UNIUNEA EUROPEANĂ GUVERNUL ROMÂNIEI Fondul Social European POSDRU 2007-2013 Instrumente Structurale 2007-2013 GUVERNUL ROMÂNIEI MINISTERUL MUNCII, FAMILIEI, PROTECȚIEI SOCIALE ȘI PERSOANELOR VÂRSTNICE OIRPOSDRU REGIUNEA CENTRU UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE "CAROL DAVILA" BUCUREȘTI

AD-COR Program inovativ de formare in domeniul cardiologiei pediatrice POSDRU/179/3.2/S/152012

Data: 22-10-2015

MODUL TEORETIC

PAEDIATRIC CARDIAC CRITICAL CARE NURSING

Imputernicit: Prof. Dr. Tammam Youssef

Activitate prestata de I.R.C.C.S. POLICLINICO SAN DONATO – MILANO, ITALIA in baza contractului nr. 18/22144/29.07.2015

UNIUNEA EUROPEANĂ

GUVERNUL ROMÂNIEI

Fondul Social European
POSDRU 2007-2013

Instrumente Structurale
2007-2013

GUVERNUL ROMÂNIEI
MINISTERUL MUNCII, FAMILIEI,
PROTECȚIEI SOCIALE
ȘI PERSOANELOR VÂRSTNICE
OIRPOSDRU REGIUNEA CENTRU

UNIVERSITATEA DE MEDICINĂ ȘI
FARMACIE "CAROL DAVILA"
BUCUREȘTI

Acest material a fost documentat/ validat/ prezentat la sesiunile de formare în cadrul proiectului *„AD-COR Program inovativ de formare în domeniul cardiologiei pediatrice”* - POSDRU/179/3.2/S/152012, proiect cofinanțat din Fondul Social Operațional Sectorial Dezvoltarea Resurselor Umane 2007-2013.

Beneficiar: Universitatea de Medicină și Farmacie „Carol Davila” București

UNIUNEA EUROPEANĂ

GUVERNUL ROMÂNIEI

Fondul Social European
POSDRU 2007-2013

Instrumente Structurale
2007-2013

GUVERNUL ROMÂNIEI
MINISTERUL MUNCII, FAMILIEI, PROTECŢIEI SOCIALE ŞI PERSOANELOR VÂRSTNICE
OIRPOSDRU REGIUNEA CENTRU

UNIVERSITATEA DE MEDICINĂ ŞI FARMACIE "CAROL DAVILA" BUCUREŞTI

AD-COR Program inovativ de formare in domeniul cardiologiei pediatrice
POSDRU/179/3.2/S/152012

PAEDIATRIC CARDIAC CRITICAL CARE NURSING

Bucharest, October 22, 2015

Matthias Angrés, MD, PhD
RobinAid Foundation
Hamburg / Germany

Declaration of Disclosure

I have no actual or potential conflict of interest in relation to this presentation.

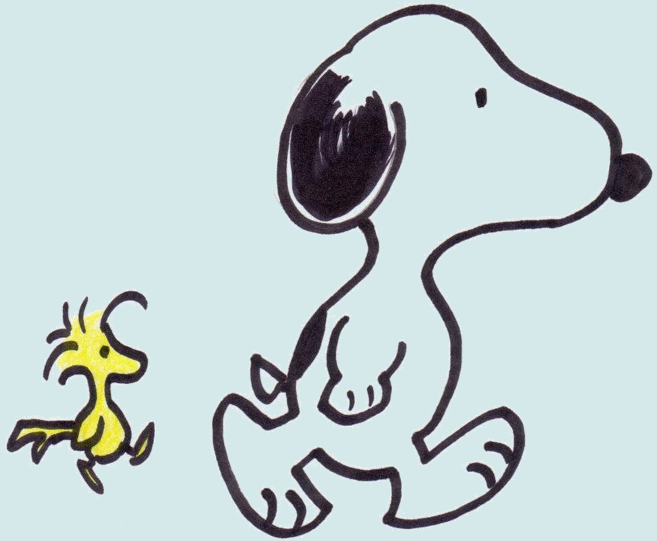
Today‘s agenda

- Short flashback
- Two lectures
- 15 minutes break between both lectures

Let‘s continue our walk

Important topics in
Paediatric Cardiac Critical Care

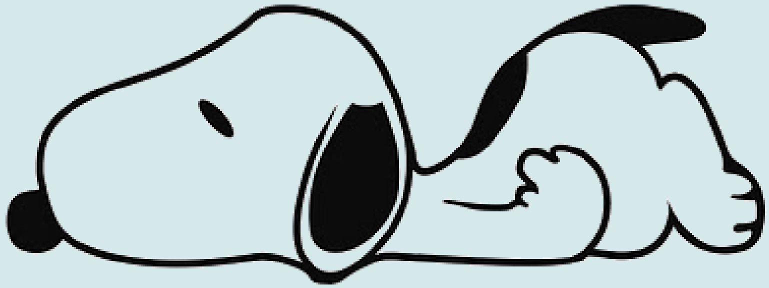
14 important topics



1. *The importance of cardiac output and cardiovascular medications* √
2. Human factors in paediatric cardiac critical care
3. Receiving patient from OT: assessment, preparation and handing-over process
4. Invasive and non-invasive methods of monitoring in the PCICU
5. Principles of mechanical ventilation and blood gas interpretation
6. *Importance of pain management in paediatric cardiac critical care* √
7. Fluid management and treatment of metabolic disorders

14 important topics

8. Fast-track extubation in pediatric cardiac surgery
9. Resuscitation: management of cardiac arrest
10. Medistinal bleeding and cardiac tamponade blood transfusion, coagulation disorders, and postoperative anticoagulation
11. Infections in the cardiac intensive care unit
12. Cardiac arrhythmias and care of patients with temporary pacemaker
13. Renal failure: prevention, identification, management, and replacement therapy
14. Neurological complications, gastrointestinal complications, and nutrition

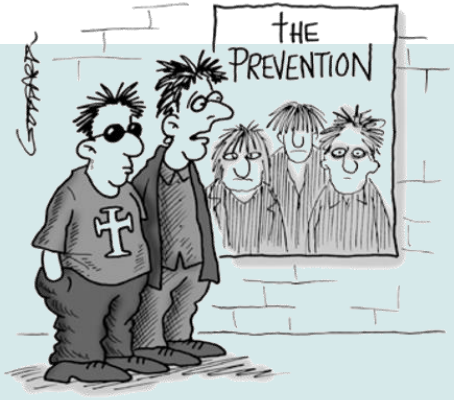


As you may remember

The highly complex paediatric patients with congenital or acquired heart disease require **interprofessional teamwork** and collaboration **to ensure high quality** outcomes **with low mortality and morbidity.**

As you may remember

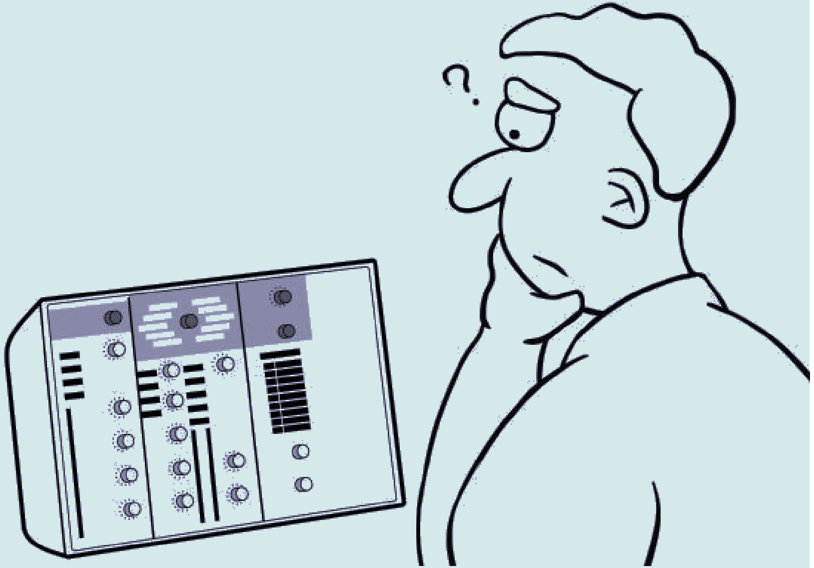
Anticipation and prevention are the most important **keys for recognition, diagnosis, and successfull management** of all potential risks and complications in the postoperative critical care of paediatric cardiac patients.



"Apparently they're better than The Cure"

Let‘s continue with the next topic

Principles of mechanical ventilation and blood gas interpretation



Small remark at the beginning

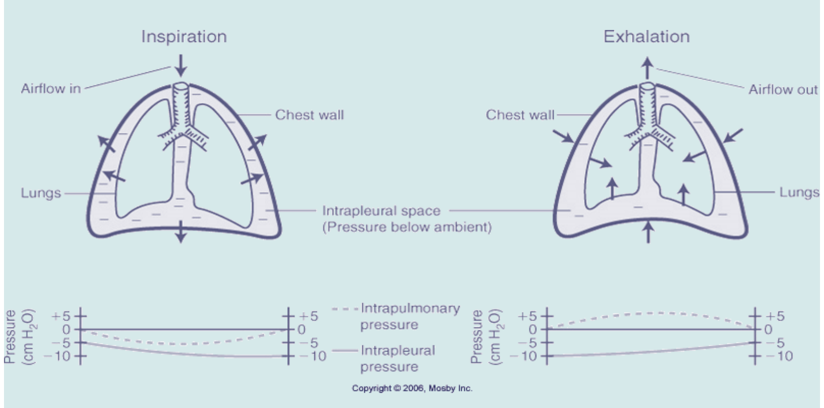
Lots of monitors and knobs to turn.

Small remark at the beginning

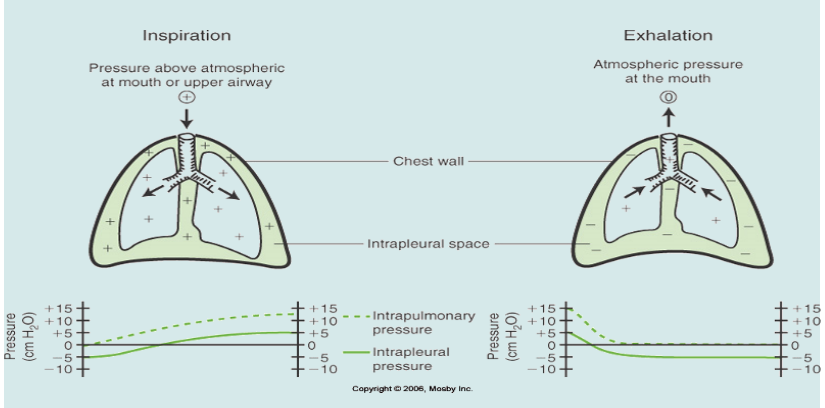
Some are more complicated than others.

Basics of respiratory mechanics

- **Natural breathing:**
  - negative inspiratory force
  - air pulled into lungs

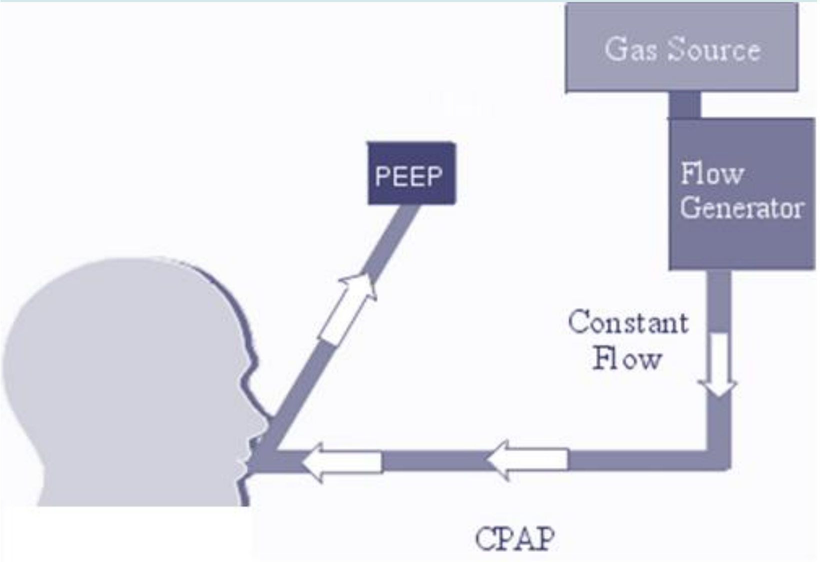


- **Mechanical ventilation:**
  - positive inspiratory pressure
  - air pushed into lungs



Mechanical ventilation

- **Oxygenation:**
  - determined by inspired oxygen and sufficient mean airway pressure
  - FIO_2
  - PIP, PEEP, I-time, flow
- **Carbon dioxide removal:**
  - determined by (minute ventilation - dead space ventilation) = alveolar ventilation
  - rate, tidal volume



Important terms

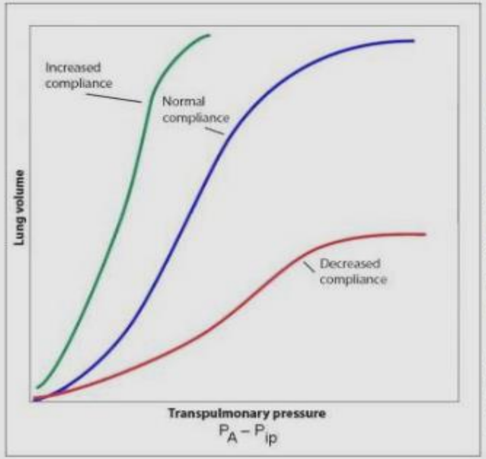
- **Tidal Volume** (TV): volume of each breath
- **Rate**: breaths per minute
- **Minute Ventilation** (MV): total ventilation per minute; MV = TV x Rate
- **Flow**: volume of gas per time

- **Compliance**: the distensibility of a system
- **Resistance**: impediment to gas flow
- **Pressure:** measure of impedance to gas flow rate

Important terms

- **Lung Compliance**

$$C = \frac{V}{P}$$



1. Varies with lung size. Compliance decreases at high lung volumes.

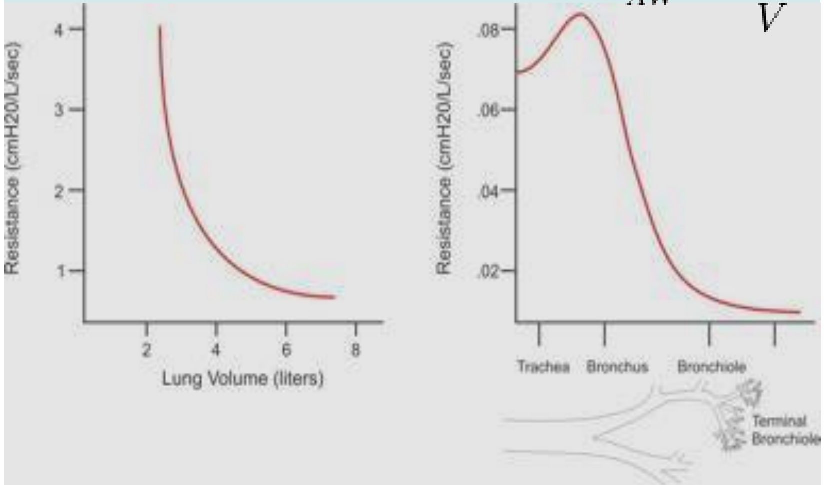
2. When compliance is abnormally low, the lung is stiff, inhalation is difficult but exhalation is easy.

3. Increased compliance filling is easy, exhalation is difficult.

- The higher the compliance, the easier it is to inflate the lungs

- **Airway Resistance**

$$R_{AW} = \frac{\Delta P}{\dot{V}}$$



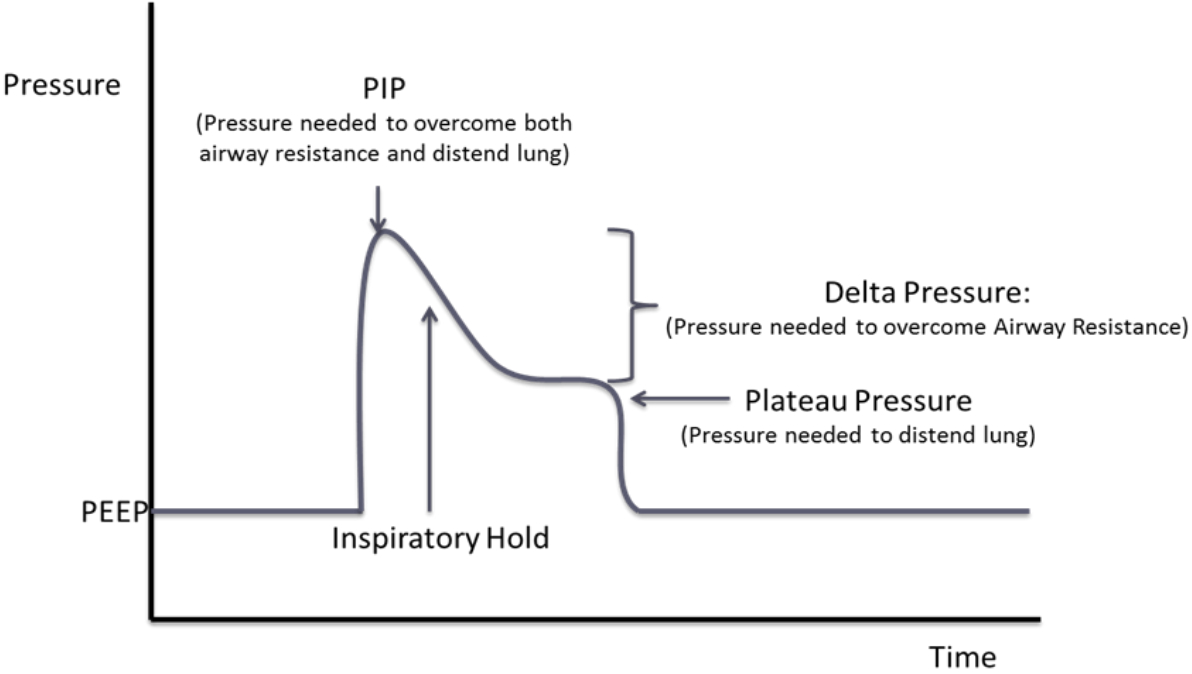
- The higher the resistance, the more difficult is to inflate / deflate the lungs

Important terms

- PEEP: **P**ositive **E**nd **E**xpiratory **P**ressure
  - pressure maintained in the airways at the end of exhalation
  - keeps alveoli from collapsing
- PIP: **P**eak **I**nspiratory **P**ressure
  - point of maximal airway pressure
- Delta P: difference between PIP – PEEP
- MAP: **M**ean **A**irway **P**ressure

- Time:
  - **i** - Time: amount of time spent in **I**nspiration
  - **e** - Time: amount of time spent in **E**xpiration

Important terms



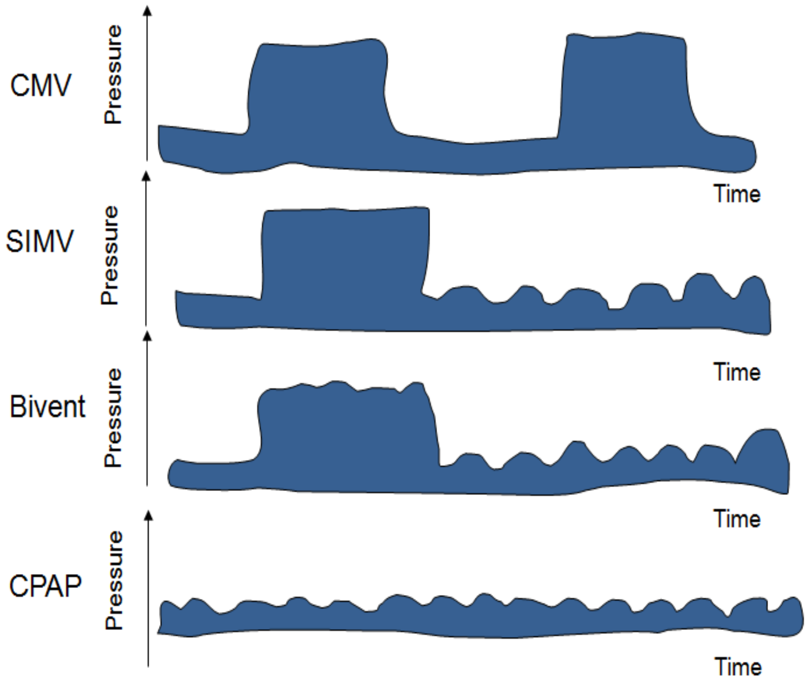
Important terms

- SIPPV**: S**ynchronous **I**ntermittent **P**ositive **P**ressure **V**entilation
- CMV**: C**ontrolled **M**echanical **V**entilation
- SIMV**: S**ynchronized **I**ntermittent **M**andatory **V**entilation

- PSV**: P**ressure **S**upport **V**entilation or **A**ssisted **S**pontaneous **B**reathing **(ASB)**
- BIVENT: **B**iphasic **P**ositive **A**irway **P**ressure
- AC: **A**ssist **C**ontrol
- CPAP: **C**ontinuous **P**ositive **A**irway **P**ressure

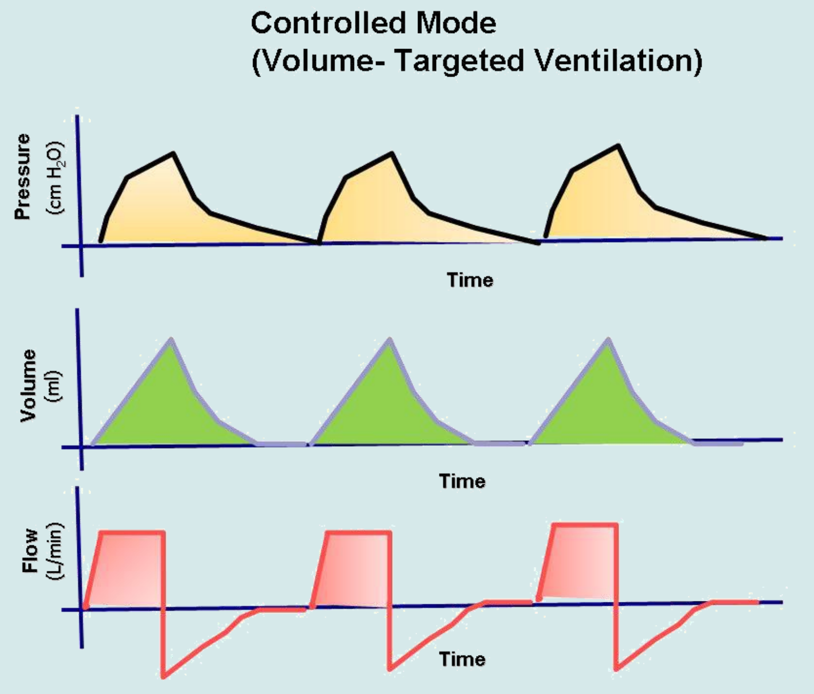
Modes of ventilation

- **Controlled:**
  - Volume Control
  - Pressure Control
- **Fully or partially assisted**:
  - SIPPV
  - SIMV
  - A/C
  - PSV
  - SIMV + PSV
- **Spontaneus:**
  - CPAP



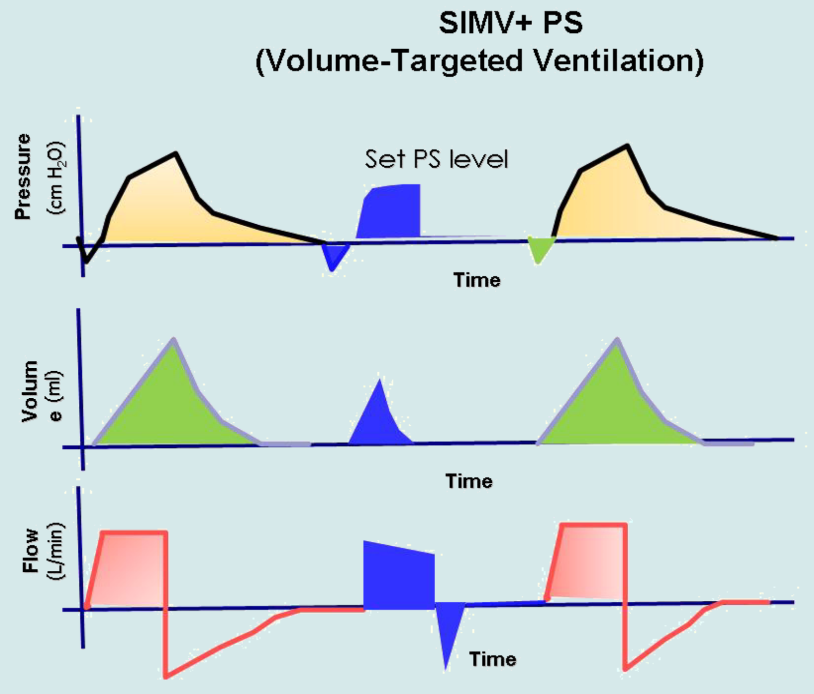
Volume Control

- The patient is given a specific volume of air during inspiration
- The ventilator uses a **set flow** for a **set period of time** to deliver the volume:
  – **TV (cc) = Flow (cc/sec) x i-time (sec)**
- The **PIP** observed is a product of the **lung compliance, airway resistance** and **flow rate.**



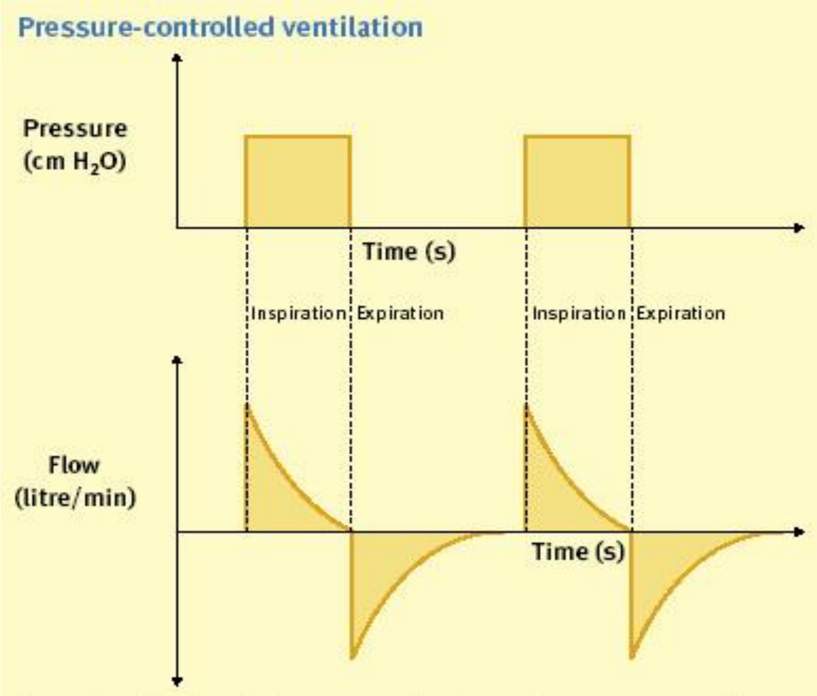
Volume Control

- The ventilator does not react to the PIP unless the **alarm limits** are violated.
- The PIP tends to be higher than during pressure control ventilation to deliver the same volume of air.
- With **SIMV**, the patient **can breath spontaneously** between vent breaths; this mode is often combined **with PS** (ASB)



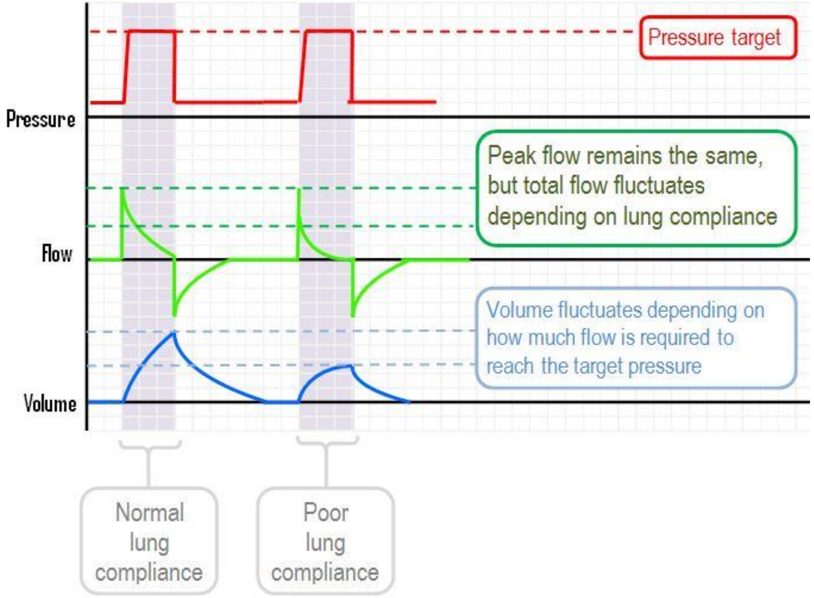
Pressure Control

- Patient receives a breath at **a fixed airway pressure**
- The **ventilator** adjusts the flow to **maintain the pressure**
- **Flow decreases** throughout the inspiratory cycle.
- The **pressure is constant** throughout inspiration.



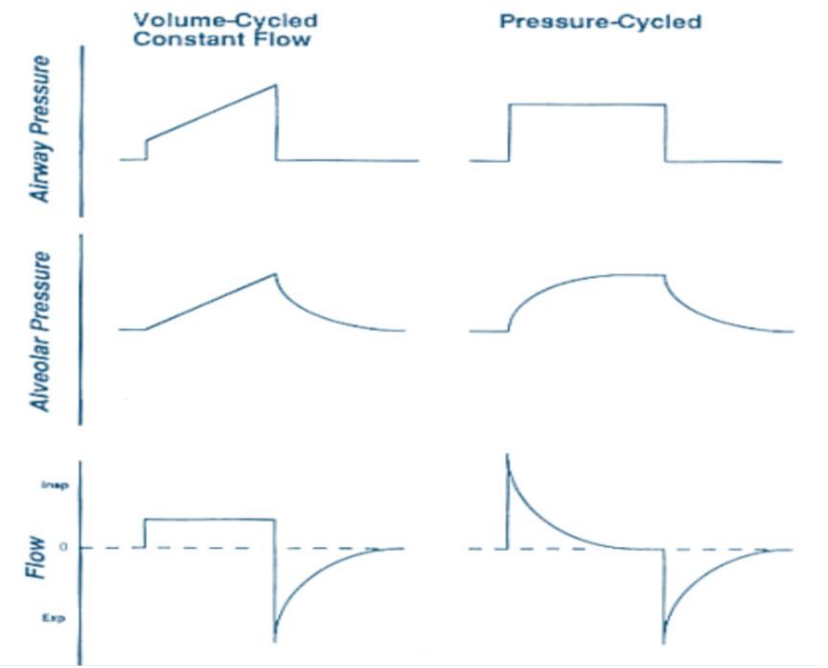
Pressure Control

- Volume delivered depends upon the **inspiratory pressure**, **I-time**, lung **compliance** and airway **resistance**
- The **delivered volume can vary from breath-to-breath** depending upon the above factors.
- **MV not assured**



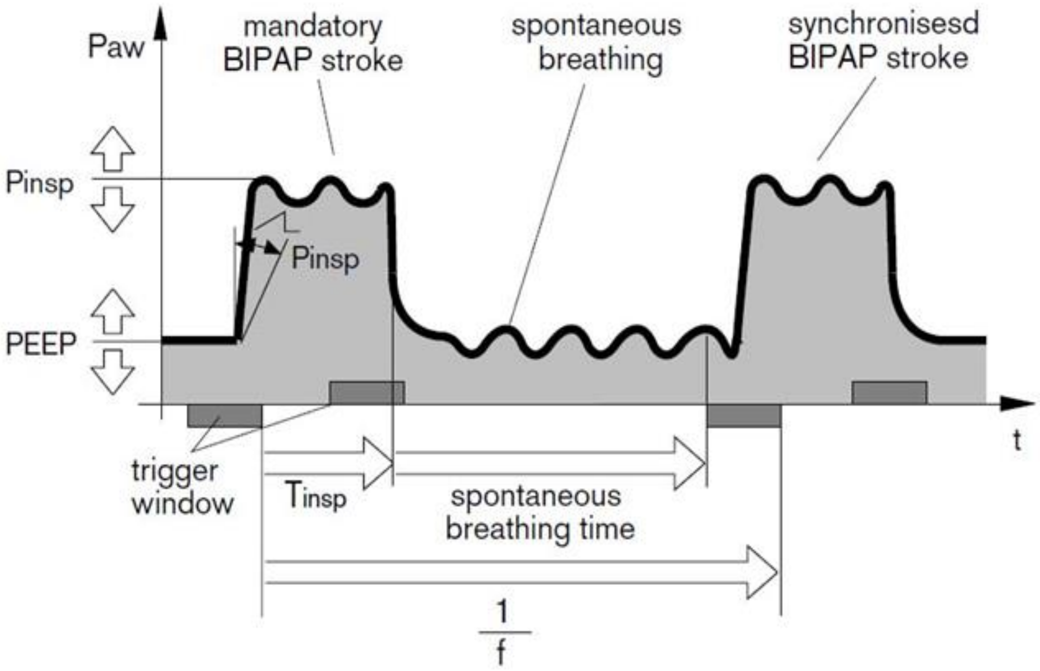
Volume versus Pressure Control

- **Volume control (SIMV):**
  - constant flow during inspiration
  - PIP dependent variable
  - fixed minute ventilation
- **Pressure control (A/C):**
  - constant pressure inspiration
  - tidal volume dependent variable
  - decelerating flow pattern
  - lung compliance and airway resistance determine gas delivery
  - **less risk of barotrauma**



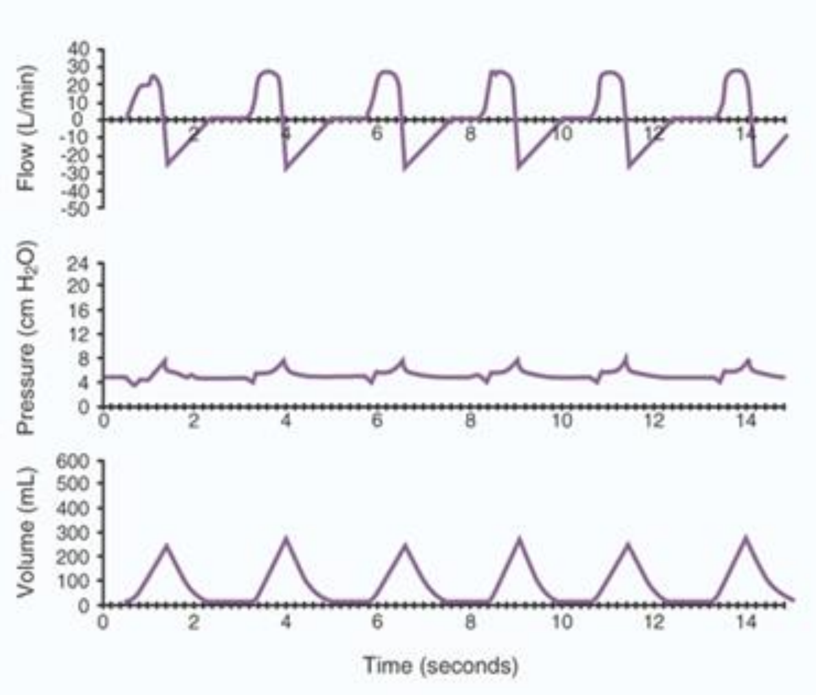
BIVENT / BIPAP

- Biphasic Positive Airway Pressure **(BIPAP)** can be described as pressure controlled ventilation in a system allowing unrestricted spontaneous **breathing at any moment of the ventilatory cycle**



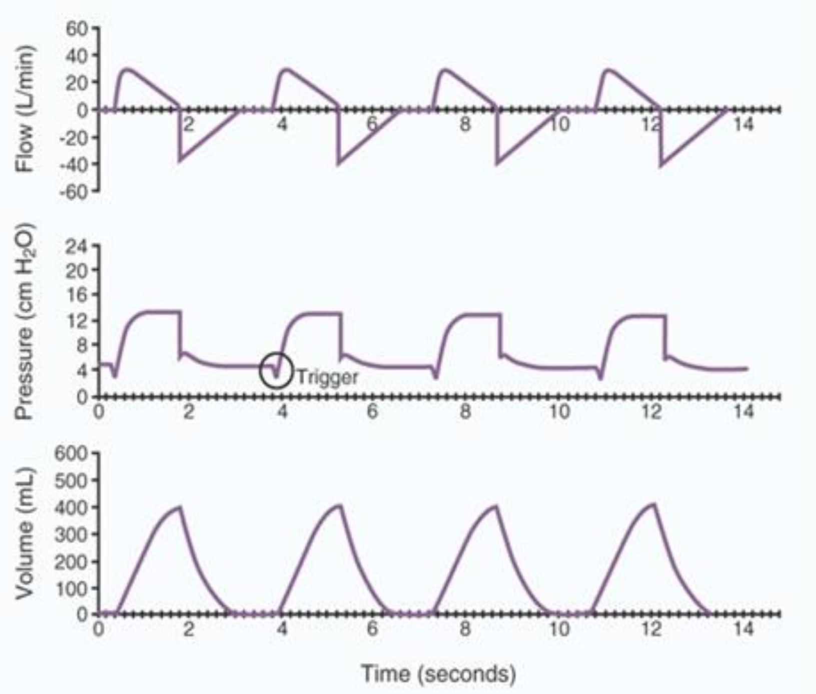
CPAP

- No mandatory breaths
- Patient sets the rate, I-time, and respiratory effort
- CPAP performs the same function as PEEP, except that it is constant throughout the inspiratory and expiratory cycle



Pressure Support

- Pressure Support (PS) helps to overcome airway resistance and inadequate pulmonary effort and is added on top of the CPAP during inspiration
- The ventilator increases the flow during inspiration to reach the target pressure and make it easier for the patient to take a breath



Initial ventilator settings

- **Neonate < 5.0 kg:**
  - iT 0.4 - 0.7 sec
  - I : E ratio 1:1.5 – 2.0
  - PEEP 5 cm H_20
  - PS + 6 - 8 cm H_20
  - TV 8 - 10 ml/kg
  - rate 25 - 40/min
  - PIP max 20 cm H_20

Initial ventilator settings

- **Infant / Child:**
  - IT 0.7 - 1.0 sec
  - I : E ratio 1:2 – 3.0
  - PEEP 5 cm H_20
  - PS + 5 cm H_20
  - TV 10 ml/kg
  - Rate 15 – 40 / 10 - 20
  - PIP max 30 cm H_20

Adjusting the ventilator

- pCO_2 too high
- pCO_2 too low
- pO_2 too high
- pO_2 too low
- PIP too high

pCO_2 too high

- Patient's **minute ventilation** is too **low**
  - **increase rate** or **TV** or both
  - if using **PC ventilation**, **increase PIP**

- If **PIP too high**, increase the rate instead
- If **air-trapping** is occurring, decrease the rate and the I-time and increase the TV to allow complete exhalation

pCO_2 too low

- Patient’s **minute ventilation** is too **high**
  – **lower either** the **rate** or **TV**

- If using **PC ventilation**, **decrease PIP**
- TV needs to be 8ml/kg or higher to prevent progressive atelectasis
- If patient is spontaneously breathing, consider lowering the pressure support if spontaneous TV > 8 ml/kg

pO_2 too high

- **Decrease** the **FiO_2**
- When FiO_2 is less than 40 **%, decrease** the **PEEP** to 3-5 cm H_2O

- While patient is on ventilator, don't wean FiO_2 to < 25 % to give the patient a margin of safety in case the ventilator quits

pO_2 too low

- **Increase** either the **FiO_2** or the mean airway pressure (MAP)
- Try to avoid $FiO_2 > 70$ %

- Increasing the **PEEP** is the most efficient way of increasing the MAP in the PICU
- Can also increase the **I-time** to increase the MAP (PC)
- Can increase the **PIP** in Pressure Control to increase the MAP

PIP too high

- **Decrease** the **PIP (PC)** or the **TV (VC)**
- Increase the **I-time (VC)**
- **Change** to another **mode of ventilation**

- Generally, pressure control achieves the same TV at a lower PIP than volume control
- If the high PIP is due to high airway resistance, generally the lung is protected from barotrauma unless air-trapping occurs

Weaning priorities

- Wean **PIP to < 35** cm H_2O
- Wean **FiO_2 to < 60** %
- Wean **I-time to < 50** %
- Wean **PEEP to < 8** cm H_2O

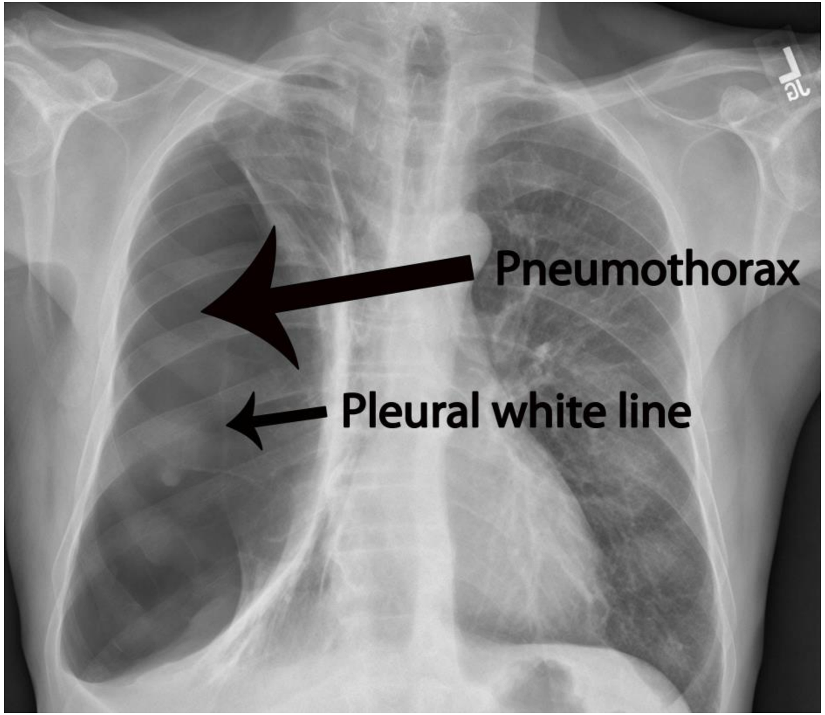
Acute deterioration

- **Differential diagnoses:**

- Pneumothorax
- Right mainstem intubation
- Pneumonia
- Pulmonary edema
- Loss of airway
- Airway occlusion
- Ventilator malfunction
- Mucus plugging
- Air leak

Examination

- **Tracheal shift**
  - pneumothorax
- **Wheezing**
  - bronchospasm
  - mucus plugging
  - pulmonary edema
  - pulmonary thromboembolism



Examination

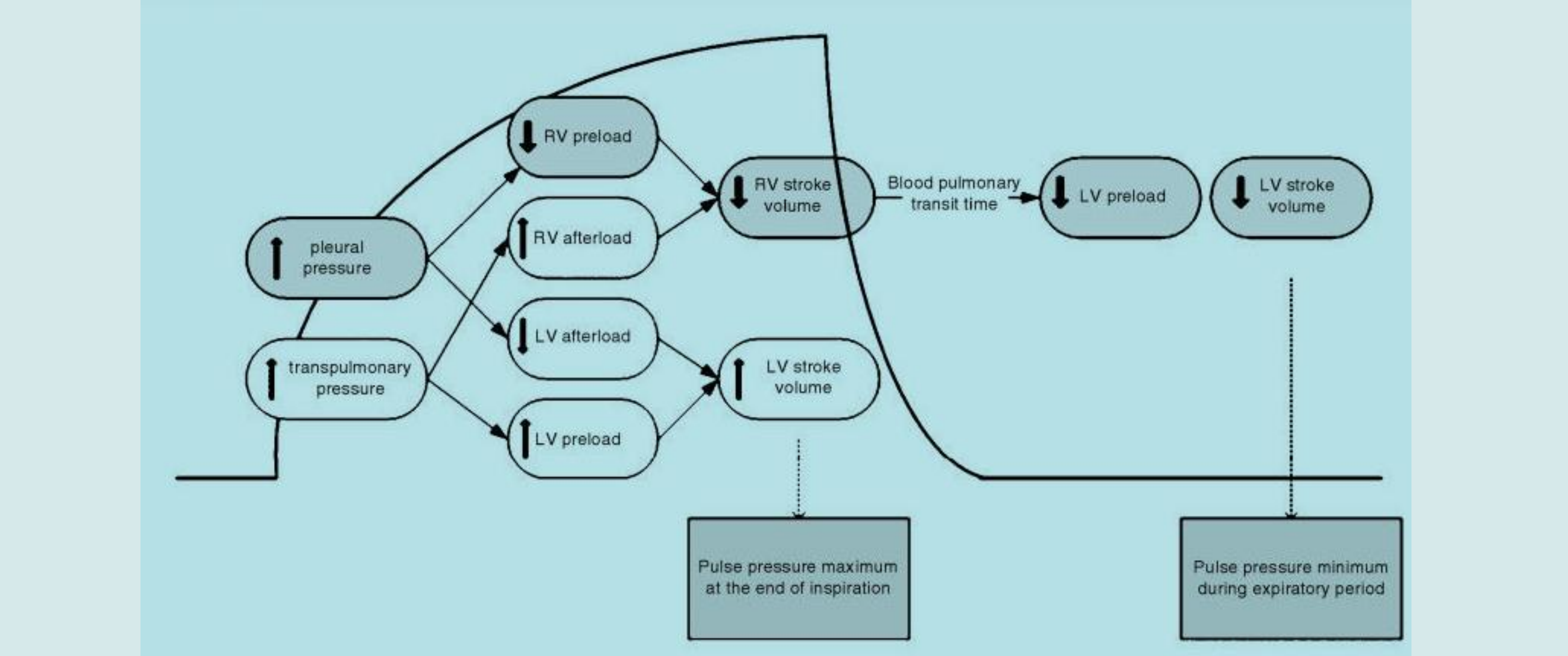
- **Asymmetric breath sounds**
  - pneumothorax
  - mainstem intubation
  - mucus plugging with atelectasis
- **Decreased breath sounds bilaterally**
  - tube occlusion
  - ventilator malfunction
  - loss of airway

Pressure patterns

- **Elevated peak and plateau pressures**
  - pneumonia
  - pulmonary edema
  - pneumothorax
  - atelectasis
  - right mainstem intubation

- **Elevated peak pressure, normal plateau pressure**
  - airflow obstruction
  - mucus plugging
  - partial tube occlusion
- **Reduced peak and plateau pressure**
  - cuff leak
  - ventilator malfunction
  - large bronchopleural fistula

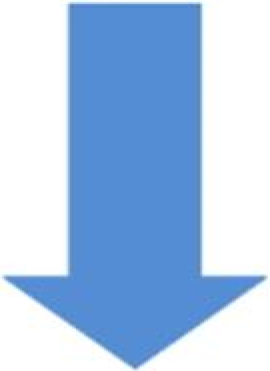
Cardiovascular effects



Mechanical ventilation and PVR

- **Increase Pulmonary vascular resistence:**
  - Acidosis
  - Hypoventilation
  - Hyperinflation
  - overdistension

- **Decrease PVR:**
  - Hyperventilate
  - Alkalosis
  - PEEP
  - FIO_2



Extubation criteria

- **Ideal settings for extubation:**

- Haemostasis
- Optimal cardiac output
- Stable haemodynamics
- Normothermia
- Stable lung function
- Optimal haematocrit
- Correction of electrolytes
- Correction of acidosis
- Appropriate status of reflexes

Extubation failure

- **Reasons why patients fail:**

- **Pulmonary processes:**
  - effusions, pneumonia, atelectasis
  - diaphragm or vocal cord paralysis
  - airway obstruction, RAD
- **Cardiac reasons:**
  - residual anatomic leasion
  - poor function/low output
- **Neurologic reasons:**
  - oversedation, weakness
  - CNS event--hypoxic ischemic encephalopathy, intracranial hemorrhage

Blood gas interpretation

- **Normal values:**

Item	Normal range*	Units
pH	7.35 - 7.4 - 7.45	
PCO_2	4.8 - 5.3 - 5.9	kPa
	36 - 40 - 44	mmHg
PO_2	11.9 - 13.2	kPa
	90 - 100	mmHg
HCO_3 (actual bicarbonate)	22 - 24 - 26	mmol/l
standard bicarbonate	22 - 24 - 26	mmol/l
base excess	-2, 0, +2	mmol/l

Blood gas interpretation

- **What do the different numbers mean:**

- **pH**
  - the total acidity or alkalinity of the sample
  - this indicates if the patient has an acidaemia or an alkalaemia
- **PCO_2**
  - the respiratory component

Blood gas interpretation

- **What do the different numbers mean:**

- **PO_2**
  - indicates the oxygenation status of the patient and must not be confused with the acid base status.
  - in general it is an indicator of the severity of lung disease, but cannot really be interpreted without knowing the FiO_2

Blood gas interpretation

- **What do the different numbers mean:**

- **HCO_3- (actual bicarbonate)**
  – the bicarbonate system is used to regulate the whole-body pH
  – HCO_3- is regulated by the kidneys
- **Standard Bicarbonate**
  – another measure of the renal (metabolic) component
  – more useful than the actual bicarbonate as it has been corrected for an abnormal PCO_2

- **What do the different numbers mean:**

- **Base excess**
  - the amount of strong acid (or base if there is a base deficit) needed to titrate 1litre of blood back to pH 7,4 at PCO_2 = 5,3kPa and Temperature = 37° C
  - another measure of the renal (metabolic) component
  - it gives the same information as the standard bicarbonate except that the normal value is 0 instead of 24

Acid base disturbances

- **Respiratory acidosis:**
  – $PaCO_2$ increased

- This occurs when there **is inadequate ventilation** and CO_2 production is greater than CO_2 elimination

Acid base disturbances

- **Respiratory alkalosis:**
  - $PaCO_2$ decreased

- This occurs with hyperventilation
- Mechanical ventilation with a large minute volume leads to respiratory alkalosis

Acid base disturbances

- **Metabolic acidosis:**
  – HCO_3- decreased (base deficit)

- Multiple aetiologies
  – lactic acidosis
  – renal failure
  – ketoacidosis
  – toxic ingestions

Acid base disturbances

- **Metabolic alkalosis:**
  - HCO_3- increased (base excess)

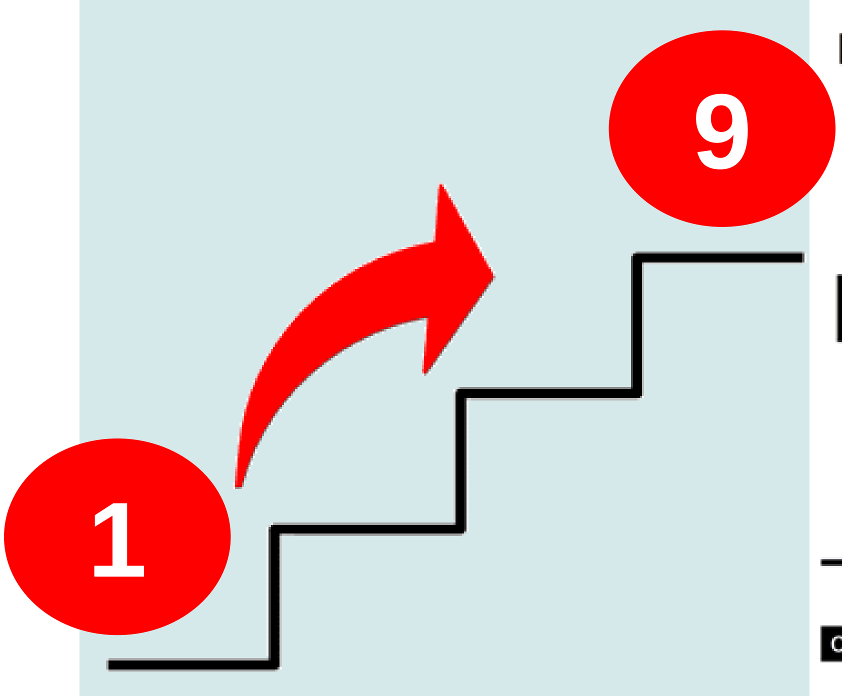
- Occurs with loss of gastric acid (e.g. pyloric stenosis) and diuretic therapy
- Metabolic alkalosis is commonly associated with low serum chloride

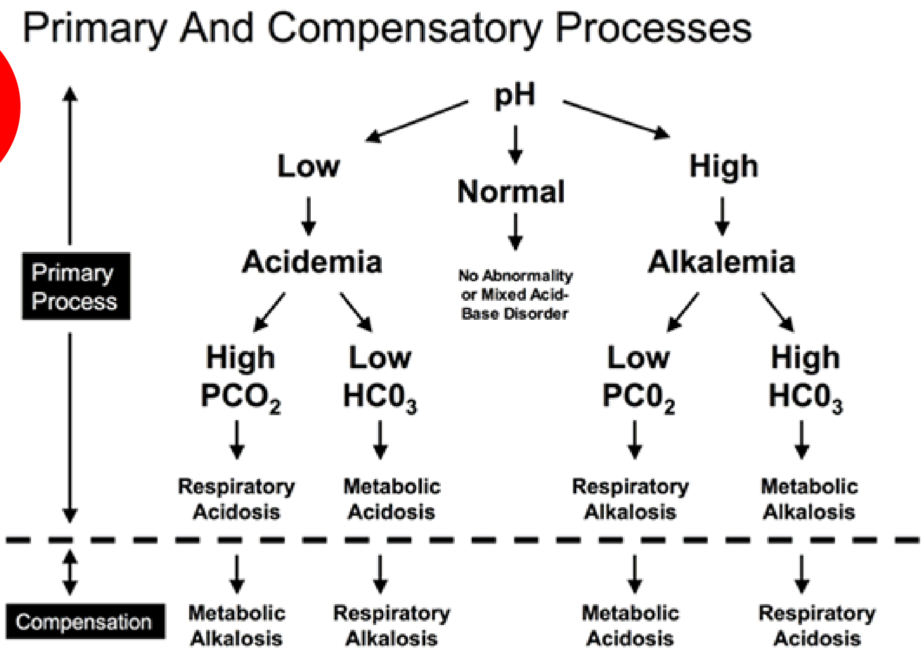
Acid base disturbances

- **Mixed metabolic and respiratory acidosis:**
  - $PaCO_2$ increased
  - HCO_3- decreased

- This is very dangerous
- Occur in severe diseases such as low cardiac output syndrom and septic shock
- It is always a sign of multiple organ dysfunction

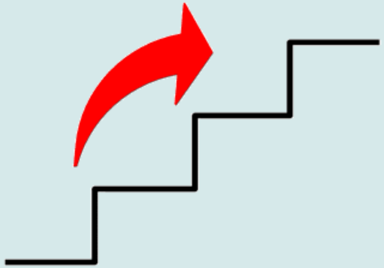
Stepwise interpretation

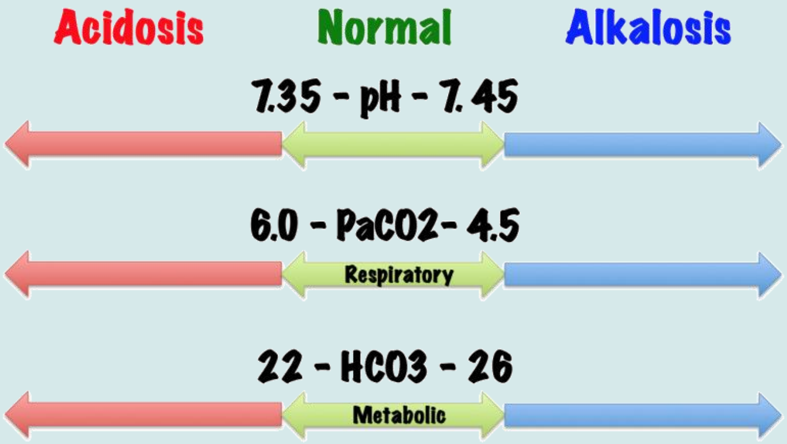




Stepwise interpretation

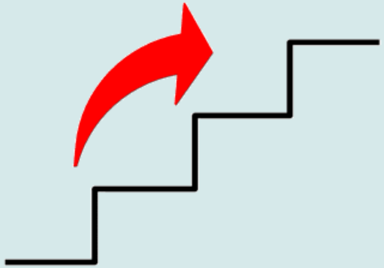
- Is the overall picture **normal, acidaemia,** or **alkalaemia**?





Stepwise interpretation

- If there is an **acidaemia**, is the primary defect **metabolic** or **respiratory** or **mixed**?

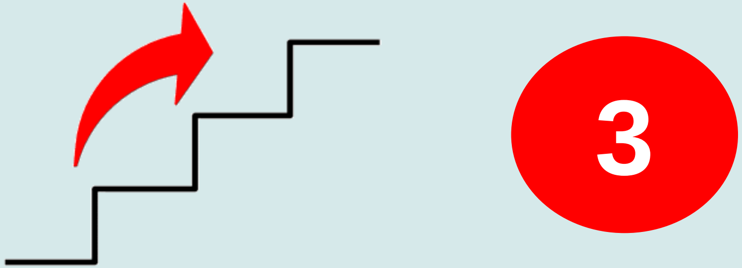


2

- CO_2 high = respiratory acidosis
- Bicarbonate low or BE negative = metabolic acidosis
- both of the above = mixed metabolic and respiratory acidosis

Stepwise interpretation

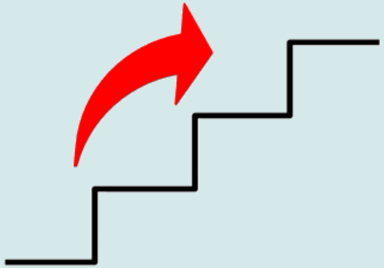
- If there is **respiratory acidosis**, is there **metabolic compensation**?



- The CO_2 is high (resp acidosis) but the metabolic component is going in the opposite direction (BE or SB high, towards metabolic alkalosis) then there is metabolic compensation

Stepwise interpretation

- If there is **metabolic acidosis**, is there **respiratory compensation**?

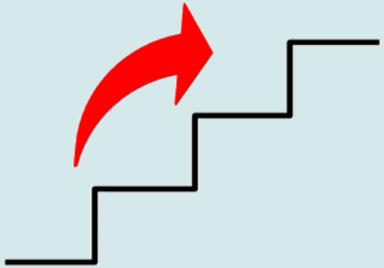


4

- BE is negative (metabolic acidosis) but the respiratory component is going in the opposite direction (CO_2 low, towards resp alkalosis), then there is respiratory compensation

Stepwise interpretation

- If there is an **alkalaemia**, is the primary defect **respiratory** or **metabolic**?

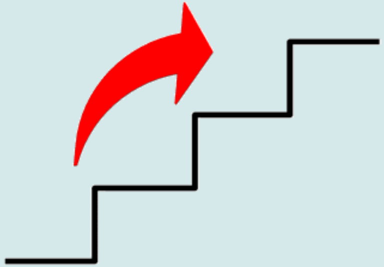


5

- Respiratory alkalosis will have low CO_2
- Metabolic alkalosis will have high SB and positive BE

Stepwise interpretation

- If **metabolic** or **respiratory alkalosis**, is there **any compensation** by the other one?

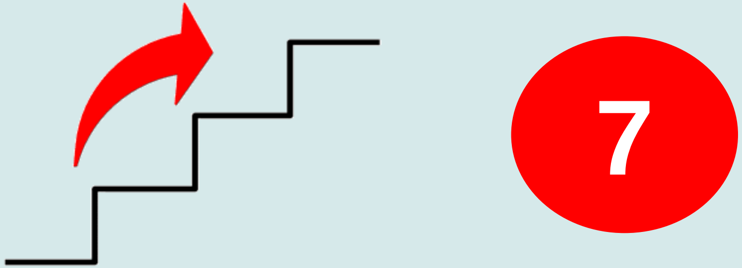


6

- Same principles as above under steps 3 + 4

Stepwise interpretation

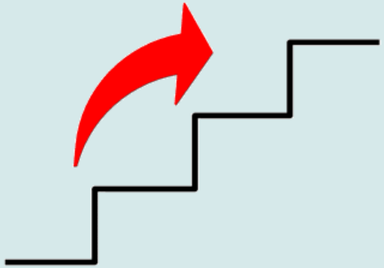
- Look at the **oxygenation!**



- Is the PO_2 consistent with the FiO_2?
- If it is lower than expected, it either indicates lung disease, right to left shunt, or venous sample

Stepwise interpretation

- **Summarise** the interpretation!

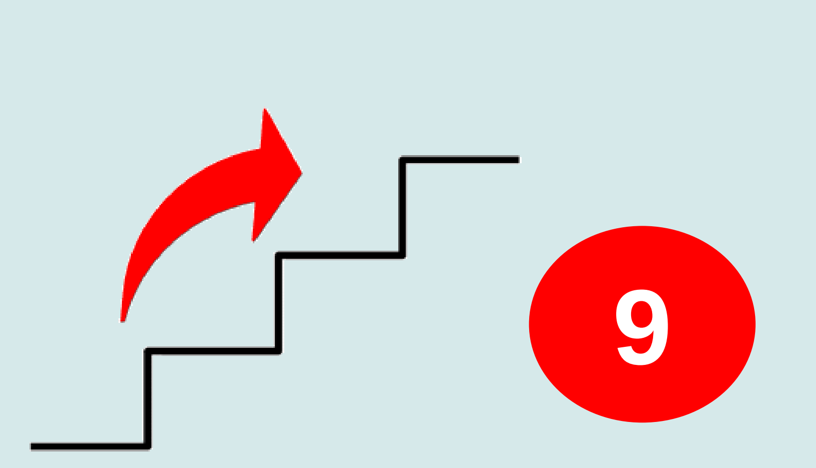


8

- eg: There is a metabolic acidosis (because the pH is low and BE is negative) with respiratory compensation (because the PCO_2 is low)

Stepwise interpretation

- Try to **establish the cause**!



Thank you for your attention

Let‘s take a break