armspan if height won’t work
- Less useful at extremes

The basics: spirometry

- Spriare = to breathe, meter = measure
- Take a deep breath in and blow out!
- (keep going keep going….)

ON THE

CAPACITY OF THE LUNGS,

AND ON THE

RESPIRATORY FUNCTIONS,

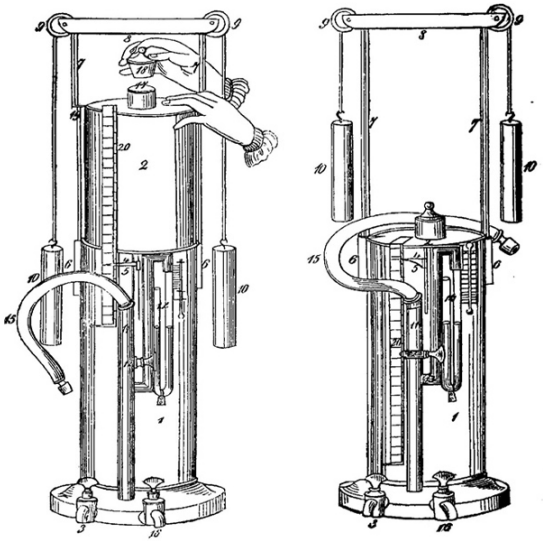
WITH A VIEW OF ESTABLISHING A PRECISE AND EASY METHOD OF DETECTING DISEASE BY THE SPIROMETER.

By JOHN HUTCHINSON, Surgeon.

Communicated by GEORGE CURSHAM, M.D.,

one of the Secretaries of the Society.

Received January 22nd—Read April 28th, 1846.

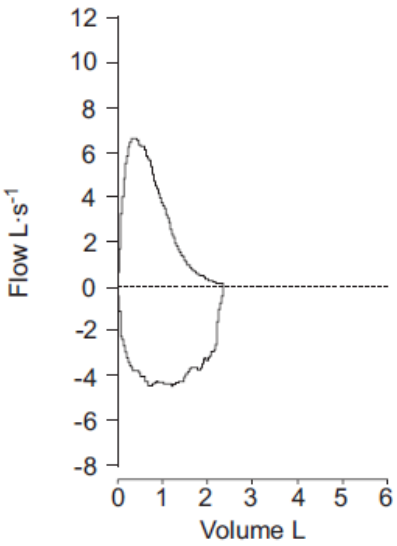


- Dr. Hutchinson measured “exhaled vital capacity” in 2,130 individuals
- Correlated the vital capacity to age and height

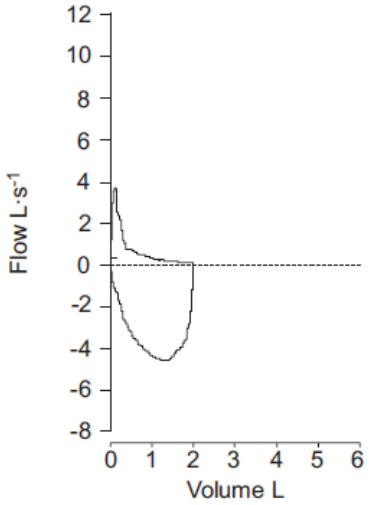
Med Chir Trans. 1846; 29: 137–252.
PMCID: PMC2116876 http://pulse.embs.org/january-2014/spirometry-a-historical-gallery/
Richard Johnston and Max Valentinuzzi | December 6, 2013

Spirometry key numbers

- FVC: forced vital capacity
- FEV1: Forced expiratory volume in 1 second
- FEV1/FVC: ratio of the two
- Slow exhalation suggests "obstruction"

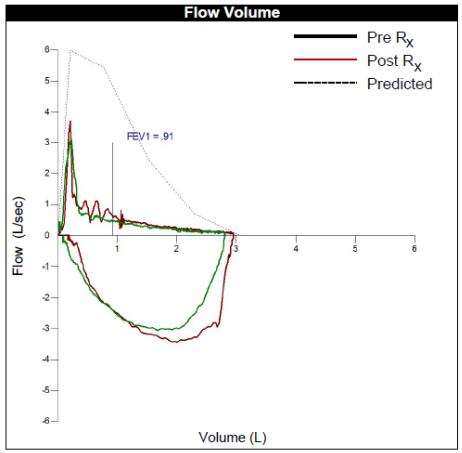


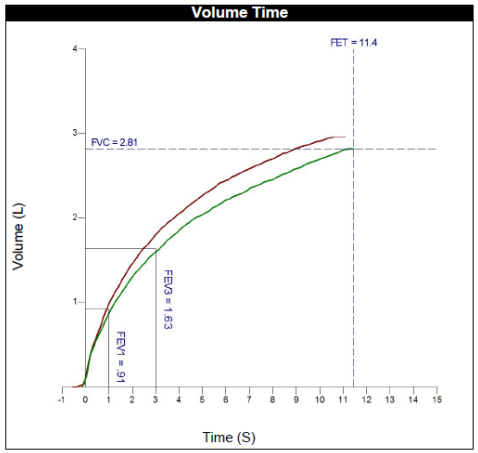
Normal

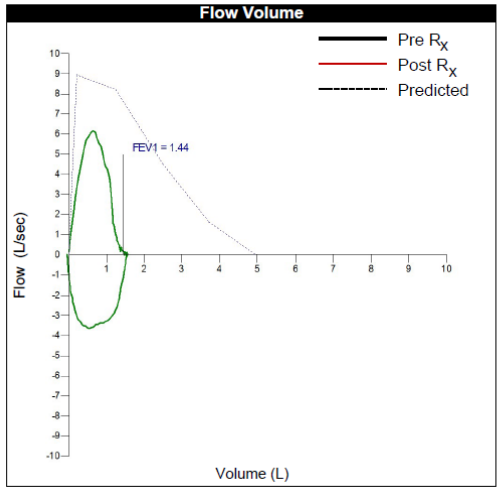


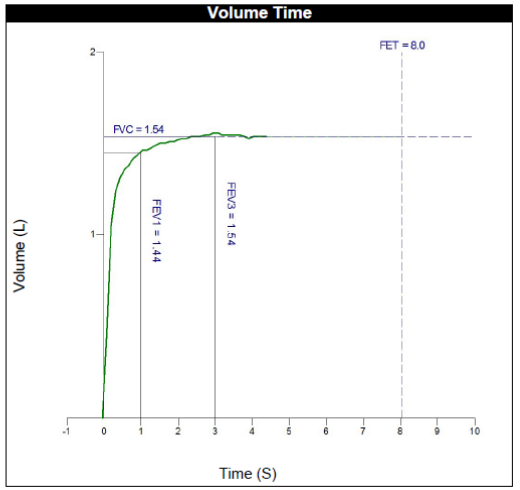
COPD

Spirometry “loops”





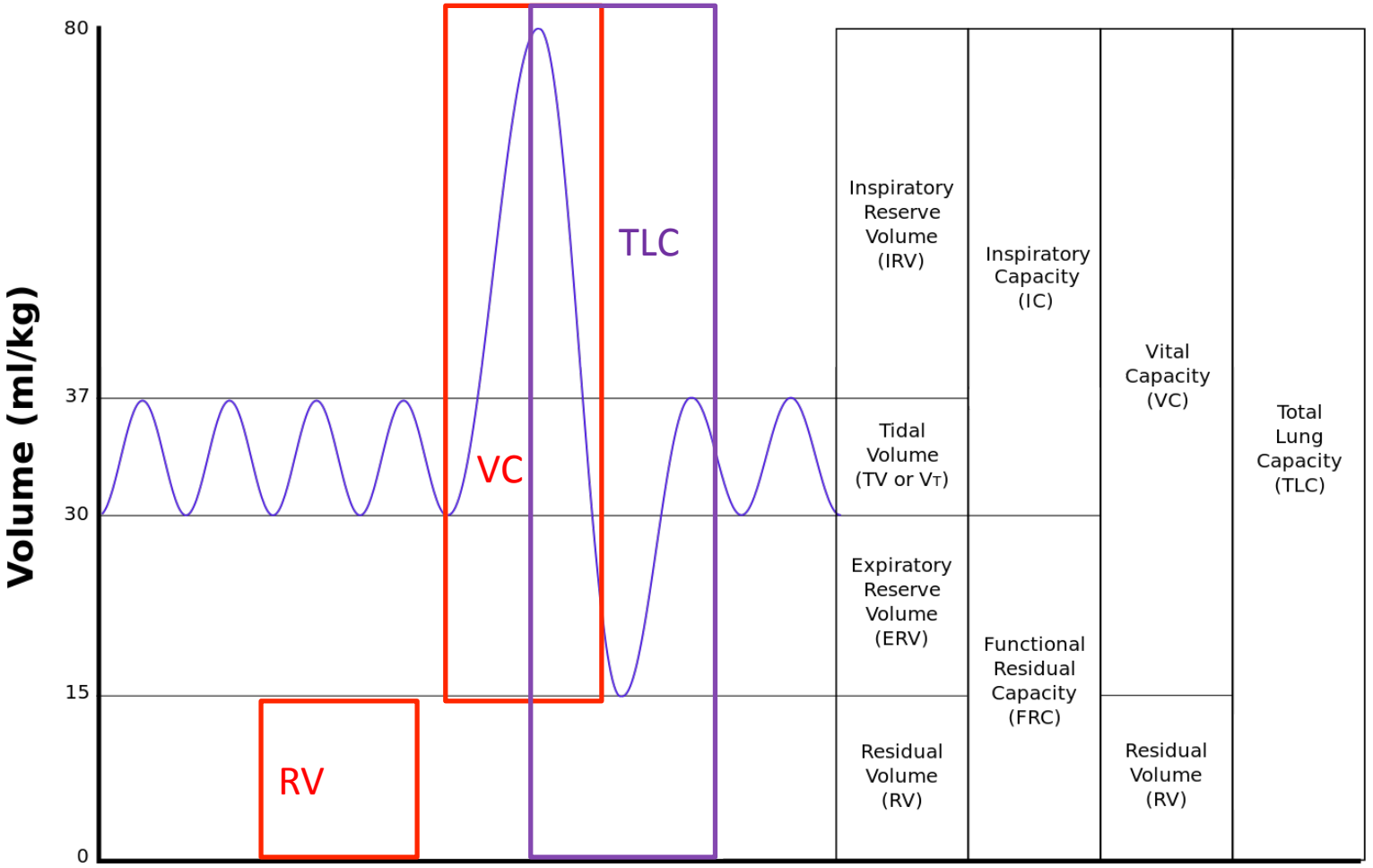




Lung volume measurement

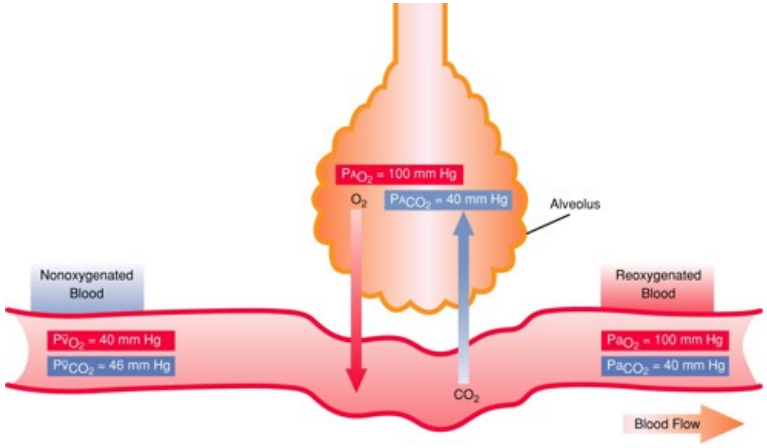
- Plethysmograph “body box”
  - Uses the change in pressure in a closed system to calculate the change in volume in the lung
- Helium dilution: known volume of helium, measures dilution when mixed with air in your lungs
- Methods give different results if there is significant “air trapping”
- Key values:
  - TLC: total lung capacity
  - VC: vital capacity
  - RV: residual volume

Lung volumes



https://en.wikipedia.org/wiki/File:Lungvolumes_Updated.png

Diffusing capacity for carbon monoxide



CO used as surrogate for O2

- Absorption of CO across lungs in a single breath
  - Inhaled mixture of 0.300% CO, 10.0% Helium, 21.0% O2 and the rest N2
- Useful values:
  - **DLCO** (corrected for hemoglobin)
  - $\mathbf{V_A}$: alveolar volume (measured using the helium)
  - **DL/ $\mathbf{V_A}$**
- Very variable test to test (and lab to lab)

https://media.lanecc.edu/users/driscolln/RT127/Softchalk/Diffusion_Softchalk/Diffusion_Lesson_print.html

More tests

- 6 minute walk test
  - Careful scripted measurement of distance walked in 6 minutes
  - Functional outcome
  - Used for pulmonary hypertension evaluations
- CPET
  - -distinguished changes in heart physiology from changes in lungs
  - -helpful if can't decide which is the problem
  - -very invasive
  - -measures exercise capacity very precisely

Use of PFTs: diagnosis

- American Thoracic Society/European Respiratory Society sets guidelines on interpretation
- “Obstructive” lung disease defined by low FEV1/FVC ratio
- “Restrictive” lung disease defined by low TLC
- Have implications for disability benefits

Disability placards

- “restricted by lung disease to such a degree that your forced (respiratory) expiratory volume (FEV) in one second, when measured by spirometry, is less than one (1) liter.

  or

- Use portable oxygen.
- (some states) arterial oxygen tension is less

than 60 mm/hg on room air at rest.

PFTs: Prognosis

- FVC and DLCO used to assess severity of disease
- “GAP” score
- https://www.acponline.org/journals/annals/extras/gap/
- Gender, Age, Physiology (PFT) - % predicted FVC and DLCO
- Calculates stage or predicted mortality

(Ann Intern Med. 2012;156:684-91).

GAP risk assessment

Stage I

- Female
- Age <60
- FVC>75%
- DLCO >55%

- GAP index: 0 (1 if male)
- One year mortality: 5.6

Stage III

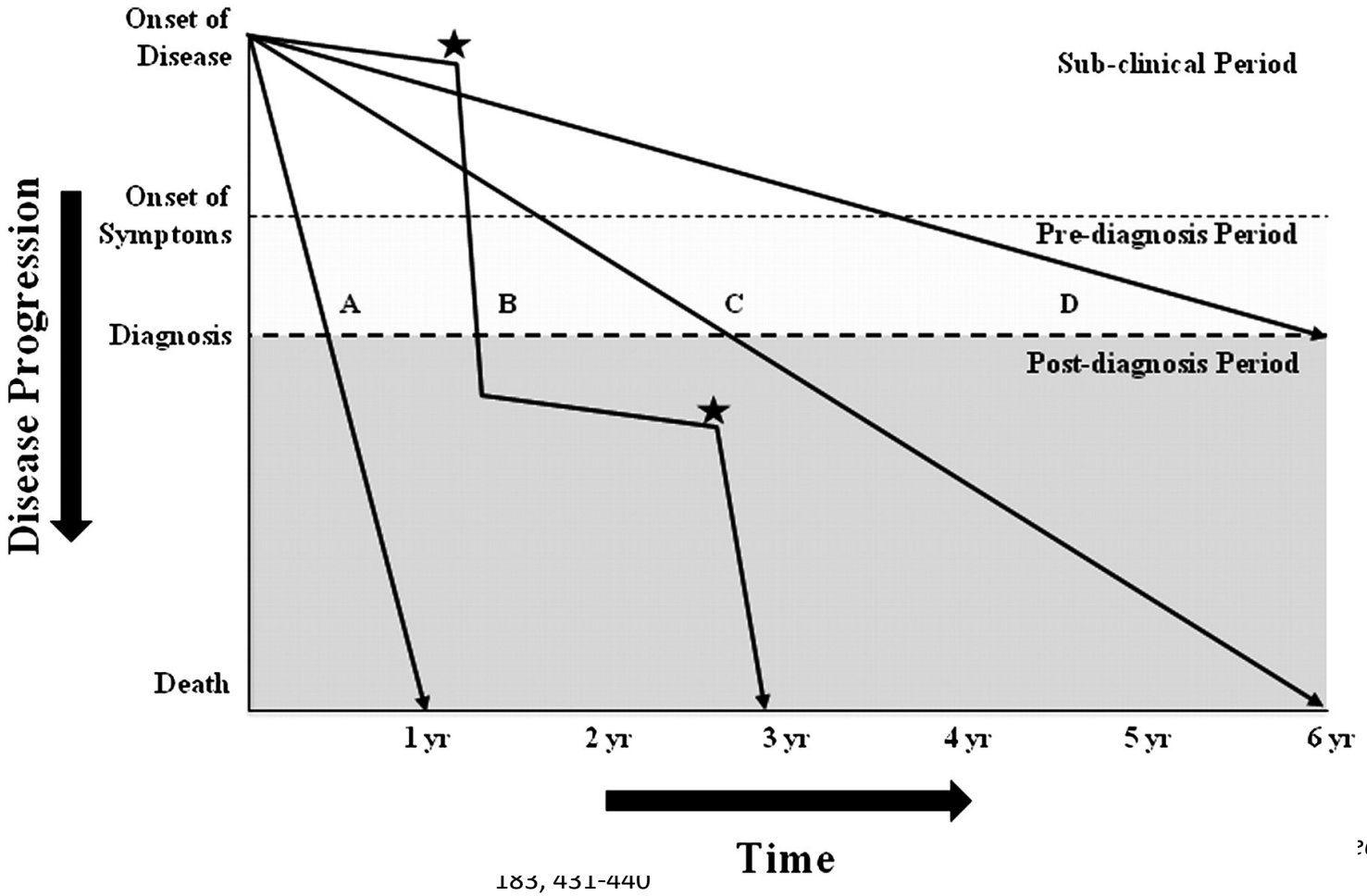
- Male
- Age >65
- FVC <55%
- unable to perform DLCO

GAP index 8 (7 if DLCO<35%)

One year mortality: 39.2

(Ann Intern Med. 2012;156:684-91).

Changes in PFTs may be more significant than specific values

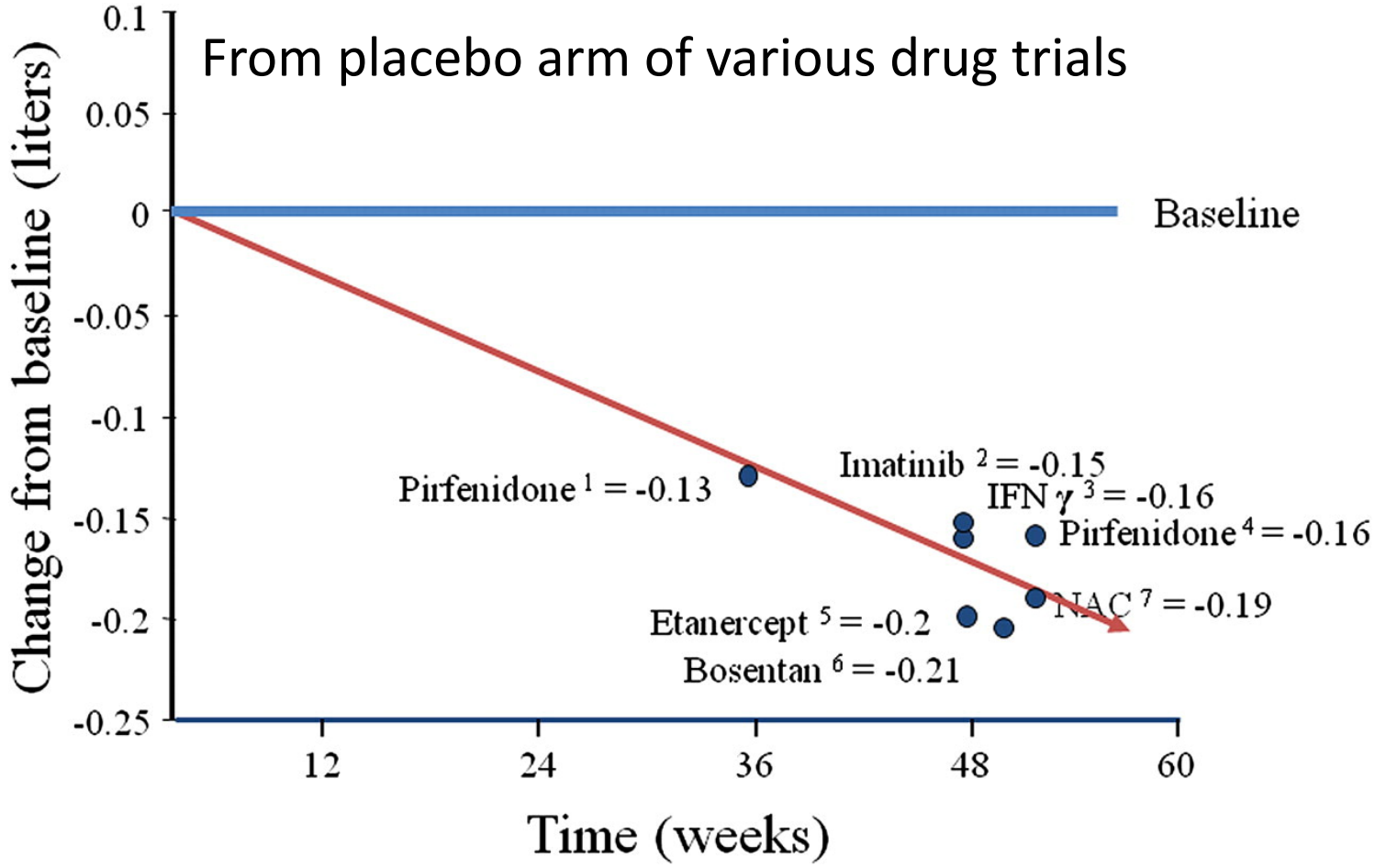


ed **2011,**

183, 431-440

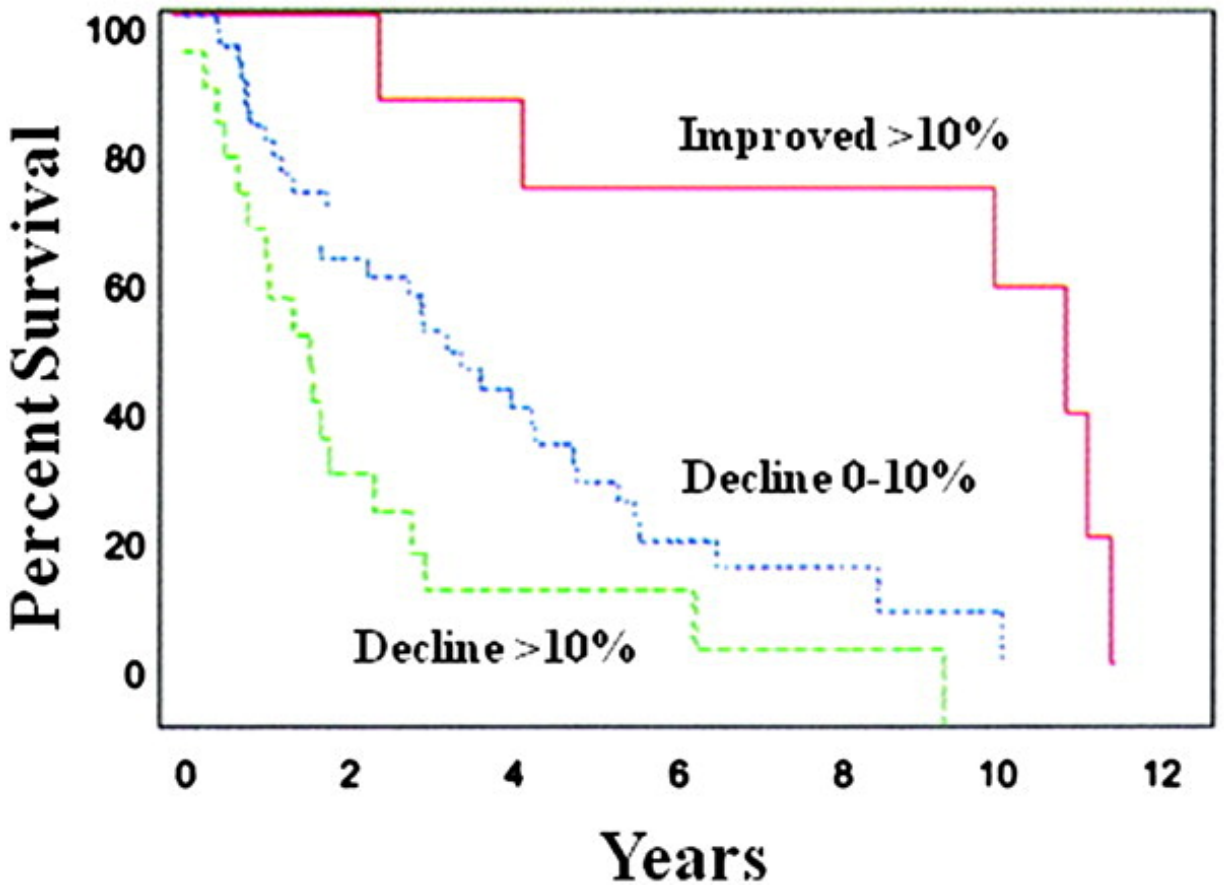
Collard et al. AJRCCM 168, No. 5 (2003), pp. 538-542.

On average in IPF:
FVC decreases 150- 200 mL/year



Brett Ley; Harold R. Collard; Talmadge E. King Jr.; *Am J Respir Crit Care Med* **2011,** 183, 431-440

Stable FVC suggests better survival



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PFTs for prognosis

- Change in FVC currently used as outcome measurement in IPF trials
  - Easy to do
  - Reproducible
  - Has clinical significance
- 10% change currently seen as significant
- Best predictor we have for disease progression
  - Not true for scleroderma related ILD, for example

Take home

- Low TLC defines restrictive disease (requires lung volume testing
- FEV1/FVC defines obstructive disease
- FVC and DLCO probably most closely relate to ILD
- FVC can help stage ILD
- Fall in FVC suggests worsening disease