Dynamic Spirometry

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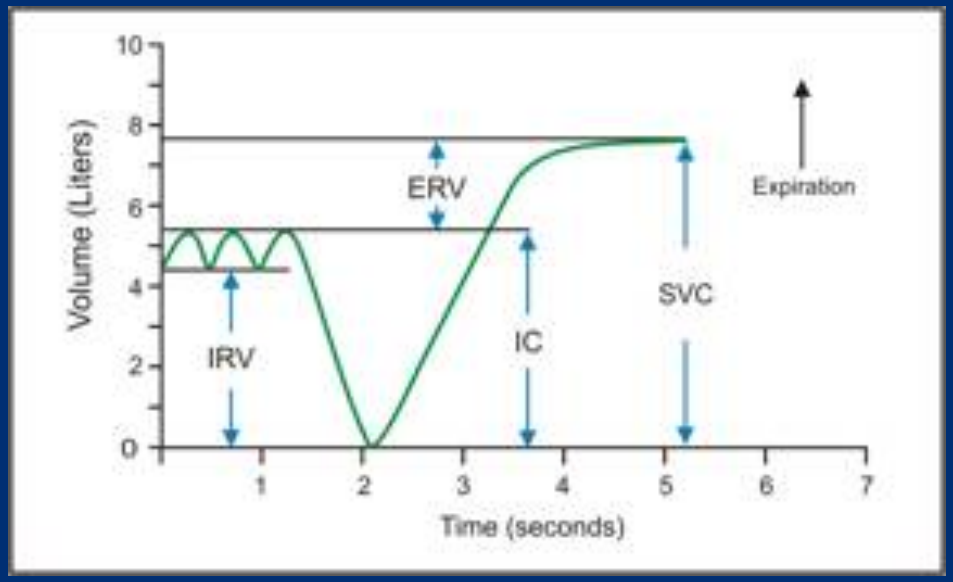
Spirometry

It provides an objective measurement of lung function.

It analyzes volume and velocity of expired air

Static test

Performed without regard to time



Relaxed Vital capacity: Max Volume of air expired during relaxed expiration after a maximal inspiration

Dynamic test

Performed at forcible and max effort against time

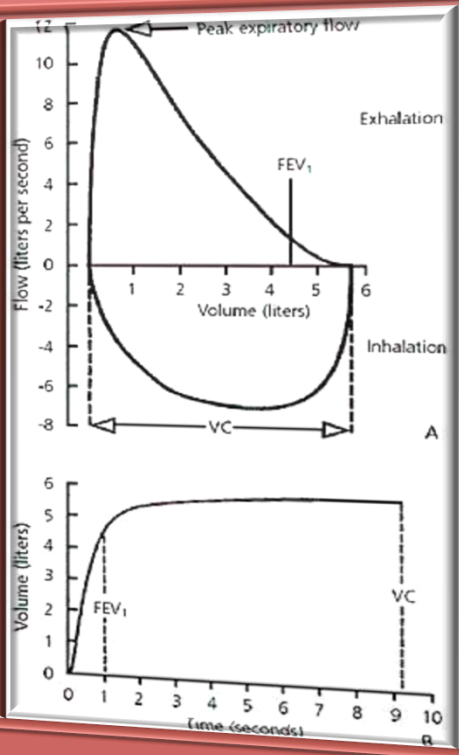
Measures the rate at which the lung changes volume during forced breathing.

Forced vital capacity

The max volume of air that can be forcibly and rapidly exhaled following a max inspiration.

Two types of curves can be obtained

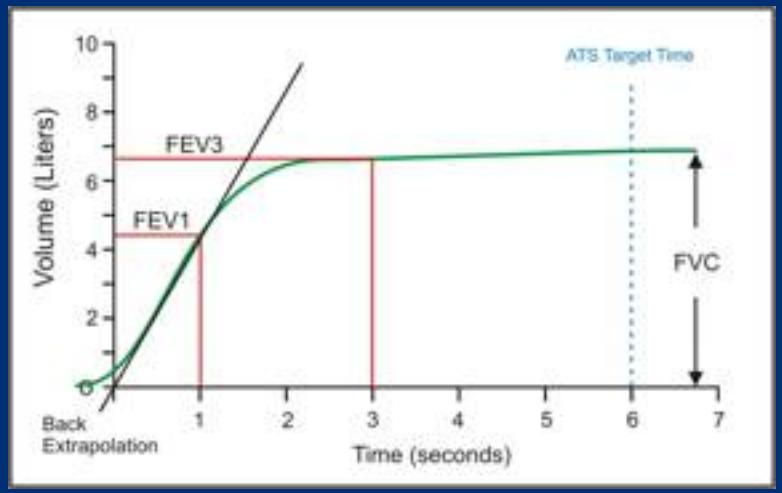
Forced expiratory curve



Flow Volume curve

Forced Expiratory Curve

- The subject takes a maximal inspiration and then exhales as rapidly, as forcibly,& as maximally as possible.
- Duration of the forced effort: 6sec
- A plot of exhaled volume against time:



FEV_1 : Volume of air expelled in the 1st sec of forced expiration starting from full inspiration

Plateau: **FVC**

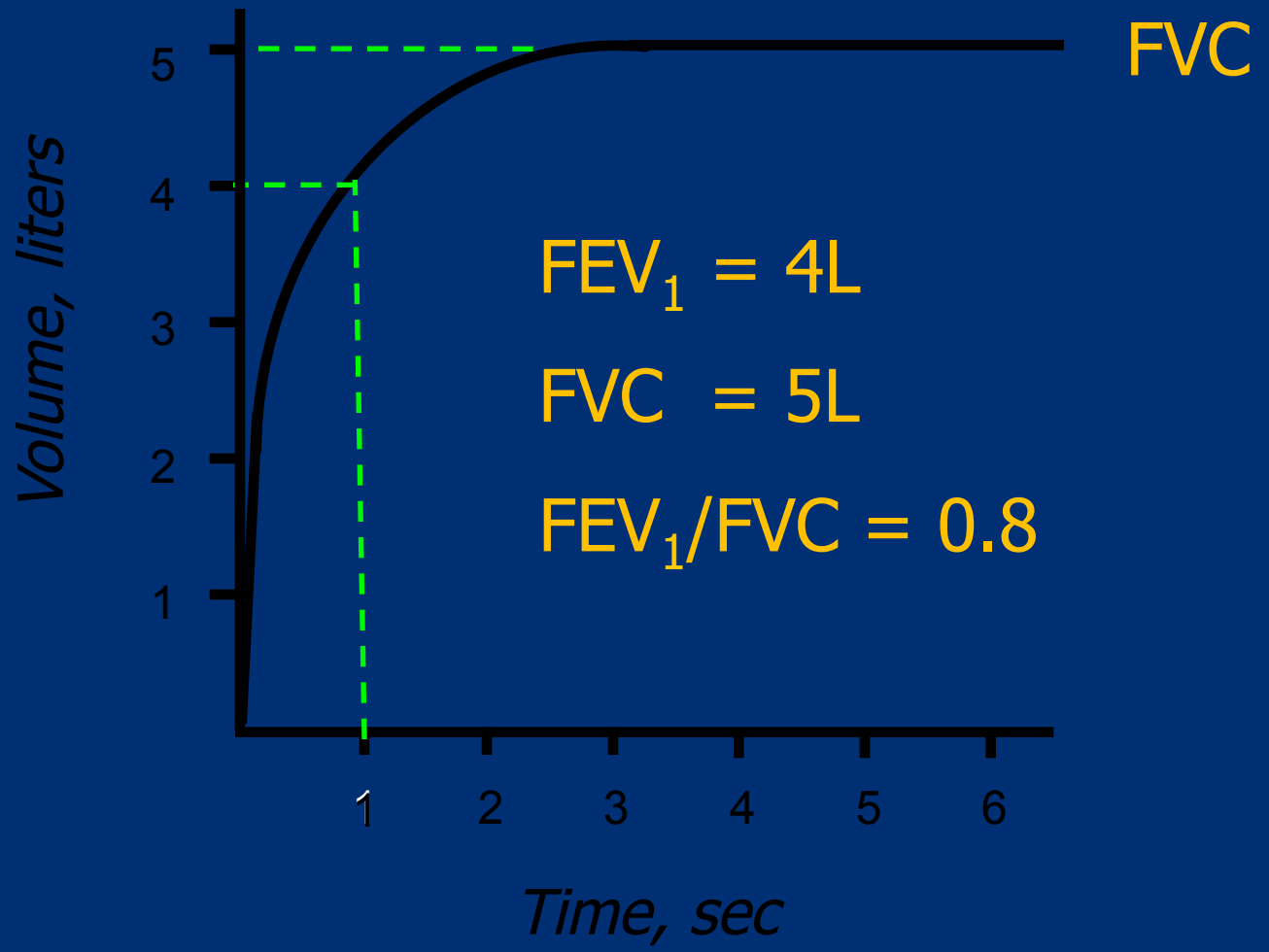
FEV_1 % or ratio = (FEV_1/FVC) * 100

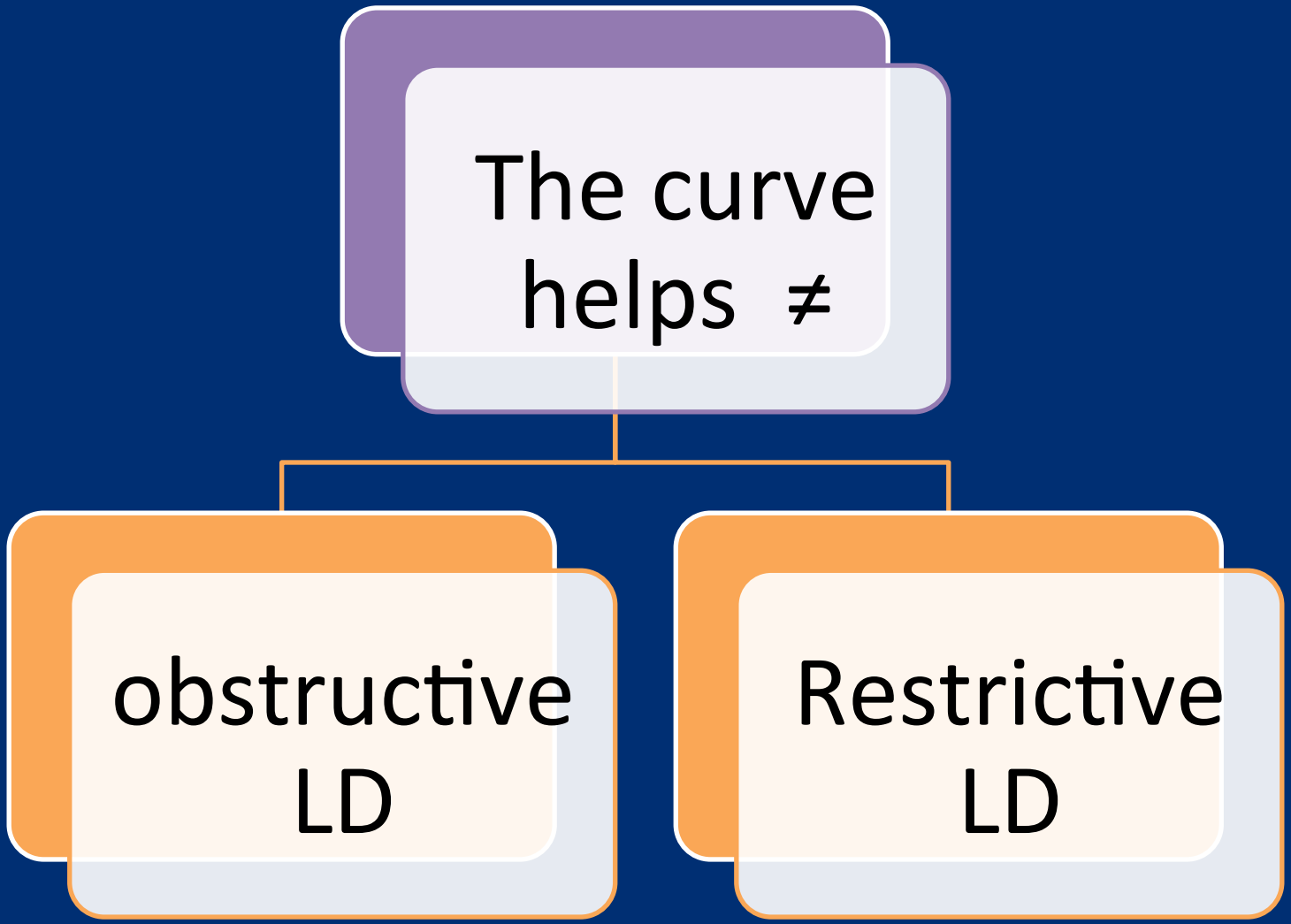
Fraction of the VC expired during the 1st sec of a forced expiration (NL 70%-80%)

- FEV_1 is useful measure of how quickly the lungs can be emptied.

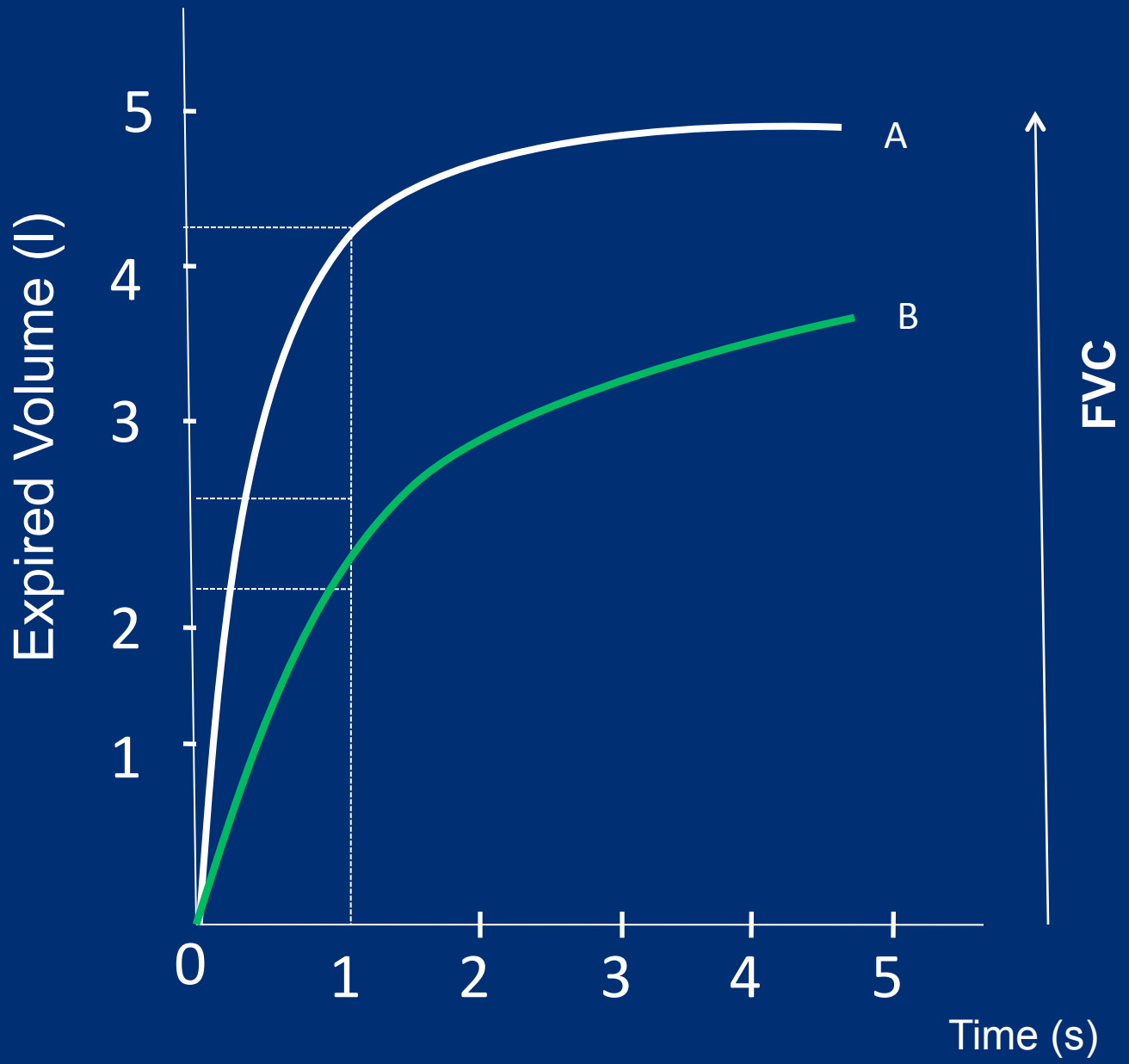
- The ratio is useful index of airflow limitation

Normal Trace Showing FEV_1 and FVC

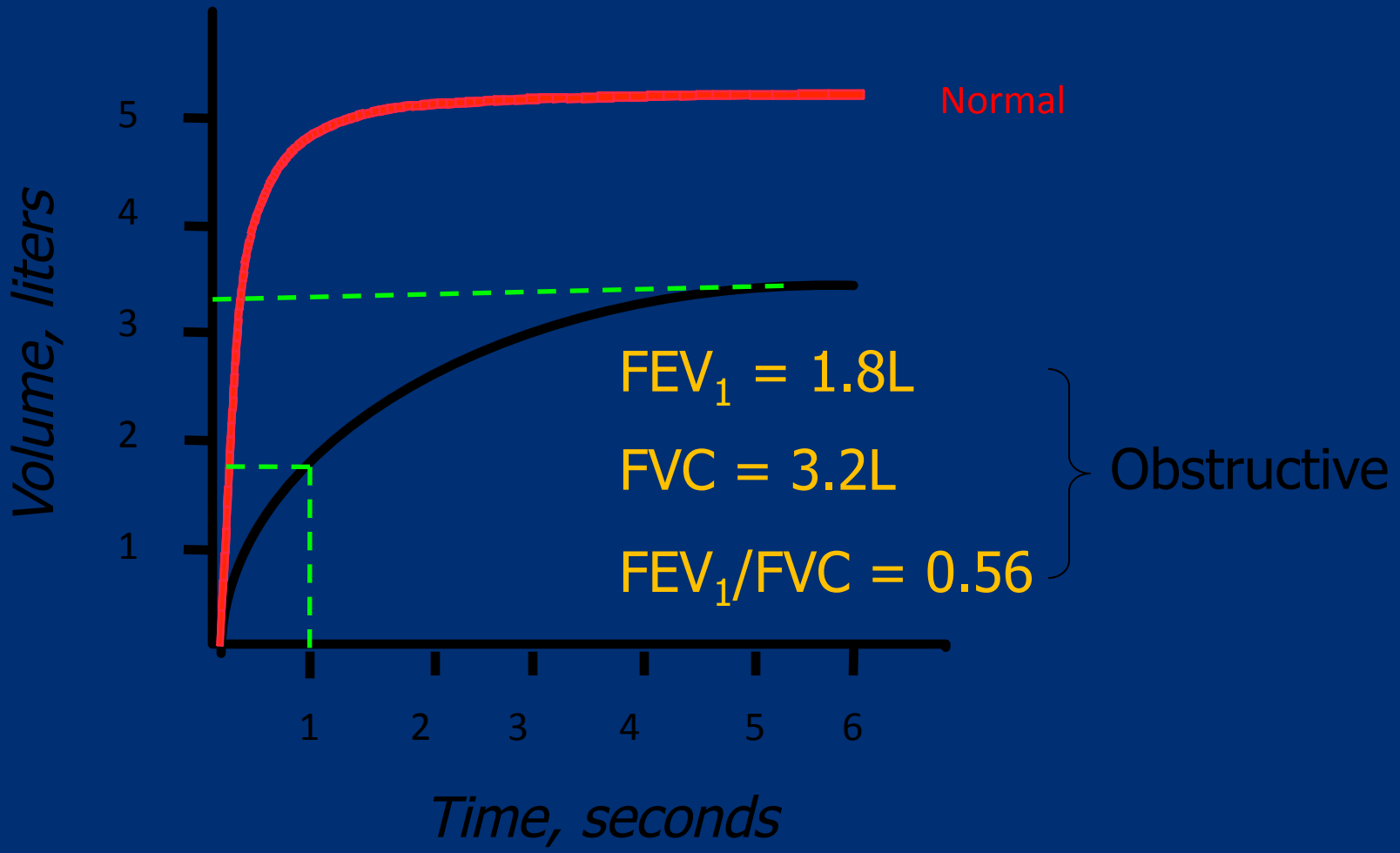



The curve helps ≠
obstructive LD
Restrictive LD

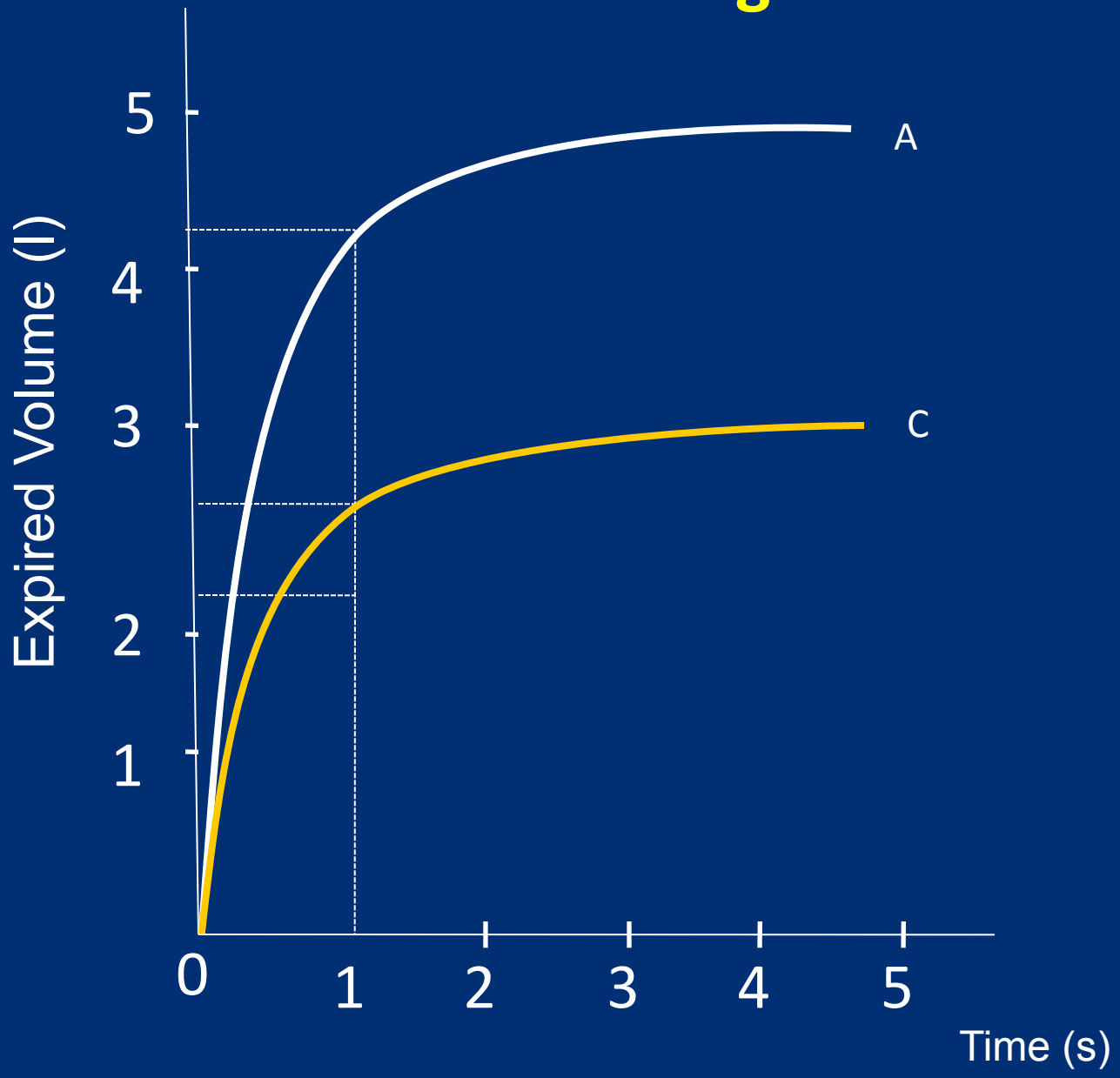
Obstructive lung disease



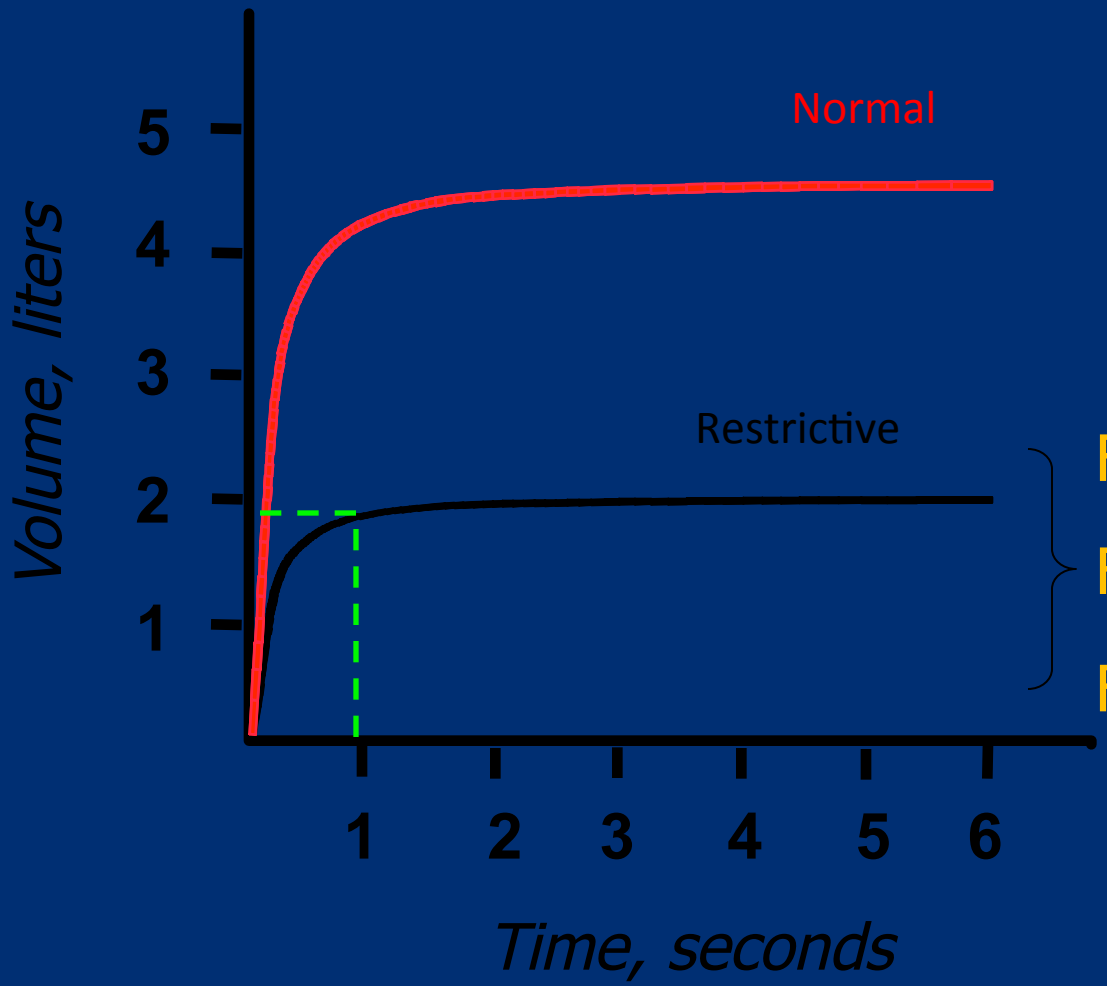
Obstructive Disease



Restrictive lung disease



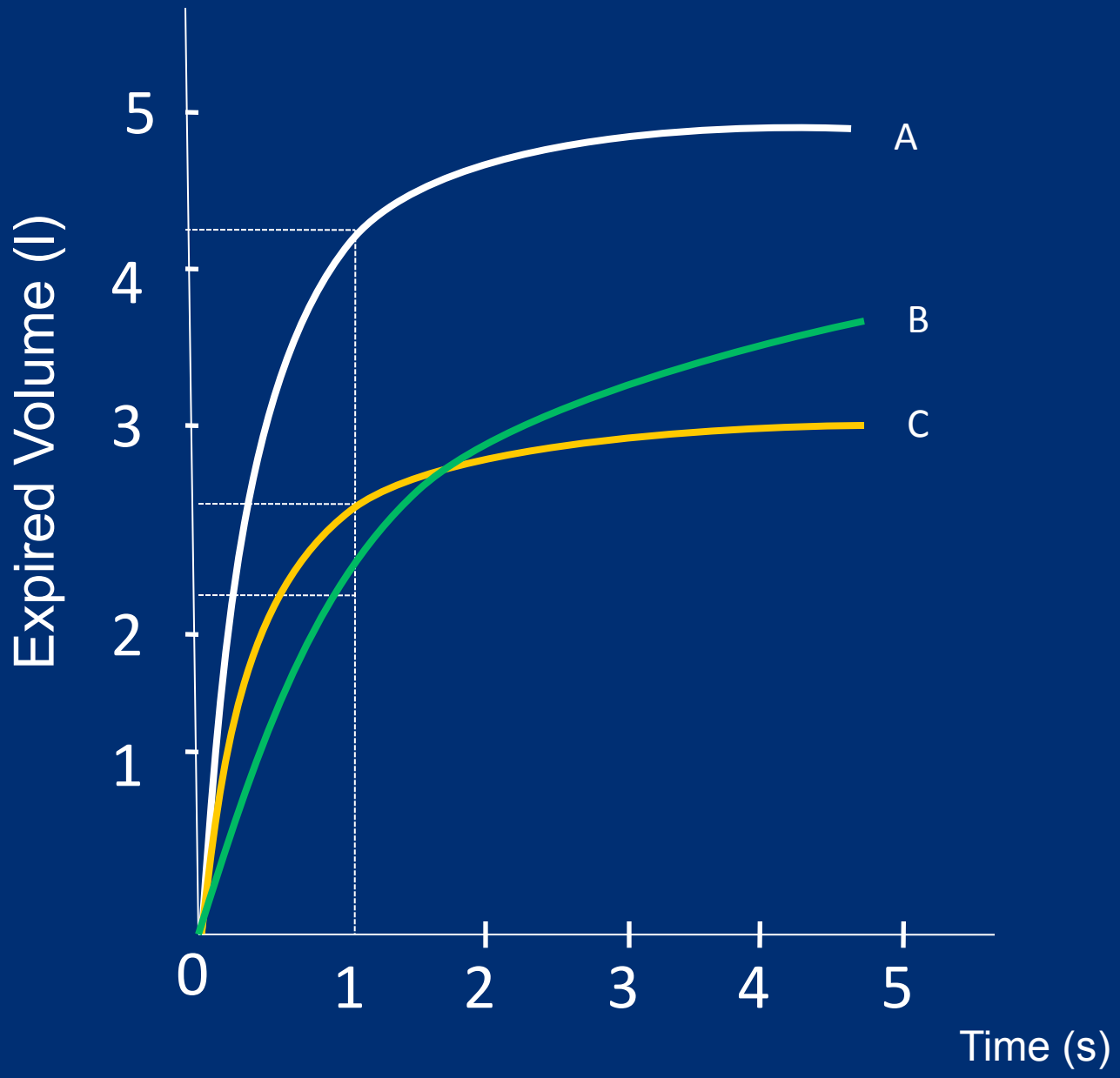
Restrictive Disease



FEV_1 = 1.9L

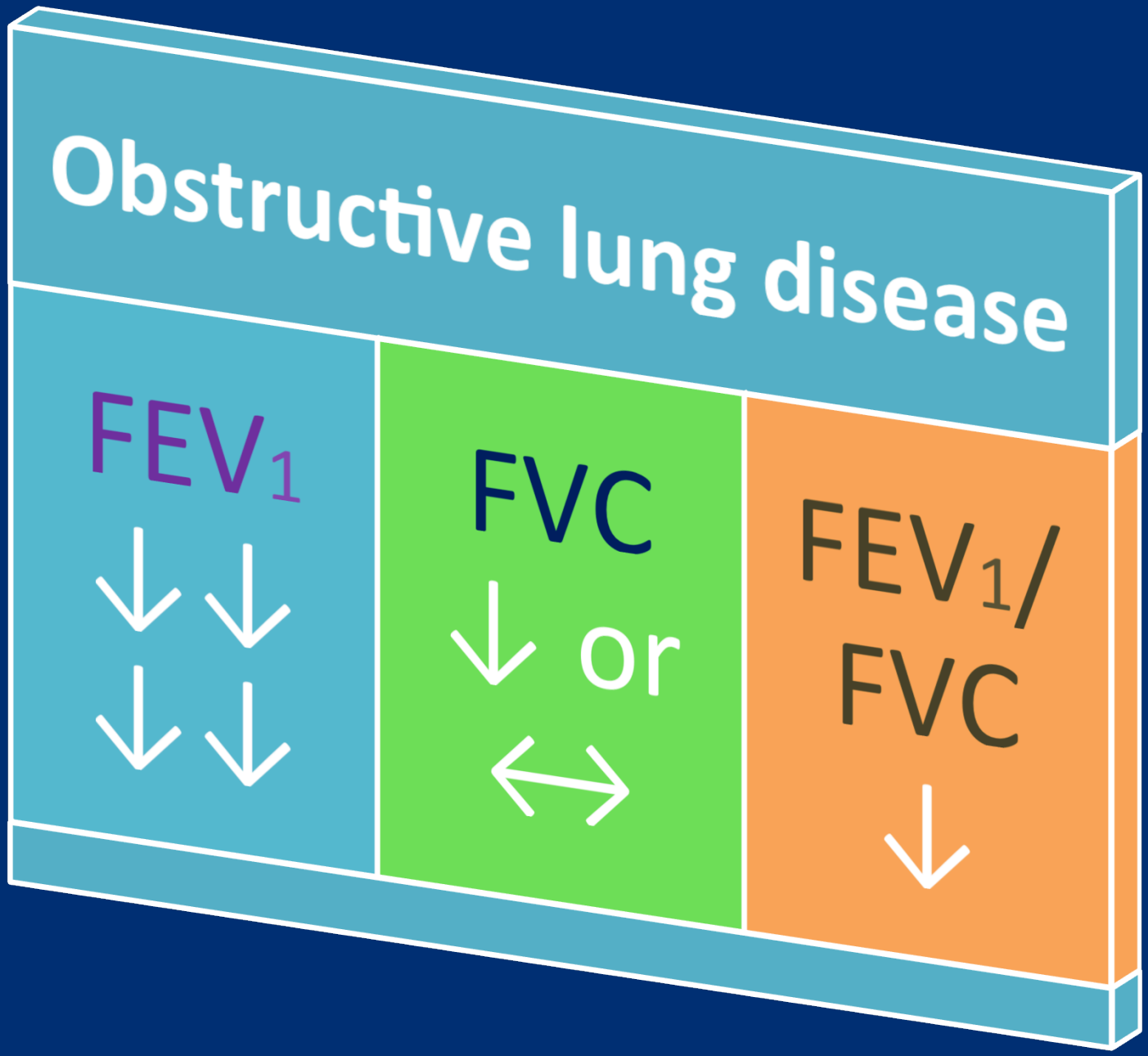
FVC = 2.0L

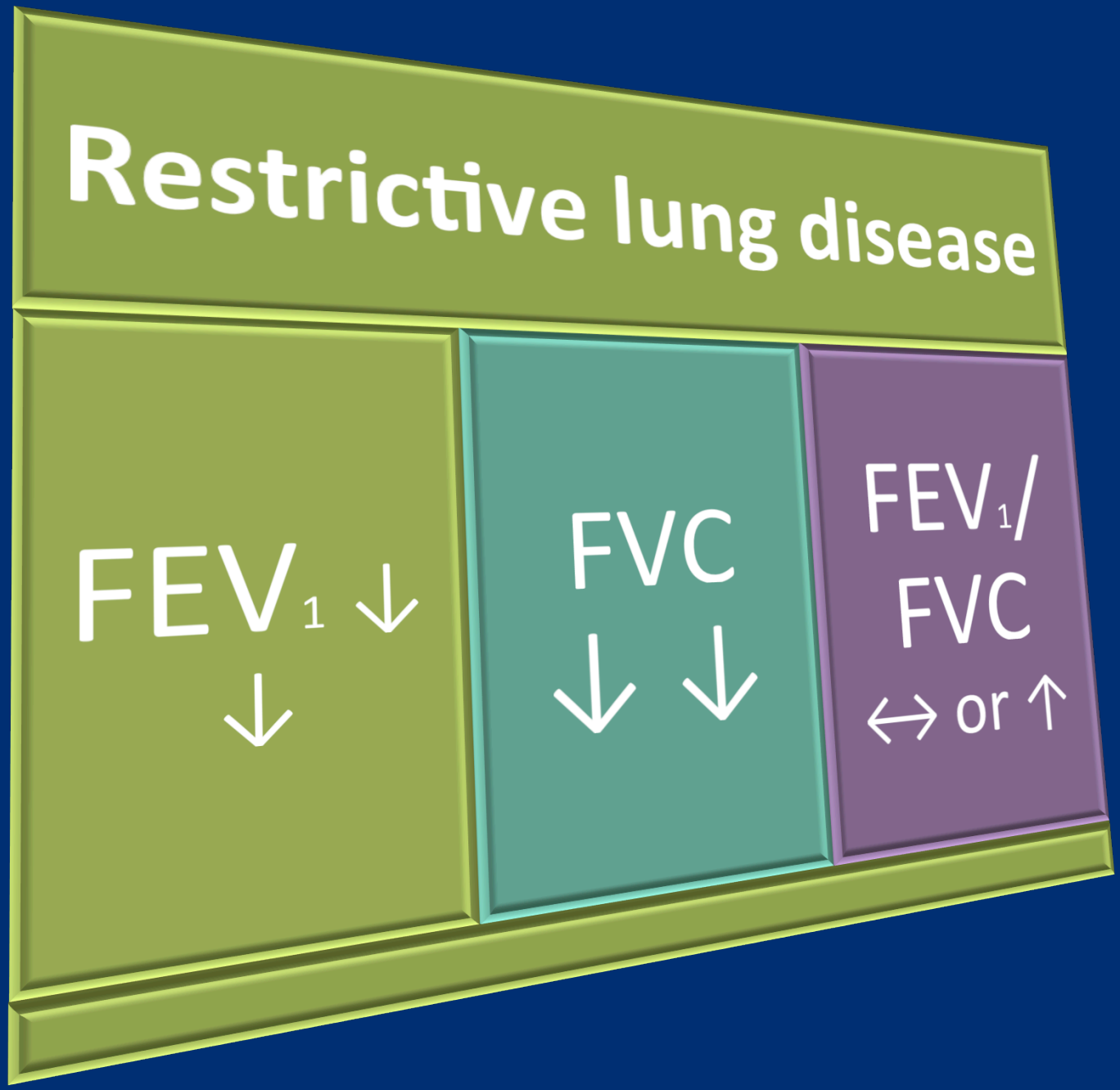
FEV_1/FVC = 0.95


Expired Volume (l)
5
4
3
2
1
0
1
2
3
4
5
Time (s)
A
B
C

- The normal and restrictive expire fully in 2 sec.

- The obstructive needs more than 2 sec, the curve rises slowly to reach its highest point.
- He may need more than 6 sec.
- He can or not get rid of all VC depending on the severity of the disease.


Obstructive lung disease
FEV1
↓ ↓
↓ ↓
FVC
↓ or
↔
FEV1/
FVC
↓


Restrictive lung disease
FEV1 ↓
↓
FVC
↓ ↓
FEV1/
FVC
↔ or ↑

Volume	Normal	Obstructive	Restrictive
FVC	5	↓ or ↔ (5)	↓ (3)
FEV_1	4	↓↓↓ (2)	↓ (2.7)
$FEV_1\%$	80%	↓ (40%) (↓ airflow)	↔ or ↑ (90) (Normal airflow)

Results interpretation

- Results are reported as absolute values (litre) ,and as percentages of predicted values based on age, height, sex, ethnicity.

- Normal: Both FVC and $FEV_1 \geq 75\%$ of predicted

- If any of FVC and FEV_1 is < 75% of predicted, calculate FEV_1 ratio:
- $FEV_1\% \geq 70\%$ ------→ Restrictive
- $FEV_1\% < 70\%$ ------→ Obstructive

Calculating percentage of predicted values

Patient: 45 year old woman, height 5'3"

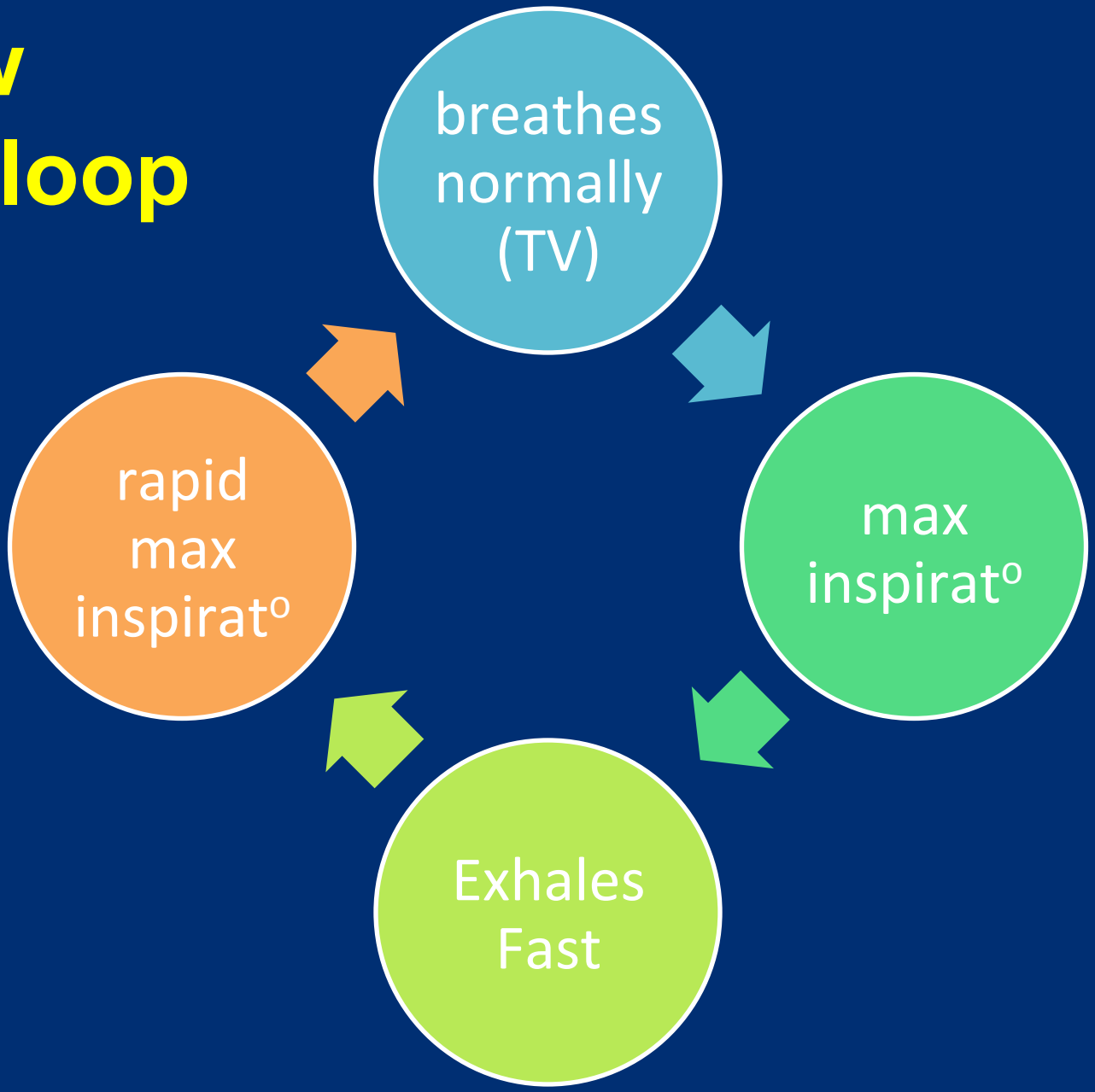
$$FEV_1 \quad \frac{\text{Reading } 1.43}{\text{Predicted value } 2.60} \times 100\% = 55\% \text{ of predicted normal}$$

$$FVC \quad \frac{\text{Reading } 2.5}{\text{Predicted value } 3.03} \times 100\% = 82.5\% \text{ of predicted normal}$$

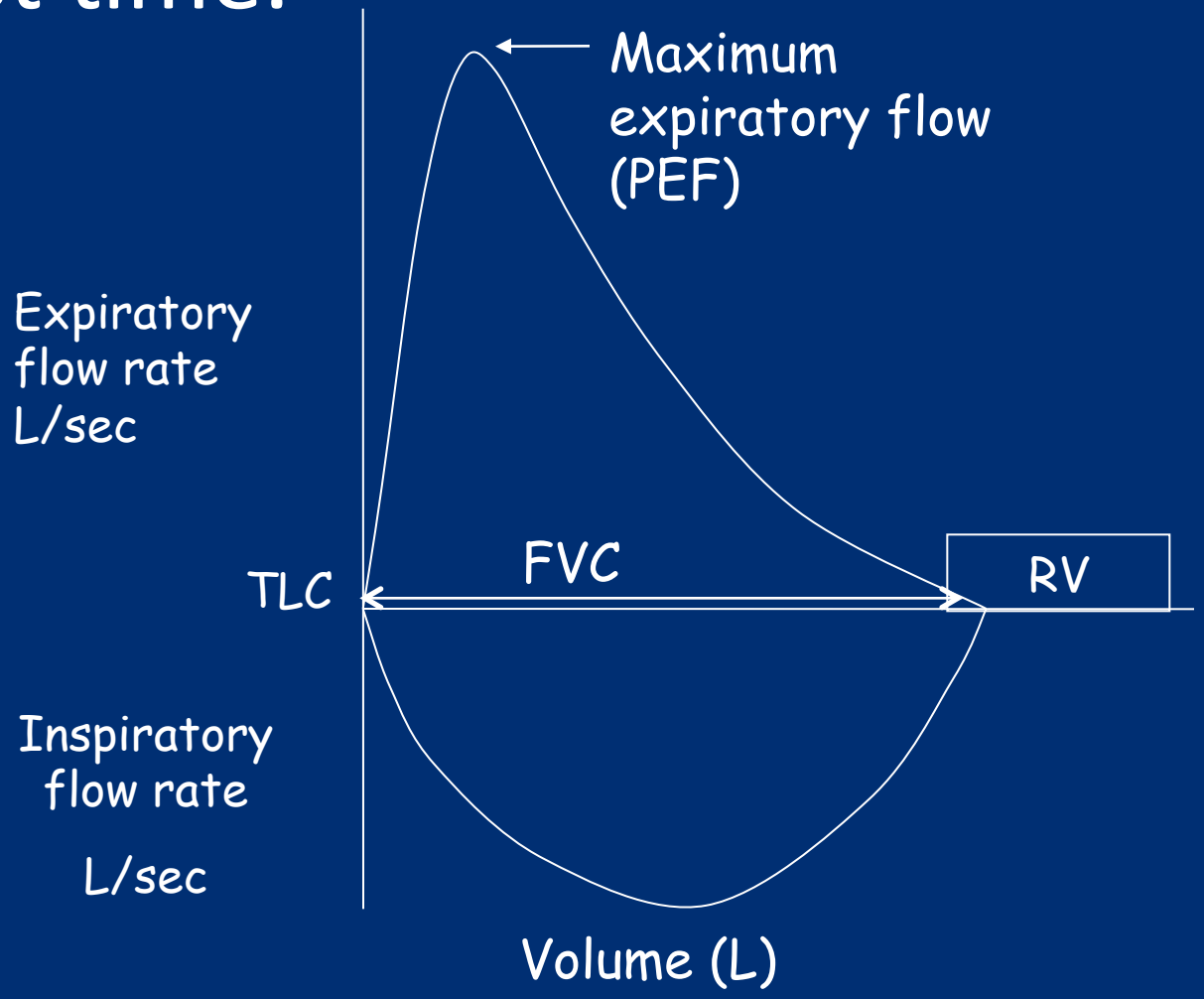
$$\frac{FEV_1}{FVC} \quad \frac{\text{Reading } 1.43}{\text{Reading } 2.5} = 0.57$$

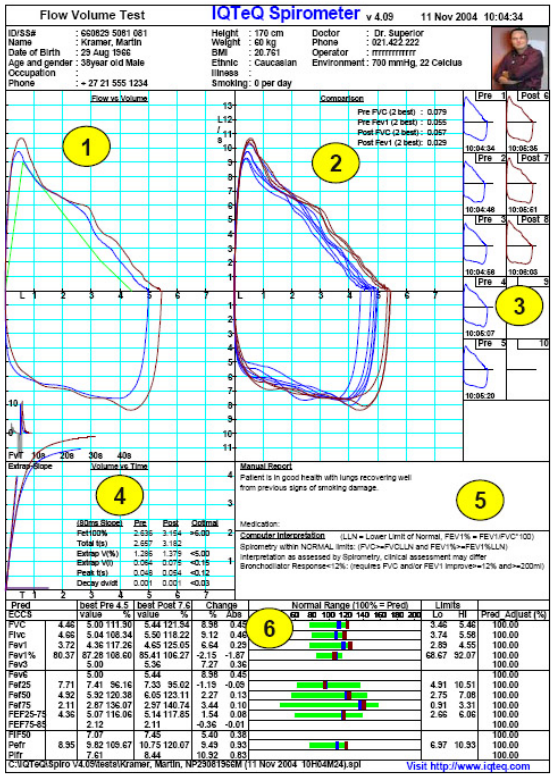
Interpretation: patient has mild airflow obstruction as FEV_1 is between 50% and 80% of predicted normal and FEV_1/FVC is <0.7.

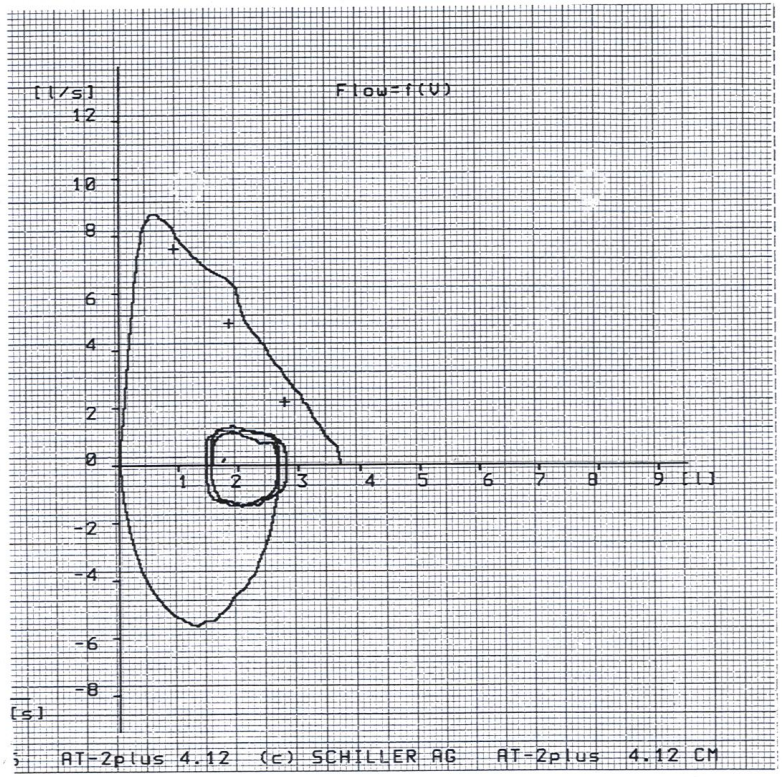
Flow Volume loop



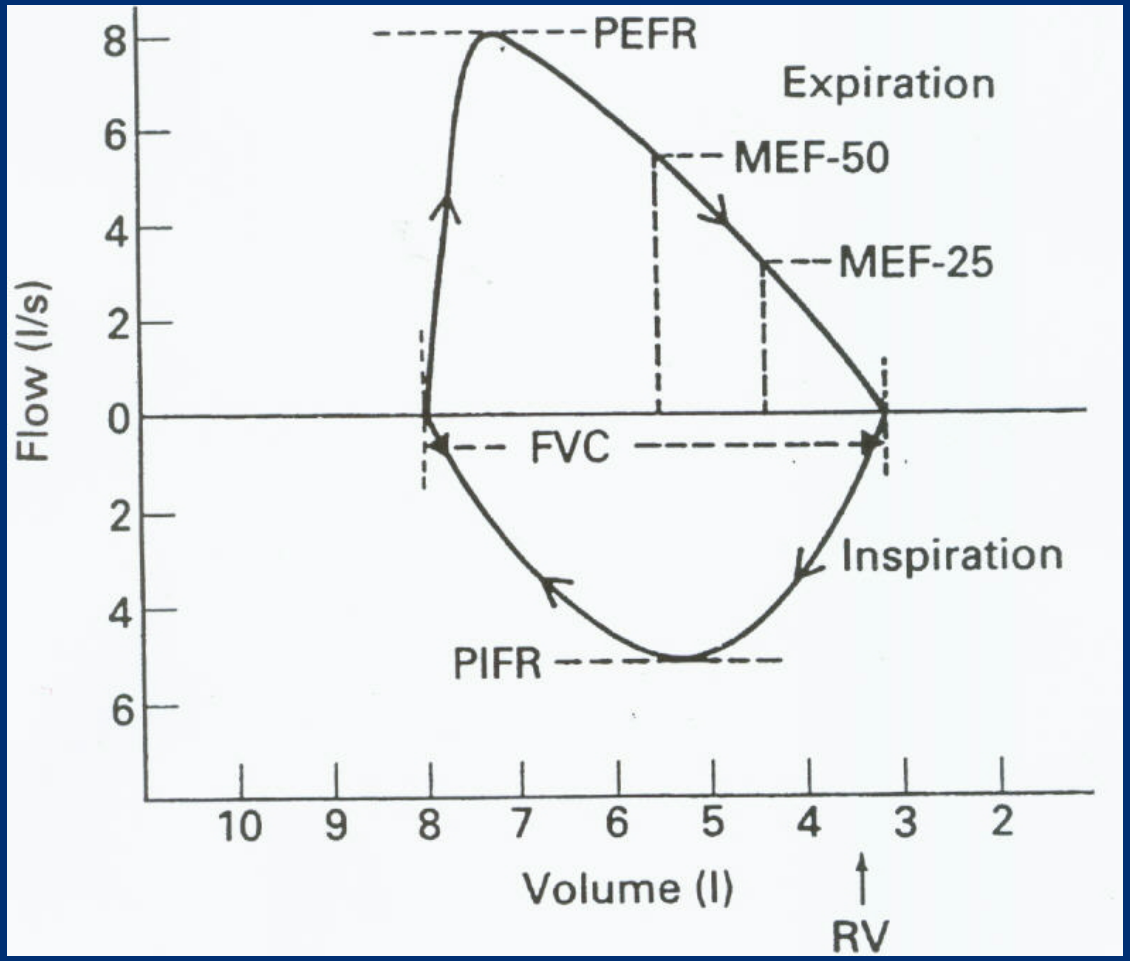
This measures exp & insp flow as a function of exhaled volume rather then against time.




Flow Volume Test
IQTeQ Spirometer v 4.09
11 Nov 2004 10:04:34
Flow vs Volume
Comparison
Pre FVC (2 best) : 0.079
Pre Fev1 (2 best) : 0.055
Post FVC (2 best) : 0.057
Post Fev1 (2 best): 0.029
Extrap Slope
Volume vs Time
Manual Report
Patient is in good health with lungs recovering well from previous signs of smoking damage.
Medication:
Computer Interpretation
Spirometry within NORMAL limits: (FVC>=FVC(LLN and FEV1%>=FEV1%(LLN)
Interpretation as assessed by Spirometry, clinical assessment may differ
Bronchodilator Response<12%: (requires FVC and/or FEV1 improve>=12% and>=200ml)
Normal Range (100% = Pred)
Visit http://www.iqteq.com


Flow=f(V)
AT-2plus 4.12 (c) SCHILLER AG AT-2plus 4.12 CM

Flow Volume loop



• Measurements on flow V loop

- **PEFR** : Greatest flow achieved during the maneuvre = 6- 12l/sec
- **PIFR** = max flow speed achieved during forceful inspiratory effort=6l/sec

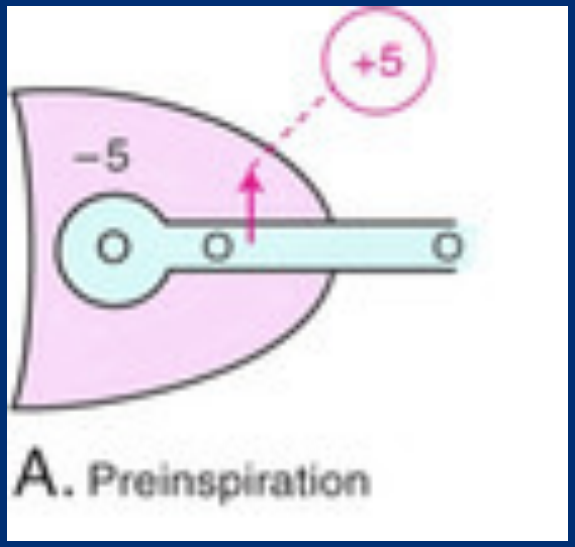
- **MEF50**: max expiratory flow at 50% of FVC = 4-6 l
- **FVC** measured over the X-axis

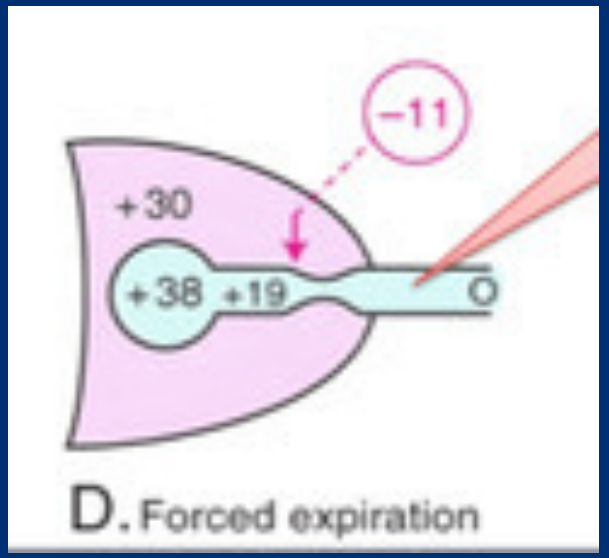
Maximal Flow

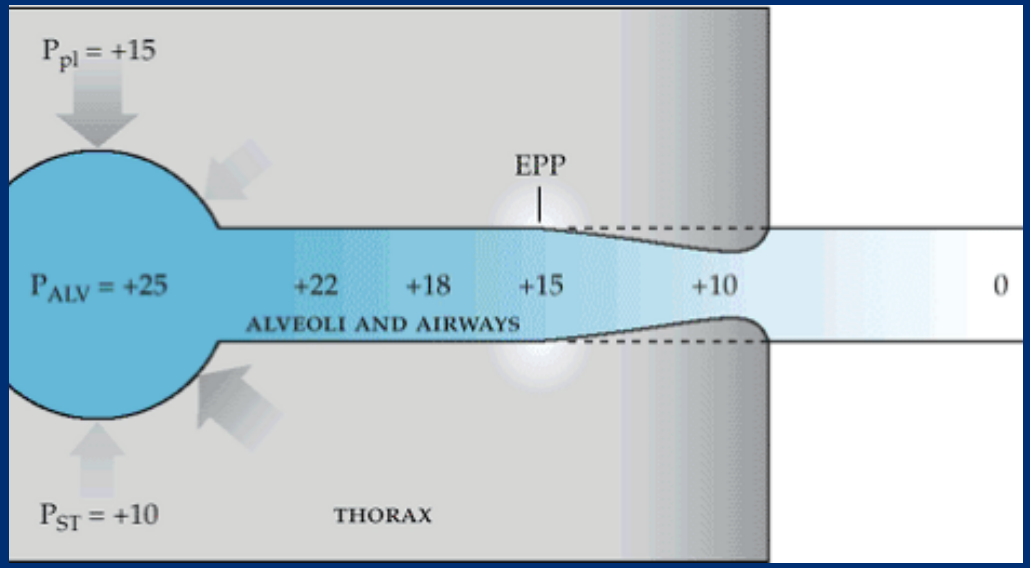
The inspiratory and the 1st early expiratory flow rates (flows generated near the TLC) are effort (muscle) dependent: the greater one can raise pleural pressure (the harder one forces the air out), the greater the resulting air flow.

Flow Volume Loop and Flow Limitation

At low lung volume, as RV is approached, after a certain pleural pressure (P_{ip}) is reached, flow rate is effort independent (it depends on the size of the bronchi): harder effort generates higher P_{ip} but no greater airflow, this is because the positive P_{ip} that tends to collapse the airway exceeds the airway pressure that tends to keep the airways open: the airways narrow, preventing any further increase in airflow despite greater effort.


+5
−5
A. Preinspiration


−11
+30
+38
+19
D. Forced expiration


P_{pl} = +15
EPP
P_{ALV} = +25
+22
+18
+15
+10
0
ALVEOLI AND AIRWAYS
P_{ST} = +10
THORAX

Between breaths: no airflow.

- $P_{alv} = P_{atm} = 0$.
- P_{ip} is negative (subatmospheric, e.g. -5).
- Transpulmonary pressure (P_{trans})

  $= P_{alv} - P_{ip} = 0 - (-5) = +5$.

- P_{trans}: force acting to expand the lungs is opposed by the elastic recoil acting to collapse the lungs.
- Volume of lungs stable.

During forced exhalation:

- The expiratory muscles contract, raising both P_{alv} and P_{ip}.
- As air exits: gradual loss of pressures (↓ Pip, ↓ P_{alv}).
- P_{alv} drops significantly.
- As pressure within the airway ↓, a point is reached where $P_{alv} = P_{ip}$: Equal Pressure Point (EPP). Here, P_{trans} is 0.

- Any further loss of pressure within the airways leads to a negative P_{trans} (because $P_{ip} > P_{alv}$) and collapse of the airways.

- This occurs at low lung volume. Any ↑in P_{ip} tends to collapse the airways more, and makes the expiratory flow effort independent.

- **In normal healthy lungs** the EPP occurs in the most central airways of the lungs: collapse doesn't occur because airway is supported by cartilage. The effects of negative P_{trans} are minimised.

- **In obstructive disease** EPP occurs in more peripheral collapsible airways: flow limitation is established. The shape of the downward slope becomes concave.

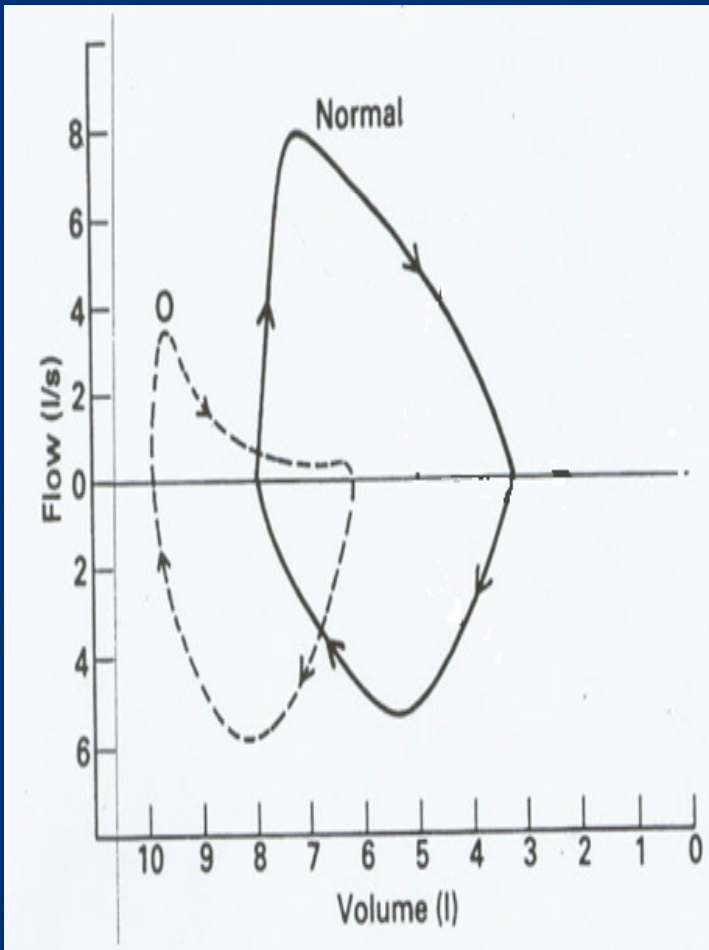
Obstructive LD

MEF50↓

Effort independent part of curve: concave

PEFR↓

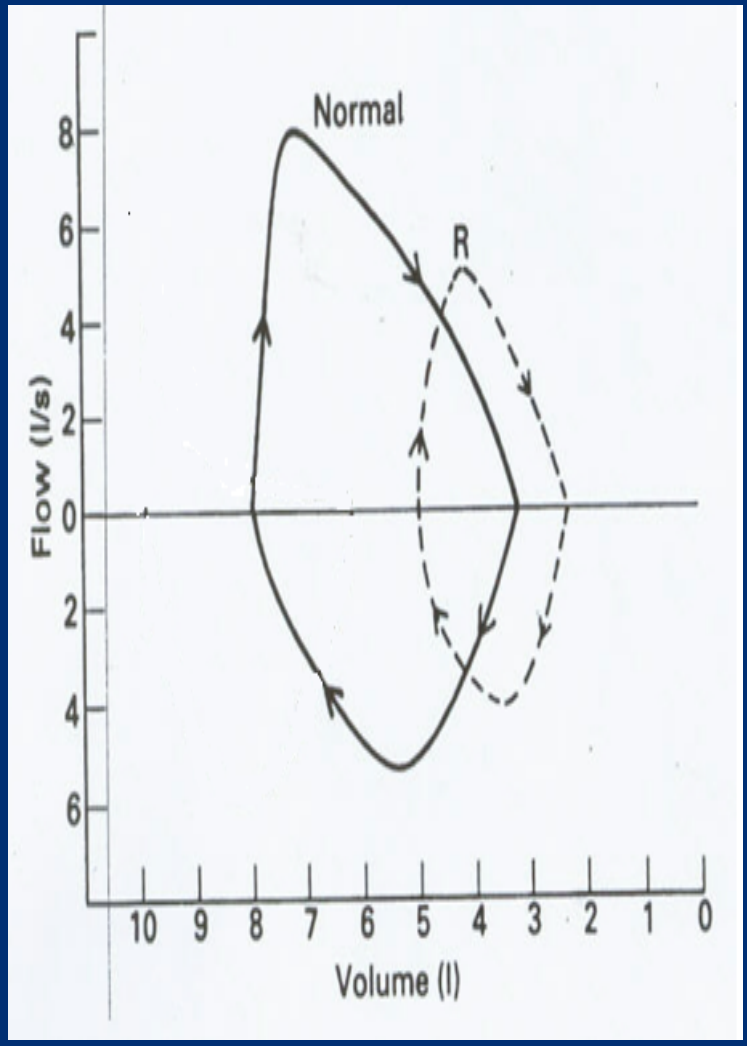
Inspiratory loop Normal

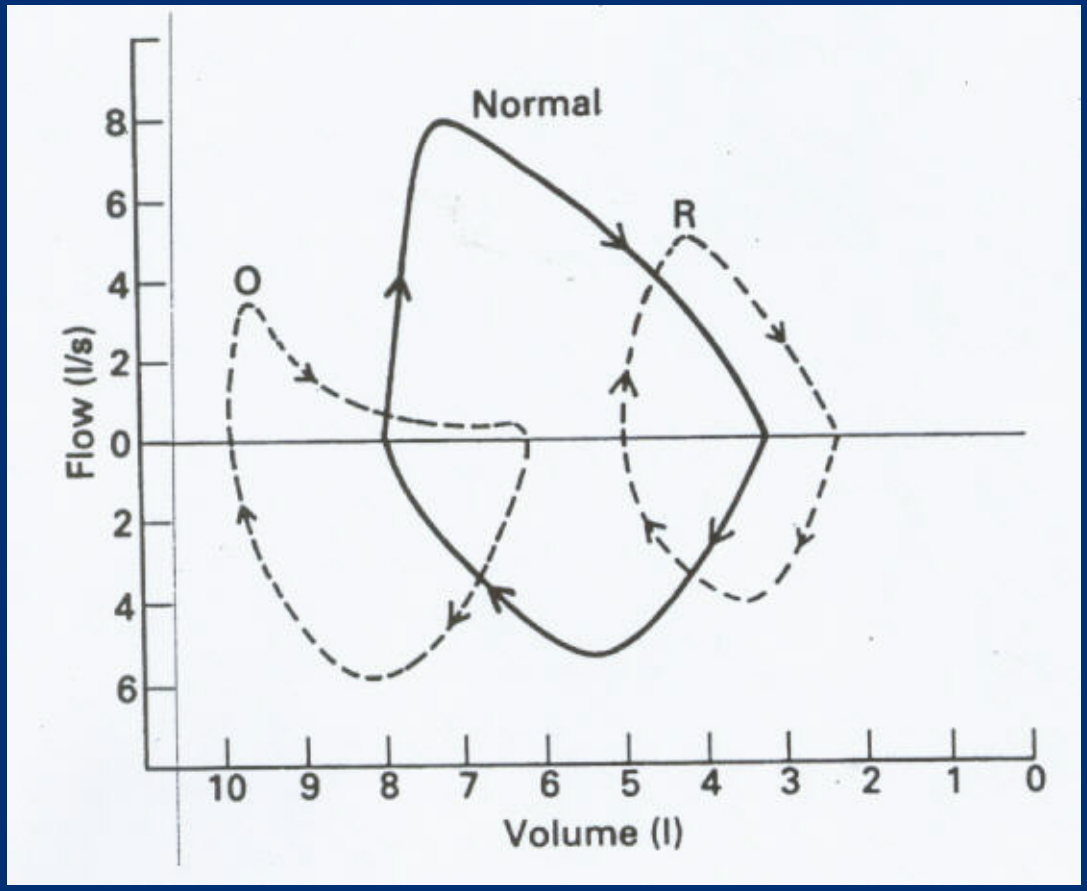


Restrictive LD

Miniature loop (elliptical)

All flow parameters ↓




Normal
R
O
Flow (l/s)
8
6
4
2
0
2
4
6
10
9
8
7
6
5
4
3
2
1
0
Volume (l)

Importance of spirometry

Assess physical fitness.

Helps in the diagnosis of certain pulmonary diseases (obstructive & restrictive).

Follow disease progression.

Thank You