The main purpose of breathing is to get adequate amount of O2 which will be used in the synthesis of ATP; (NA-K pump) spends ATP molecules more than any part in your body.

The lung is one of the most efficient machines in the body; it uses just 5% from the produced ATP in breathing, leaving 95% for the rest organs to do their job, but why we use just 5% of the ATP during inspiration?

Simply, because inspiration is easy, we need the respiratory muscles to make a little force, which means a little amount of ATP, which is enough to let the air get inside the lung " to reach the tidal volume (TV)", but if we have to make a huge force large amount of ATP will be used then the machine isn’t efficient, now why we need that little force not a huge one?

Because this force made to overcome another type of forces (collapsing forces), those collapsing forces are small, then we just need to do a little effort.

The main question which we need to answer is why the collapsing forces are small?

Because we start breathing from the FRC, let’s explain this answer.

First we have to know the term (**compliance) (المطاوعة)** which is the tendency of a subject to change its form when a force is applied on it, for example a cup of iron isn’t compliant because you can’t change its shape while a rubber band is compliant because it becomes taller when it stretched.

Compliance= L/ F, L= length F= force

For the lung we use the volume (V) and the pressure (P), then

Compliance= V/ P

Notice that compliance **directly** proportional to the change in volume, also compliance is **reversely** proportional to the collapsing forces.

Second assume we put an empty lung in an empty box then we change the pressure around it to become more negative "we force the lung to inflate", we notice that after bringing a large effort, the increase of the lung volume will be small then we notice dramatically increase in the volume "we notice that when we reach a **critical pressure**, the increasing the volume of the lung will be more easy"( لما تنفخ بالون في البداية بكون صعب بعدين بصير أسهل).

You have to know that collapsing forces become very huge for some reasons such as there’s no surfactant" and the surface tension is high" or the lung empty its content during expiration until it reach the minimal volume (MV), this case similar to our experiment, we start to inflate the lung (inspiration) from a very little volume like the **MV** where the collapsing forces are huge and the compliance is very small, here we need a big effort or force (or amount of ATP) to induce the lung inspiration (increasing its volume) until we reach a critical point where the volume is enough to make the lung compliant, the compliant lung easier to inflate so the lung volume increasing becomes easier until we reach the **TLC**, here the compliancy almost zero because the lung reaches its maximal stretch ability, then there’s very little change in volume although if we make a large effort.

-The empty lung "collapsed lung" and the already inflated lung, are **NOT** compliant.

**The inflation compliance curve** will explain what I say:

V

TLC

FRC

MV

**p**

**The slope=the tan of the angle= y2-y1/x2-x1= V/ P= the compliance**

What really happen that we start breathing (**taking the tidal volume**) from the FRC where the lung is partially inflated and the compliance is very high.

This explain why we don’t start breathing from the MV, because we will use a large amount of ATP each time we take a breath, then the machine isn’t efficient, and we will die from fatigue.

**Conclusion:** we can’t take the tidal volume if we start from very low volume (MV) or very high (TLC) because the compliance is very low, it’s better to take it from an intermediate volume or partially inflated lung (FRC) when the compliance is high.

Regarding the previous experiment if we want to deflate the totally inflated lung from the TLC to the MV, we will compress the lung by decreasing the pressure around it (make it more positive), during this we will notice that lung deflation doesn’t behave like inflation and this is clear according to :

**the deflation compliance curve**:

**V**

**TLC**

**MV**

This path doesn’t follow the same path of inflation curve, this is called **Hysteresis** which is means the backward process isn’t the same as the forward process.

What makes this hysteresis is the **surfactant**, how?

Let’s talk about surfactant, surfactant has its quality and quantity and these two factors determine if it’s effective or not.

Effective surfactant means there is an adequate amount of surfactant and it can reduce the surface tension, this reduce the work of breathing, this reduces the collapsing forces "the ATP utilized is very little", this reduces the inflation forces we need.

Let’s talk about its quantity, surfactant quantity is the same of surfactant concentration which equal to (amount of surfactant/ surface area) \*we mean by surface area, the volume", for example if we have 3 alveoli with different surface areas and the same amount of surfactant then each one has its own surfactant concentration the one whose surface area is the bigger has less concentration of surfactant.

If we take the biggest alveolus and inflate it, this will be difficult at the beginning then become easier (the inflation compliance curve) and the surface tension is high, but when we deflate it, this will be easier (the deflation compliance curve) and the surface tension is low from the beginning although the amount of surfactant doesn’t change, why?

Because the surfactant which is a glycolipoprotien (mainly lipids in the form of phospholipids), those phospholipids have a polar head (contains glycerol which is alcohol) and two non polar tails (contains fatty acids), during inflation the head facing the air not the wall, this increase the intermolecular attraction which increase the surface tension, while in deflation the two non polar tails will face the air and the head will face the wall, this decrease the intermolecular attraction and the surface tension will decrease.

Here quality of surfactant plays its role, during inflation the quantity is missed although the quantity is the same.

According to the two curves, at the same volume such as (-3) we have different value of pressure, the pressure in the deflation is smaller (assuming it will be -6 then during inflation it will be -9 for example), this also explained by the change of the surfactant quantity.

Surfactant is very important because it reduces the surface tension and this reduces the work done for breathing, and if there’s no surfactant breathing will be very difficult and need huge effort (too much ATP).

Surfactant start to produce by alveolus type "2 cells" at week 20 of pregnancy, at week 32-34 its production almost complete, if the baby born before its time, then he has a little amount of surfactant and the lung is immature so we called him premature"خديج" baby, with such amount of surfactant the surface tension will be very high.

According to law of **La Place** P=2T/r, T= surface tension, r=radius of alveolus, P=inflation pressure

For the lung (P) means how much negative pressure you need in the intrapulmonary cavity to maintain certain inflation in the lung (normally -4), it also means in normal situation the collapsing forces are (+4), you know that collapsing forces comes from the surface tension (T) mainly, actually the (+4) divided into (2/3 from the surface tension) and (1/3 from the elastin) which irrelevant to the surfactant (surface tension is very important, it induce the passive expiration process).

In premature baby the surface tension is very high, also (r) is very low that mean he facing a very danger situation, because of the huge collapsing forces he need to re-inflate the lung from the MV by maintain very high negative pressure, this need very strong muscle contraction, the stress will be huge and he will start fighting to breath until he dead from fatigue….WE CALL THIS respiratory distress syndrome (RDS).

Also maintaining very high negative pressure leads the fluids leaking from the capillaries to the interstisuim, this ends with pulmonary edema SO if the premature baby does not die from the muscle fatigue, he will die from pulmonary edema.

To decide if the lung is mature or not, we take a sample from the amniotic fluid that surrounds the baby (the process called aminocenthesis) looking for certain markers (called lung markers), the surfactant is one of them, if it’s exist so the lung is mature, but if not so the lung is immature.

Now if lung is immature, the doctor has to do some procedures:

Try to delay the delivery

Start giving the mother glucocorticoid (cortisone) which accelerates the production of surfactant in the baby; it reaches the baby through the placenta because it is a steroid….cholesterol is the father! Of steroids…cholesterol is 27 carbons.

ABOUT STEROIDS…

The cholesterol divided into 3 divisions:

1. Contain 21 carbons "C21">>glucocorticoid "cortisone with aldosterone".
2. Contain 19 carbons "C19">>testosterone.
3. Contain 18 carbons "C18">>estrogen.

\*\*BUT there is synthetic one "C22" (dexamethasone…we will use it a lot in our work in the future "IF the GOD want^^")

If there’s two alveolus beside each other one of them is smaller than the other then according to law of *la Place* when **r** becomes smaller, then (**P**)becomes larger so we expect more than (-4) intrapulmonary pressure, but this doesn’t occur, because the smaller alveoli has smaller surface tension because the surfactant there is more concentrated, if the surfactant isn’t concentrated, then the small alveoli will collapse and empty their content in the large one, this called **alveolar stability** which is the co-existence of small with large alveoli .

***Please don’t forget to prey for Syrian people "this great words from our colleague (Layth)"…..But THESE words from me>> Please don’t forget to prey to ALL Muslims…ALL Arabs..and ALL Humanness ☺***

