

# Lung Volumes & Capacities

*By*

**Dr.Nour A.Mohammed**

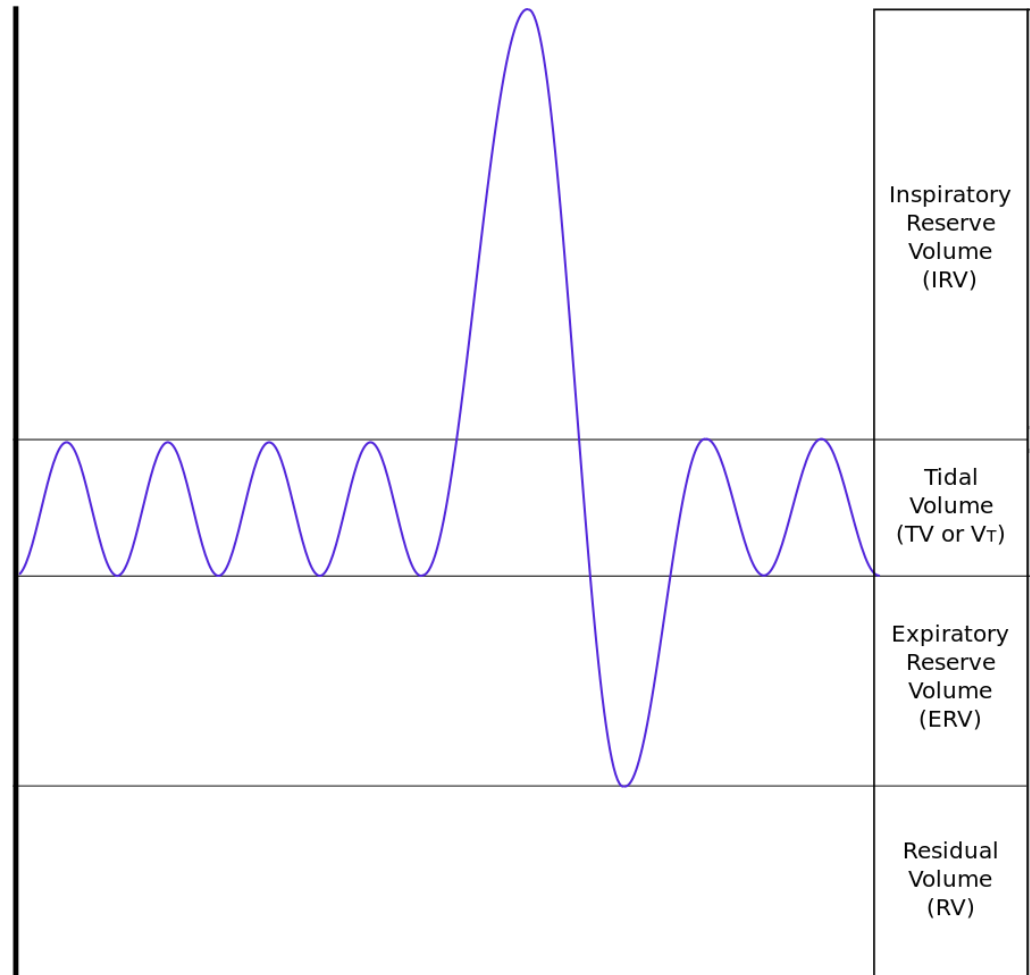
*Associate professor of physiology*

*Faculty of medicine, Muthah University*

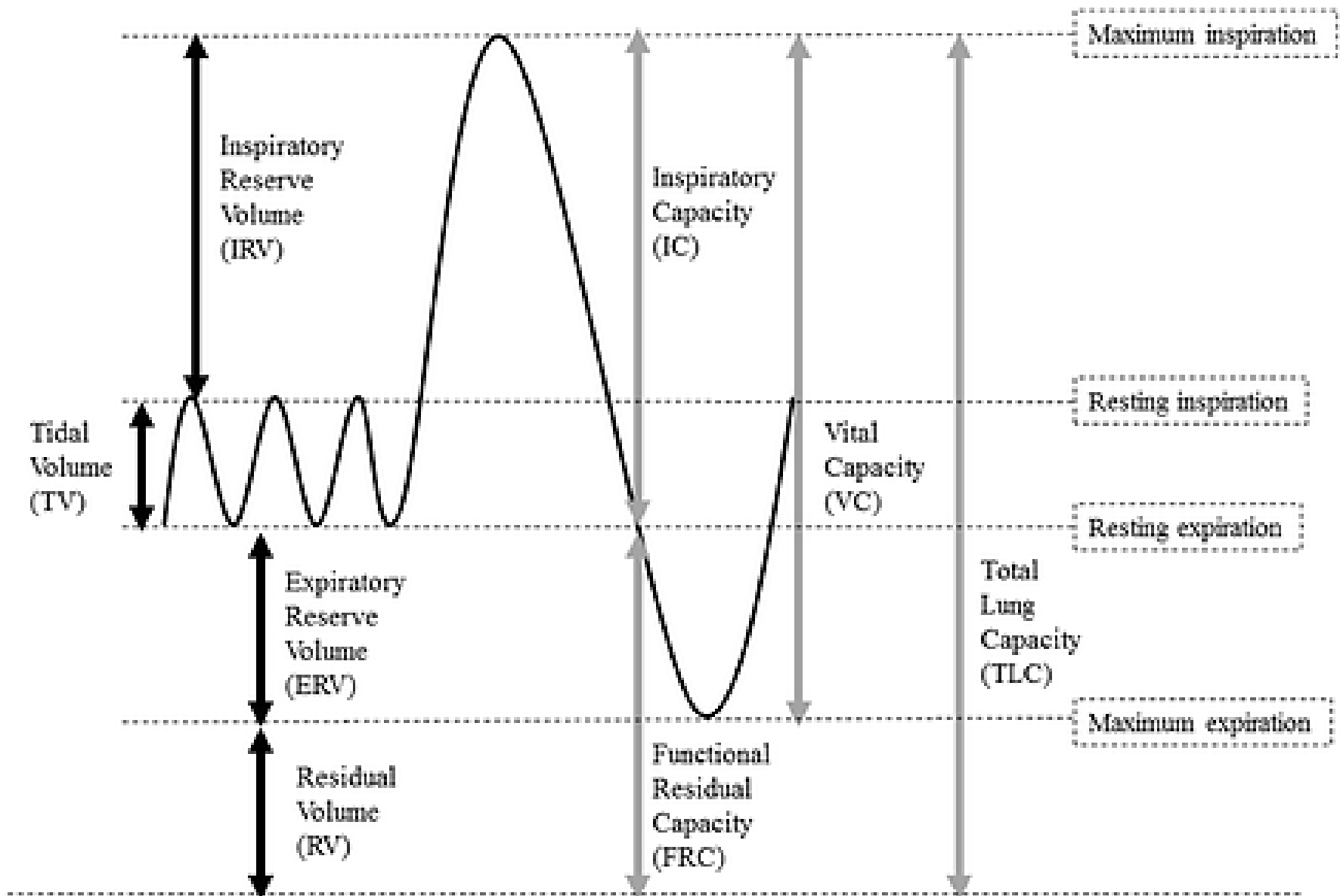
*2024-2025*

# Lung volumes

- **Tidal volume (TV) = 500 ml**  
Vol. of air inspired or expired with each normal breath of normal quiet breathing (**eupnea**)
- **Inspiratory reserve volume (IRV) = 3000 ml**  
Vol. of air which can be inspired by **maximum forced inspiration** ***AFTER*** normal inspiration.
- **Expiratory reserve volume (ERV) = 1100 ml**  
Vol. of air which can be expired by **maximum expiration** ***AFTER*** normal expiration.
- **Residual volume (RV) = 1200 ml**  
Vol. of air remaining in the lung after maximal expiration.  
**Can't be tested by spirometry.**



# Lung capacities



### 1- Inspiratory capacity (IC):

- It is the volume of air that can be inspired by maximal inspiratory effort *After* the end of normal resting expiration
- $IC = TV + IRV = 500 + 3000 = 3500 \text{ ml.}$

### 2- Expiratory capacity (EC):

- It is the volume of air that can be expired by maximal expiratory effort *After* the end of normal resting inspiration
- $EC = TV + ERV = 500 + 1100 = 1600 \text{ ml.}$

### 3- Functional residual capacity (FRC):

- It is volume of air remaining in lungs after normal expiration.
- $FRC = ERV + RV = 1100 + 1200 = 2300 \text{ ml.}$

Can't be tested by spirometry.

### 4- Vital capacity (VC):

- Volume of air expired maximally after maximal inspiration.
- $VC = IRV + TV + ERV = 3000 + 500 + 1100 = 4600 \text{ ml.}$

### 5- Total lung capacity (TLC):

- Volume of air present in the lung at end of maximal inspiration.
- $TLC = VC + RV = 4600 + 1200 = 5800 \text{ ml}$

Can't be tested by spirometry.

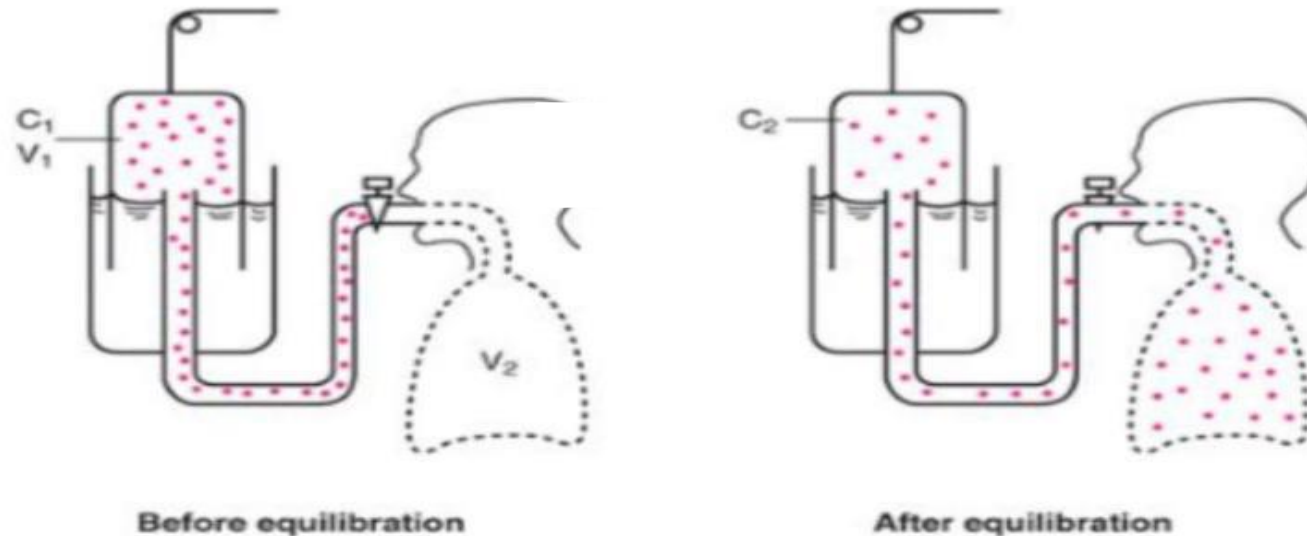
# Static pulmonary function tests

## 1. Residual volume:

Measured by **Helium dilution method**, using the dilution principle

$$C_1 \times V_1 = C_2 \times V_2$$

**Helium** is used as an inert gas & not diffuse to blood from alveolar air



# Importance of Residual volume

- 1) Provides air in alveoli to oxygenate the blood between breaths
- 2) Prevents lung collapse & Keeps the lung distended
- 3) Prevents marked changes in PO<sub>2</sub> & PCO<sub>2</sub> in the blood with each respiration
- 4) Prevents marked changes in inspired air temperature & humidity
- 5) RV / TLC Less than 30% (increase in **bronchial asthma** & **emphysema** due to **insufficient expiration** )
- 6) **Medico legal importance**

It determines cause of death of baby after birth

If baby is born alive, he will respire, so contain RV → lung float in water while If baby is born dead, he will not respire, so no RV → lung sink in water



**Minimal air:** Few air remain in lung even after lung collapse  
**(150 ml)**

## 2. Total lung capacity (TLC)

- **Definition:** the volume of air present in the lung at the end of maximal inspiration

- **Measurement:**

$$\text{TLC} = \text{IRV} + \text{TV} + \text{ERV} + \text{RV}$$

$$\text{TLC} = \text{VC} + \text{RV}$$

**Normal value:** 5800 ml

- **Significance:**

Decreases in pneumothorax



### 3. Vital capacity (VC)

**Definition:** It is the amount of air expired maximally after maximal inspiration

**Measurement:** by spirometer

**Value:**  $VC = IRV + TV + ERV = 4600 \text{ ml}$

**Significance:**

It indicates the strength of respiratory muscles and lung elasticity

# Factors affecting Vital Capacity

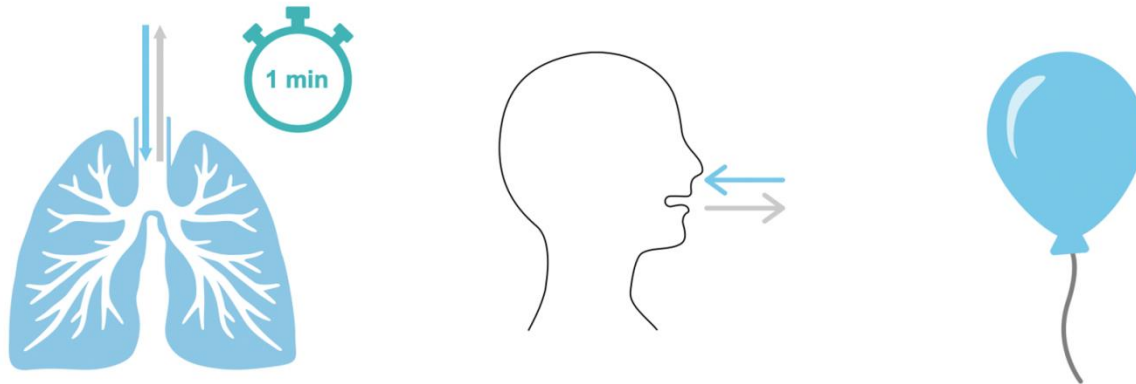
	Increase	Decrease
<b>Physiological</b>	Athletes	Females, old age, pregnancy and recumbent position due to return of more blood to the lung.
<b>Pathological</b>		<p><b>a- Chest wall diseases:</b></p> <ul style="list-style-type: none"> <li>- Paralysis of respiratory muscles &amp; myasthenia gravis</li> <li>- Fracture ribs or kyphosis (limit expansion of thorax)</li> </ul> <p><b>b- Lung diseases:</b></p> <ul style="list-style-type: none"> <li>- Decreased compliance (stretchability) as (<b>fibrosis, hydrothorax, pneumothorax</b>)</li> <li>- Decreased elasticity as (<b>emphysema</b>)</li> <li>- Obstructive conditions like <b>bronchial asthma</b> as resistance to air flow <u>mainly during expiration</u></li> </ul> <p><b>c- Increased blood volume in the lung:</b> as in pulmonary congestion by left side heart failure.</p> <p><b>d- Presence of intra-abdominal masses:</b> as tumour and ascites. So, prevent free descent of diaphragm.</p>

# *Dynamic pulmonary function tests*

## ❖ **Respiratory minute volume (RMV) (Minute ventilation):**

It is the volume of air respired/min.

At rest =  $TV \times \text{respiratory rate} = 0.5 \times 12 = 6 \text{ L/min.}$



Minute ventilation = respiratory rate (RR)  $\times$  tidal volume ( $V_T$ )

# Dead space (DS)

➤ **Def.:** Volume of air which does not undergo gas exchange in respiratory system

➤ **Types:**

**1. Anatomical DS:** thick respiratory passages (from nose to terminal bronchioles).

**2. Alveolar DS:** non functioning alveoli (normally absent)

**3. Physiological DS:** = anatomical + alveolar DS.  
Normally, DS = anatomical = **150 ml**

**N.B.:** Inspiration through a tube → **increases DS**

# Significance of dead space

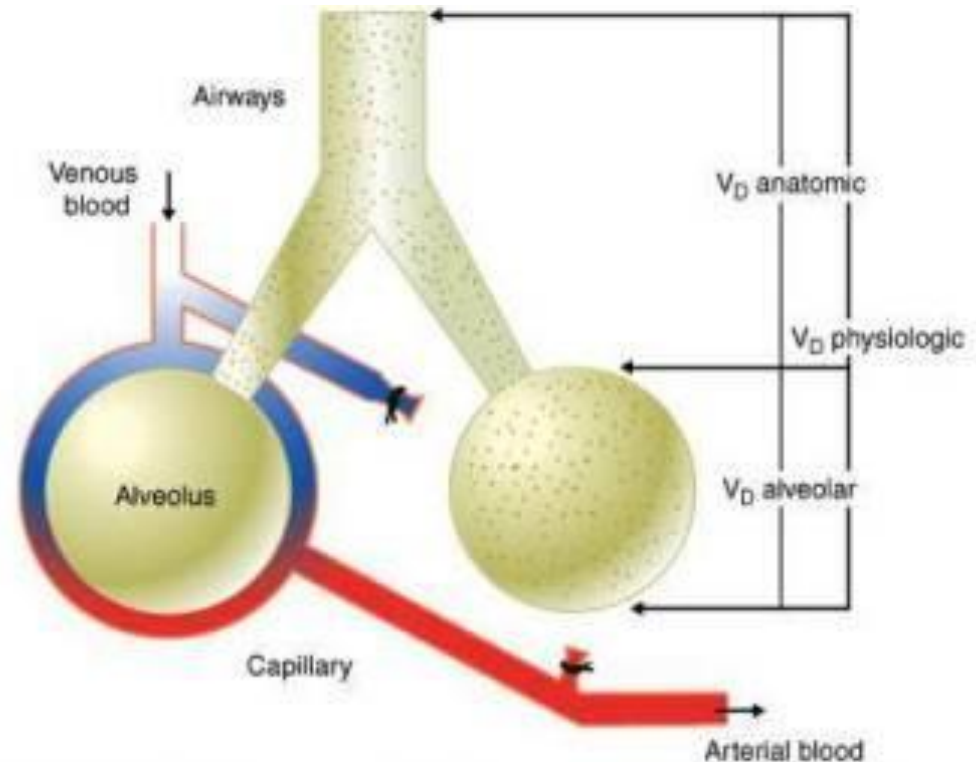
- 1) Protective functions
- 2) Prevents marked changes in **PO<sub>2</sub>** & **PCO<sub>2</sub>** in the blood with each respiration.
- 3) Prevents marked changes in inspired air temperature & humidity.
- 4) It is responsible for difference between Respiratory minute volume (**RMV**) & Effective ventilation volume (**EVV**)

## ❖ Effective ventilation volume (E<sub>V</sub>):

It is the volume of air that enters in gas exchange/ min.

At rest = (TV – DS) x respiratory rate = 0.35 x 12 = 4.2 L/min.

Dead space



❖ **Maximum breathing capacity (MBC) or maximum voluntary ventilation:**

Maximal volume of air that can be inspired or expired using the deepest and fastest respiratory movements.

Measured in 15 seconds then multiplied by 4.

**MBC**= 80 to 160 L/min in **males**, 60 to 120 L/min in **females**.

## ❖ Breathing reserve:

- The difference between the MBC and RMV
- $BR = 100 - 6 = 94 \text{ L.}$

## ❖ Dyspneic index (DI):

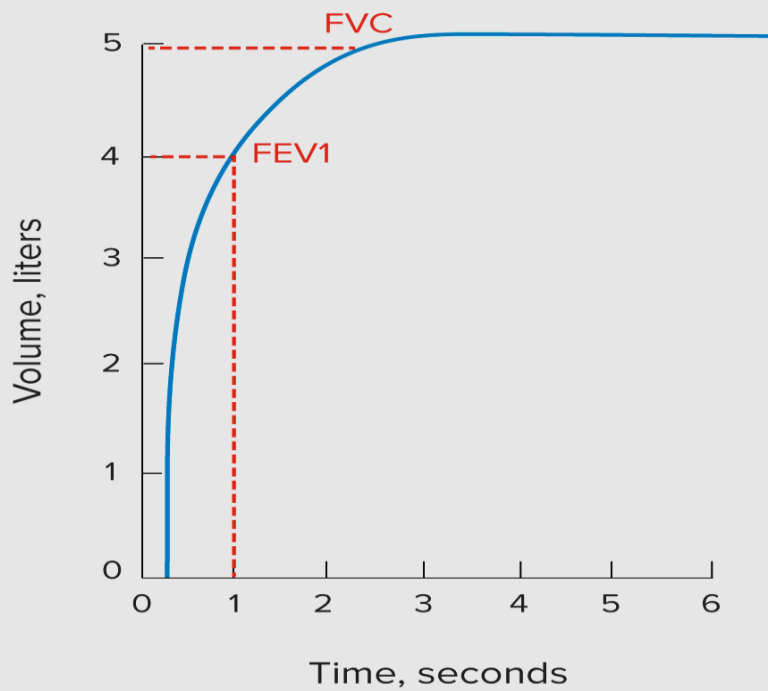
- The percentage between the **breathing reserve** and the **MBC**.
- Normally  $DI > 90\%$
- If  $DI < 70\%$  Dyspnea



## ❖ **Timed vital capacity:**

□ **FEV1**: The fraction of vital capacity expired maximally and rapidly in the first second. **FEV1 = 83% of VC**, and reaches **97% in three seconds** (good test for airway resistance so, it is helpful in **obstructive lung diseases** diagnosis & prognosis (e.g. asthma & emphysema))

# Healthy



## Obstructive lung disease

- E.g. Asthma & Emphysema
- VC decreased
- FEV1 decreased markedly
- FEV1/ VC is reduced
- TLC is almost normal
- RV is increased

## Restrictive lung diseases

- E.g. Lung fibrosis
  - VC is decreased
  - FEV1 is decreased
  - FEV1/ VC *may be normal*
- As both decreased equally*
- TLC reduced

**THANK YOU**

