Spirometry

Objectives :

- Use a spirometer and determine lung volumes and capacities
- Define and provide values for the various lung volumes and capacities .
- Recognize the physiological and some pathological factors that modify lung volumes and capacities.

Physiology lab Team 436 – Respiratory block

This work include Boy's + girl's slides + girl's handout

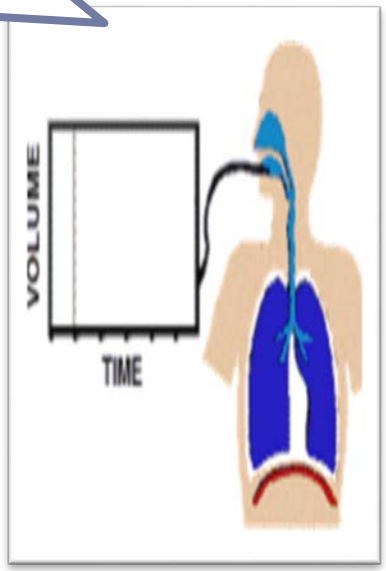
Team work : *Leena Alwakeel – Hassan Alshammari – Ruba Ali*

What is spirometry ?

It is a pulmonary function test that measures lung volumes and capacities.

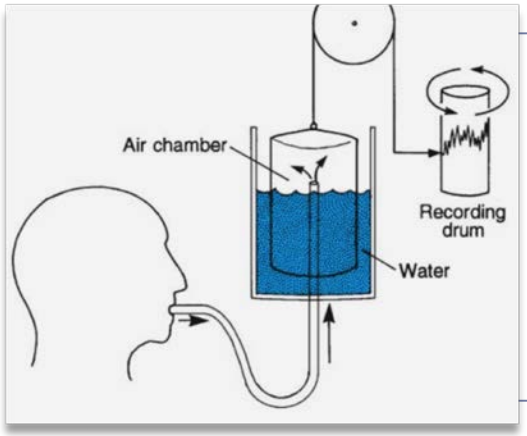
Why a spirometry test ?

1. *To determine the cause of shortness of breath*
2. *To rule out any kind of obstructive or restrictive disease*
3. *To diagnose and monitor lung problems*
4. *To monitor how well medications for lung problems are working*



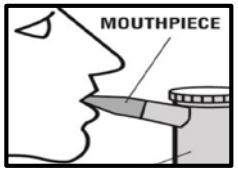
Doctor's note : Just understand it

Simple Spirometer



- Drum inverted over a chamber of water with the drum counterbalanced by a weight.
- The drum contains air or Oxygen.
- A Tube connects the mouth with the gas Chamber.
- When one breathes in and out of the chamber, the drum rises and falls.
- An appropriate recording is made on a moving paper.

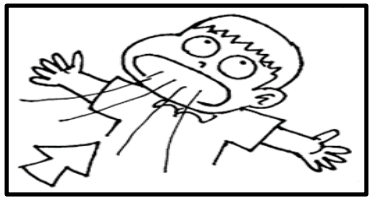
Method of spirometer :



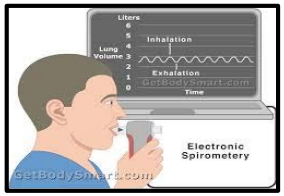
1- Insert sterilized mouthpiece

2- Close the nose with the nose clip

3-Take normal breath through the mouthpiece for a short time then take a deep inspiration to fill the lungs completely, then breathe normally for a short time. Do the same for expiration



4- Take a deep forceful inspiration and immediately expire forcibly and as completely as possible, then breathe normally.

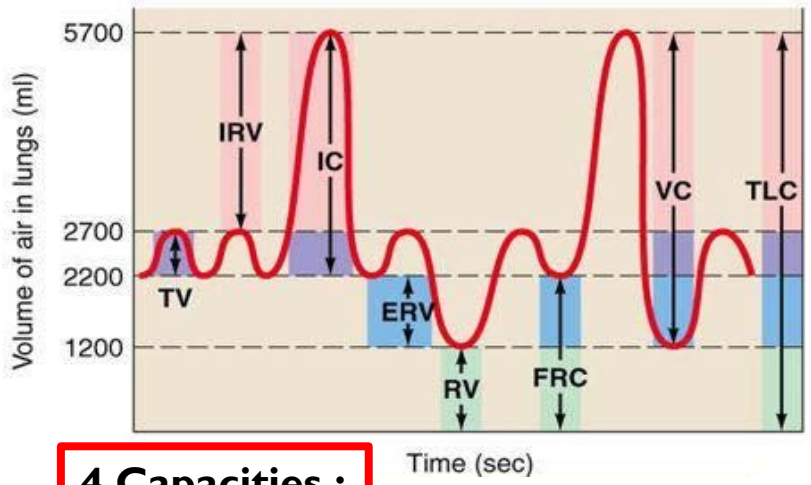


5- The spirogram is recorded on a moving drum

Doctor's note :Very important with numbers

Air in the lungs is subdivided into :

(4 volumes and 4 capacities) :



4 volumes :

Tidal volume : (TV)
The volume of air that inspired or expired during normal breathing it is normal value is = **500ml or 0.5L**

Expiratory reserve volume: (ERV)
The volume expelled by an active expiratory effort after passive expiration (after the end of a normal tidal expiration)
= **1.1L \ 1100ml**

Inspiratory reserve volume : (IRV)
The extra volume of air that can be inspired above the normal tidal volume = 3L \ 3000ml

Residual volume: (RV)
The air left in the lungs after the most forceful expiration = **1.2L**

Measured by : Helium dilution technique (can't be measured by Spirometry)

4 Capacities :

Total lung Capacity:
TLC=VC+RV
The max volume to which the lungs can be expanded with the greatest possible inspiratory effort = 5.8L

Measured by : Helium dilution technique (contain RV)

Vital Capacity :
VC= IRV+TV+ERV
Maximum amount of air a person can expel after maximal inspiration = **4.6L \ 4600ml**

Functional Residual Capacity :
FRC= ERV+RV
Amount of air that remains in the lungs at the end of normal expiration = **2.3L**

Measured by : Helium dilution technique

The Inspiratory Capacity :
IC=TV+IRV
The volume of air that can be maximally inhaled after normal expiration . It is normal value is = **3.5L \ 3500ml**

Physiological significance of RV & FRC :
Prevent lung collapsing , make breathing easier, maintain continuous gas exchange

Numbers could be asked by ml or L (1L= 1000ml)
Numbers are taking from female handout according to doctors' note

factors influencing lung volumes and capacities

Physiological factors

- Gender: female 20-25% less in all volumes & capacities.
- Age: with age… ↑ RV, ↑ FRC while ↓ VC.
- Obesity (weight): ↓ FRC, ↓ VC.
- Height: ↑ VC.
- Athletes: ↑ VC .
- Pregnancy & Posture (Body position).

Pathological factors

Vital capacity is decreased with :

- ↓lung volume:
  E.g: surgical removal of lung tissues large tumors.
- Restrictive lung disease: inability to fully expand the lungs. E.g: Pneumonia, pulmonary edema\fibrosis , broken ribs. ↑ elastic recoil of the lungs , ↓VC, ↓ IRV, ↓ ERV, ↓ RV, ↓TV , ↑ breathing frequency.
- Obstructive lung disease E.g: Chronic bronchitis, asthma, emphysema and foreign body.
  ↓ elastic recoil of the alveoli , ↑TLC, ↑ FRC, ↑ RV, ↑TV , ↓VC, ↓ ERV .
- Loss of elastic recoil E.g: emphysema.
- Chest wall deformities & respiratory muscle weakness.

لتسهيل الحفظ في الزيادة و النقص في ال volumes & capacities لازم أن يفهم السلايد الماضي.

Dynamic spirometry

Objectives :

- Understanding **Forced expiratory volume curve (FEV).**
- Understanding **Flow-volume curve (Loops).**
- Calculating : FVC, FEV1and FEV1% of **FEV Curve.**
- Calculating : FVC, PEFR, PIFR and MEF50 of **Loops Curve.**

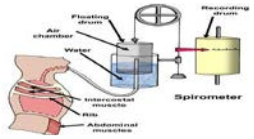
Physiology lab Team 436 – Respiratory block

This work include Boy's + girl's slides + girl's handout

Team work : *Leena Alwakeel – Hassan Alshammari – Ruba Ali*

Type of spirometry

Static test
(1st lecture)

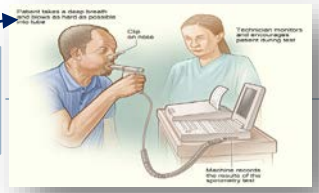


Relaxed Vital Capacity :

Max Volume of air expired during relaxed expiration after a maximal inspiration

Performed without regard to time

Dynamic test



* It provides an objective measurement of lung function.

* It analyzes volume and velocity of expired air

Forced vital capacity :

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

* Performed at forcible and max effort against time

* Measures the rate (with time) at which the lung changes volume during forced breathing

Requirements Of Dynamic spirometry:

- Vitalograph (device).
- Mouthpiece (disposable).
- Nose clip

Procedure:

- ✓ Make a tight seal around the mouthpiece.
- ✓ Ask subject to inhale deeply.
- ✓ In standing position , ask the subject to breath normally for 3 time then exhale as strong and as fast as possible.

Doctor's note : Just understand it

Importance of Dynamic spirometry

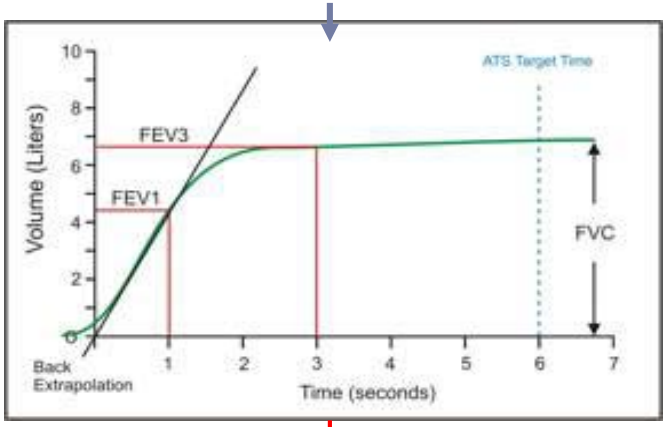
1- Assess physical fitness

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

3- Follow disease progression

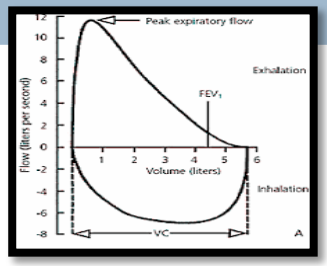
There are TWO type of curve in dynamic spirometry

Forced Expiratory volume Curve



- The subject takes :
  1- A maximal inspiration
  2- Then exhales as rapidly , as forcibly & as maximally as long as possible.
- A plot of exhaled volume against time :

Flow volume curve (slide 11)



FEV1 : Volume of air expelled in the 1st sec of forced expiration starting from full inspiration .

Function : measure of how quickly the lungs can be emptied.

Forced Vital Capacity (FVC) = Plateau (Horizontal curve line)

FVC : the volume of air expired with forceful effort after a maximum inspiration

FEV1 % (FEV1 ratio) = (FEV1/FVC) * 100 : Fraction of the Vital capacity (VC) expired during the 1st sec of a forced expiration

Normal range : (70% - 80%)

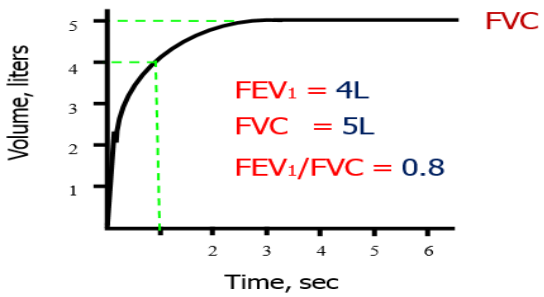
Function : The ratio is useful index of airflow limitation

- The equation -

Forced Expiratory Curve

Doctor's note :Very important
They will give you a curve and u should come up with FEV1 , FVC & FEV1 ratio then you will decide if it Obstructive or restrictive curve

Normal Trace



Duration or forceful expiration : ***3-5 sec***

Normal FEV1 ratio = **(70-80)%**

How to get the information from the curve for diagnosis (obstructive , restrictive) :

FEV1 = draw a vertical line from the 1st sec (on x-axis) until it reaches the curve then draw a second horizontal line (from the end of the 11st line) toward Y- axis (the volume)= 4

FVC = we draw a horizontal line from the moment that the curve begin to be a plateau (horizontal) = 5

FEV1/FVC = 4/5 X100 = 80% (normal)

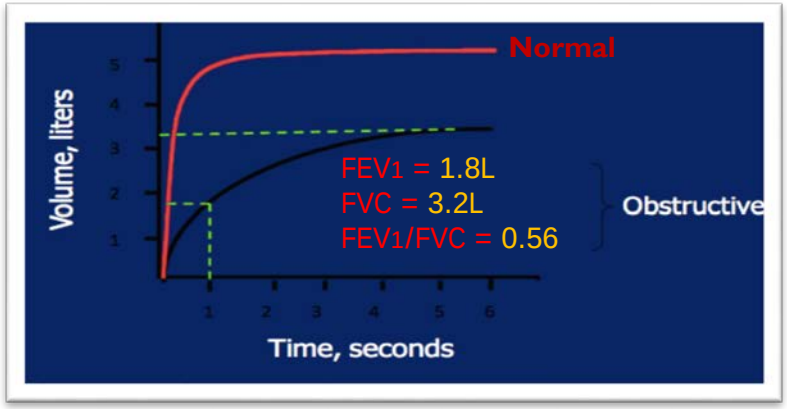
1- Obstructive LD

E.g : COPD

Duration or forceful expiration : ***>5 sec***

Almost = ***6sec***

FEV1 = ↓
FVC = ↓ or ↔
FEV1/FVC = ↓



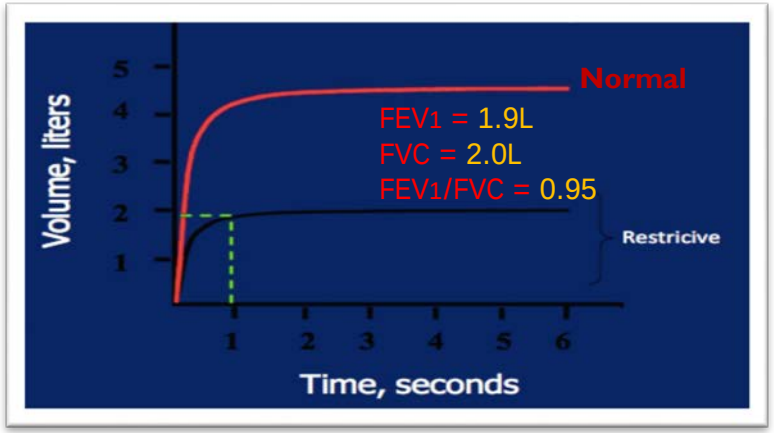
↑ Airway resistance

2- Restrictive LD

E.g : pulmonary fibrosis

Duration or forceful expiration : ***3-5 sec***

FEV1 = ↓
FVC = ↓
FEV1/FVC = ↑ or ↔



↓ Lung compliance

(((FVC in Restrictive lung disease is only **decreased**)))

LD = lung disease

Results Interpretation (Extra example)

When we do this test on a patient Results of patient are reported as absolute values (liter) ,and as percentages of predicted values (normal value of person) based on age, height, sex, ethnicity.

Example : patient has this readings (**FEV1 =** 3.16. , **FVC** = 3.97) .

Step1: calculate predicted value

Predicted value of FEV1 ⟶ (3.16 / 4) * 100 = 79%

Predicted value of FVC ⟶ (3.97 / 5) * 100 = 79%

So this patient is healthy

دائما لما نحسب ال predicted value of FEV1 نقسم على 4

اما Predicted value of FVC نقسم على 5

If both predicted values are **greater than 75 %**, we conclude that the patient is healthy .

Other example : patient has this readings (FEV1= 1.8 , FVC =3.2).

Step1: calculate predicted value

Predicted value of FEV1 ⟶ (1.8 / 4) * 100 = 45%

Predicted value of FVC ⟶ (3.2 / 5) * 100 = 0.64%

If one of the predicted values is **lesser than 75 %**, we should calculate FEV1/ FVC.

Step2 : calculate FEV1/FVC

(1.8 / 3.2) * 100 = 56.25 %

So this patient has obstructive disease

Remember :

If FEV1 % (70% - 80%) → Normal

If FEV1 % ≥ 80% → Restrictive

If FEV1 % < 70 % → Obstructive

Numbers with this color are just an example cause it differ from person to another due to age , sex , etc…

Practice Questions

- Dynamic Spirometry was done on 3 patients, the results were the following:

- A. FEV1= 4L , FVC=5L ⟶ **FEV1/FVC = 80%**

  (Normal) because ratio is within normal range 70% - 80%

- B. FEV1=1.2L , FVC=3L ⟶ **FEV1/FVC = 40%**

  (obstructive) because ratio is lower than 70%

- C. FEV1= 2.7 L, FVC=3L ⟶ **FEV1/FVC = 90%**

  (restrictive) because ratio is higher than 80%

Flow Volume loop

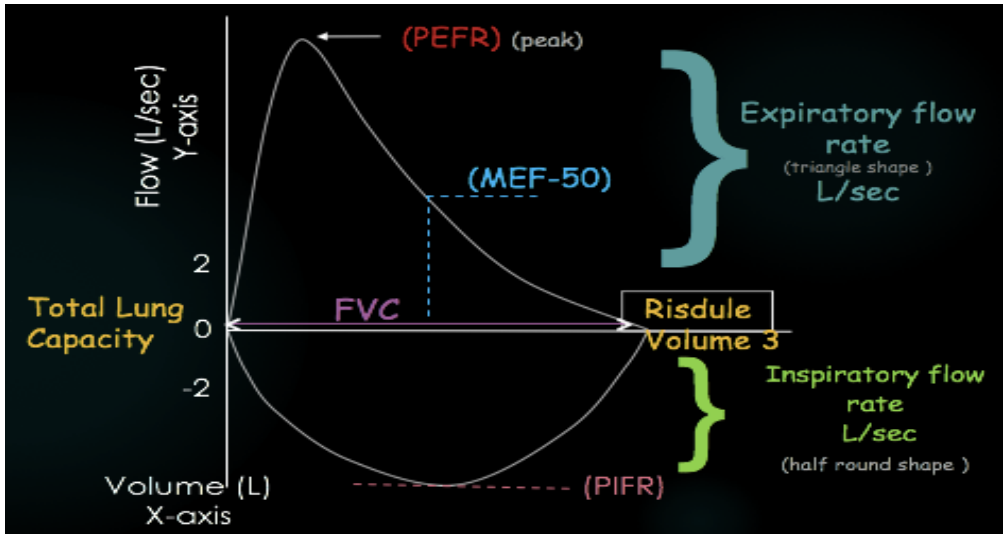
Doctor's note : Curve is Very important
They will give you a curve and u should come up with FVC , PEFR & PIFR then you will decide if it Obstructive = concave shape or restrictive = small shape curve (on the next slides)

Definition: It is a process that measures expiration & inspiration flow as a function of exhaled volume rather then against time.

Method :
Just understand it

- Breathes normally (TV)
- Max inspiration
- Exhales Fast
- Rapid max inspiration

Curve :



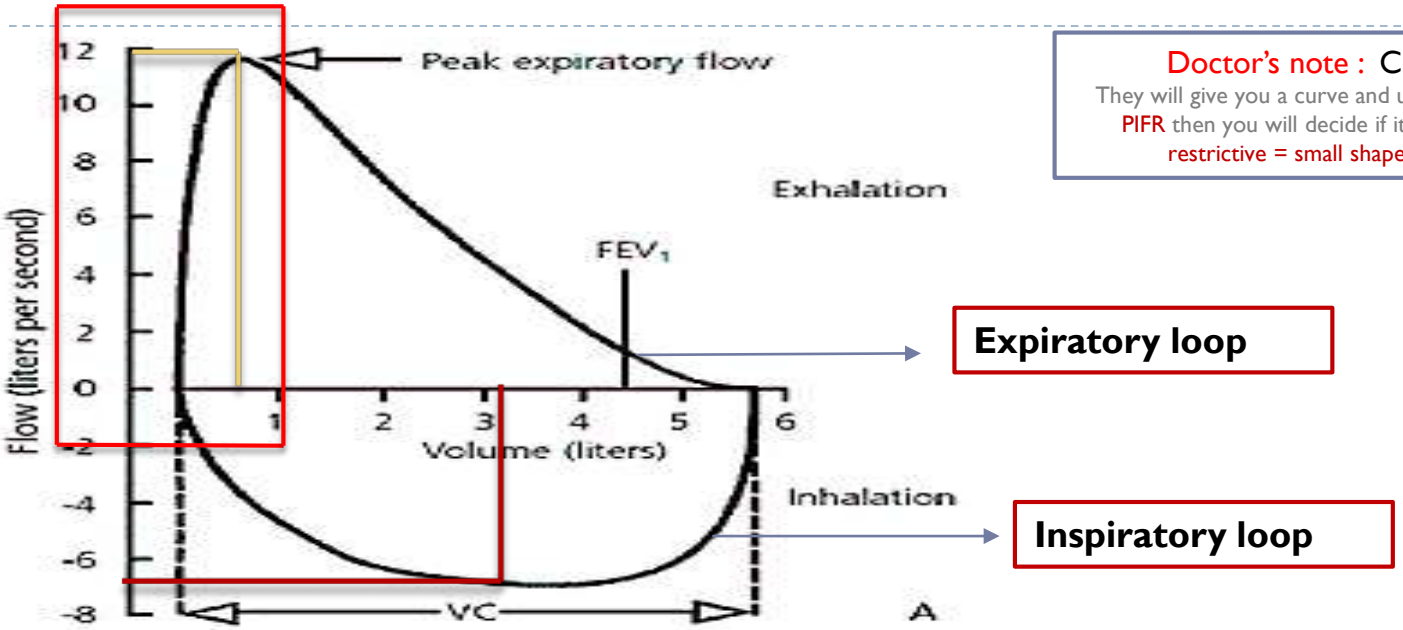
PEFR : peak expiratory flow rate.
PIFR : peak inspiratory flow rate.
MEF50 : maximum expiratory flow at 50% of VC .

•**PEFR :** maximum <u>expiratory</u> flow speed that achieved during forceful expiratory effort = 6 -12 L/sec (Y- axis).	•**PIFR** = max <u>inspiratory</u> flow speed that achieved during forceful inspiratory effort =6 L/sec (Y- axis).
MEF-50 : max expiratory flow at 50% of VC = 4- 6 L (Y- axis).	•FVC measured over the X-axis (Volume)

It is very important to know how to calculate FVC, PEFR, PIFR and MEF50

You have to know where is <u>expiratory loop</u> as well as <u>inspiratory loop.</u>

Example :How to get the information from flow-volume curve ?



Doctor's note : Curve is Very important
They will give you a curve and u should come up with FVC , PEFR & PIFR then you will decide if it Obstructive = concave shape or restrictive = small shape curve (on the next slides)

From the curve above :

FVC : it is the value of x-axis that the expiratory loop falls. (~ 5.8 L)

PEFR: look at the peak of expiratory loop and draw horizontal line towards Y-axis. (~12 L/s)

PIFR: look at the peak of inspiratory loop and draw horizontal line towards Y-axis. (~ 7 L/s)

- The numbers above are just an example.

Flow Volume Loop and Flow Limitation

Effort dependent

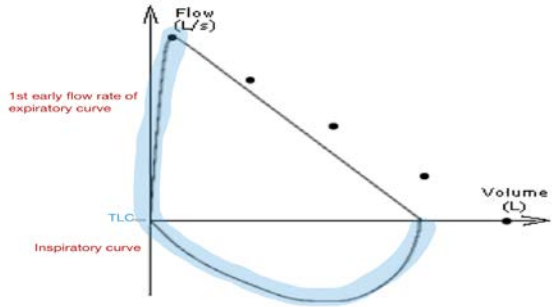
Happened in :

Inspiratory + 1st early flow rates of the expiratory curve

(flows generated near the TLC)

Harder (effort) forces the air out

→ will raise pleural pressure →
The greater effort will result an air flow



Effort independent

Happened in :

1- At low lung Volume ,(as RV is approached)

2- certain pleural pressure (Pip) is reached

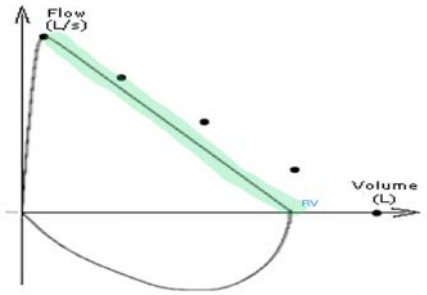
(it depends on the size of the bronchi)

Hard effort → Generates higher Pip (but no greater airflow because:

Positive Pip (that tends to collapse the airway) exceeds the airway pressure (that tends to keep the airways open) → will lead to :

1- airways narrow

2- preventing any further increase in airflow despite greater effort



The next slide contains doctor's notes witch may help you to understand this slide.

Doctor's Notes
(explanation of flow-volume curve)

Briefly describe the important characteristics of the flow-volume curve recorded with a normal healthy person.

+ inspiratory loop

It has an upward expiratory loop and a downward inspiratory loop. The expiratory loop has a rising phase and a falling phase. The rising phase is force-dependent, as the air comes out with force from the larger airways due to the contraction of expiratory muscles. The falling phase is force-independent as the air comes out from the smaller airways without any force due to the elastic recoil of the lungs.

Why is the force-independent part of the expiratory loop curvilinear in obstructive lung disease?

Because the smaller airways are narrowed due to either spasm or accumulation of secretions, they provide resistance to the airflow during expiration; therefore, the airflow slows down and the force-independent part of the expiratory loop becomes curvilinear.

What is the clinical significance of MEF50 measurements?

MEF50 becomes greatly reduced in obstructive lung diseases (less than 4 L/sec).

Doctor's note : Very important

Obstructive & Restrictive Lung disease

	OBSTRUCTIVE LD	RESTRICTIVE LD
PARAMETER	PEFR : ↓ MEF50 :↓	All flow parameters :↓
CURVE SHAPE	Inspiratory loop: Normal **affect effort :** independent **curve:** concave	**Miniature loop** **(elliptical)** (both inspiration & expiration)
CURVE