Ministry of Higher Education and Scientific Research

College of Health and Medical Technology

Anaesthesia Techniques Department

Teaching package for anaesthesia techniques

Subject: Intensive Care Unit, 3rd stage.

2023-2024

INTENSIVE CARE UNIT

L 1

INTENSIVE CARE UNIT

An intensive care unit (ICU), also known as an intensive therapy unit or intensive treatment unit (ITU) or critical care unit (CCU), is a special department of a hospital or health care facility that provides intensive care medicine.

HOW INTENSIVE CARE UNITS WERE BORN?

- Harvey Cushing was the most brilliant brain surgeon of his generation. His patients adored him, describing him as caring and kind, but he kept his staff in a perpetual state of terror. He was intolerant of mistakes and could be cold, harsh and bullying. But he was forgiven, because his results spoke for themselves.
- Before Cushing, eight out of 10 brain surgery patients died. In his hospital, the surgeon reduced mortality to just 8%.
- In a time before antibiotics, and the ever-present risk of bacterial infection killing anyone going under the knife, Cushing operated under the strictest cleanliness. He wore gloves and a mask, doing whatever he could to sterilise the wound and reduce the chance of disease. Crucially, Cushing continued the care after he had finished his operations – the period when patients were at greatest risk of dying.

HOW INTENSIVE CARE UNITS WERE BORN?

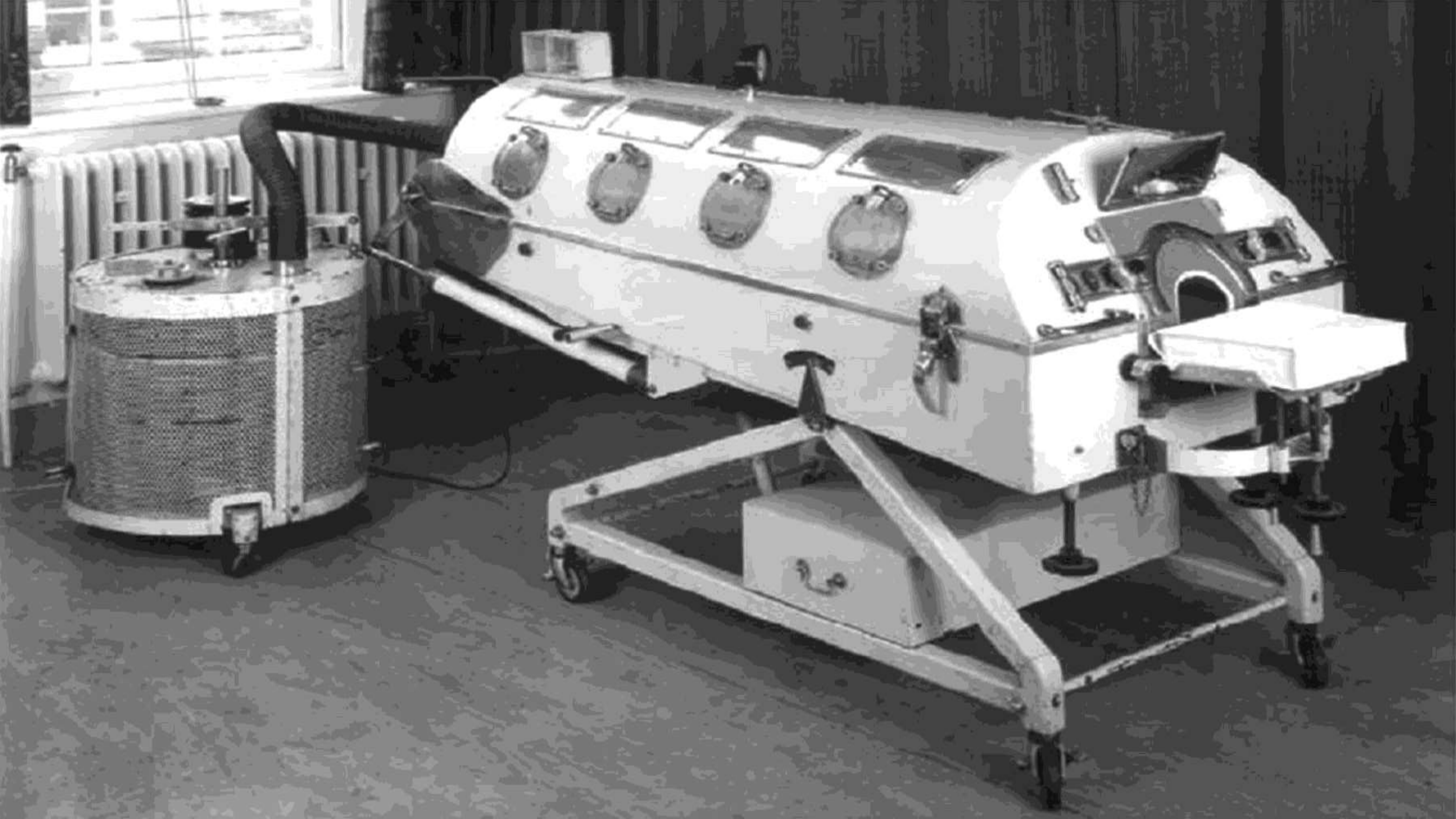
- Cushing carried over his meticulousness during surgery to the post-operative care of the patients
- He often tended to patients' wounds himself, ensuring they were kept free of infection. He introduced strict observation systems and record keeping – and the first widespread use of x-rays and blood pressure monitoring. Each individual patient was the focus of care by a team of specialist staff.

- "Cushing's whole ward was more like an intensive care unit than other surgeons," Spencer explains. "The nurses and junior surgical staff knew that if the bed sheets were not tucked in properly, the dressing wasn't clean or the patient was complaining, they were going to be in big trouble."

HOW INTENSIVE CARE UNITS WERE BORN?

- As operations became more complex through World War Two and into the 1950s – with, for example, the first open heart surgery – Cushing's pioneering post-operative care became widespread, saving countless lives
- In August 1952, the Blegdam Hospital in the Danish capital Copenhagen was overwhelmed by hundreds of seriously ill polio patients. Without assistance to help them breathe, most would die. The only treatment available was a mechanical respirator system, known as an iron lung.

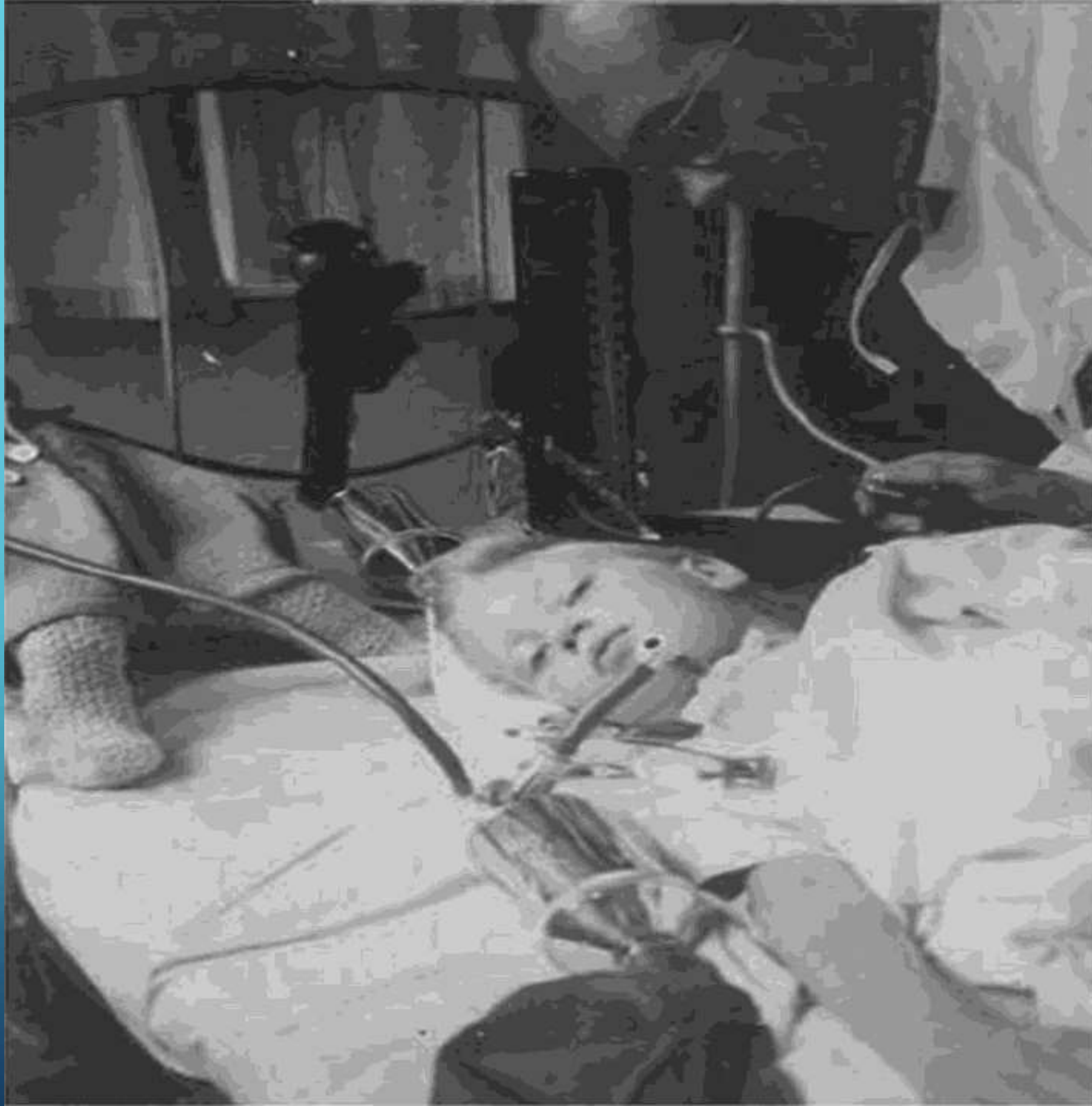
- The polio epidemic in Copenhagen resulted in 316 patients developing respiratory muscle paralysis and/or bulbar palsy, with subsequent respiratory failure and pooling of secretions. The Blegham Hospital, the hospital in Copenhagen for communicable diseases, had only one tank respirator and six cuirass respirators at the time. This was completely inadequate to support the hundreds of polio patients with respiratory failure and bulbar palsy. The mortality rate from polio with respiratory failure and bulbar involvement was historically 85–90% and, as the epidemic progressed, the situation looked desperate.




MARCH OF DIMES
Service

- Professor Lassen, chief physician at the Blegdam Hospital, had a strong desire to provide treatment for all polio victims, despite insufficient respirators, and therefore consulted with Dr Bjorn Ibsen, a Copenhagen anaesthetist. Professor Lassen hoped that positive pressure ventilation, as used in modern anaesthesia at that time, might be a solution. Two days later, a 12-year-old girl with polio and resultant respiratory failure and bulbar palsy had a tracheostomy formed just below the larynx: a rubber cuffed tracheostomy tube was inserted and positive pressure ventilation successfully delivered manually with a rubber bag. Tracheostomies had been performed in Copenhagen for 4 years before this, but with little beneficial effect on outcome.
- Dr Ibsen had the idea of caring for all such patients in a dedicated ward, where each patient could have their own nurse. Thus, in December 1953, the specialty of intensive care was born

Intensive care has undergone enormous change since the establishment of the specialty more than 65 years ago, and further changes will undoubtedly be seen in coming years.



INTENSIVE CARE MEDICINE

Intensive care medicine, also called critical care medicine, is a medical specialty that deals with seriously or critically ill patients who have, are at risk of, or are recovering from conditions that may be life-threatening. It includes providing life support, invasive monitoring techniques, resuscitation, and end-of-life care.

- Patients may be referred directly from an emergency department or from a ward if they rapidly deteriorate, or immediately after surgery if the surgery is very invasive and the patient is at high risk of complications.


PHILIPS

MOST COMMON TYPE OF ICU

- Neonatal intensive care unit (NICU).
- Pediatric intensive care unit (PICU).
- Coronary care unit (CCU)
- Neurological Intensive Care Unit (NeuroICU).
- Post-anesthesia care unit (PACU)
- High dependency unit (HDU)

NEONATAL INTENSIVE CARE UNIT (NICU)

This specialty unit cares for neonatal patients who have not left the hospital after birth. Common conditions cared for include prematurity and associated complications, congenital disorders such as congenital diaphragmatic hernia, or complications resulting from the birthing process.

PEDIATRIC INTENSIVE CARE UNIT (PICU)

Pediatric patients are treated in this intensive care unit for life-threatening conditions such as asthma, influenza, diabetic ketoacidosis, or traumatic neurological injury.

CORONARY CARE UNIT (CCU)

Also known as Cardiac Intensive Care Units (CICU) or Cardiovascular Intensive Care Unit (CVICU), this ICU caters to patients specifically with congenital heart defects or life-threatening cardiac conditions such as a myocardial infarction or a cardiac arrest.

NEUROLOGICAL INTENSIVE CARE UNIT (NEUROICU)

Patients are treated for brain aneurysms, brain tumors, stroke, and post surgical patients who have undergone various neurological surgeries performed by experienced neurosurgeons require constant neurological exams. Nurses who work within these units have neurological certifications.

POST-ANESTHESIA CARE UNIT (PACU)

Also known as the post-operative recovery unit, or recovery room, the PACU provides immediate post-op observation and stabilization of patients following surgical operations and anesthesia

HIGH DEPENDENCY UNIT (HDU)

most acute hospitals have a transitional high dependency unit (HDU) for patients who require close observation, treatment and nursing care that cannot be provided in a general ward, but whose care is not at a critical stage to warrant an (**ICU**) bed

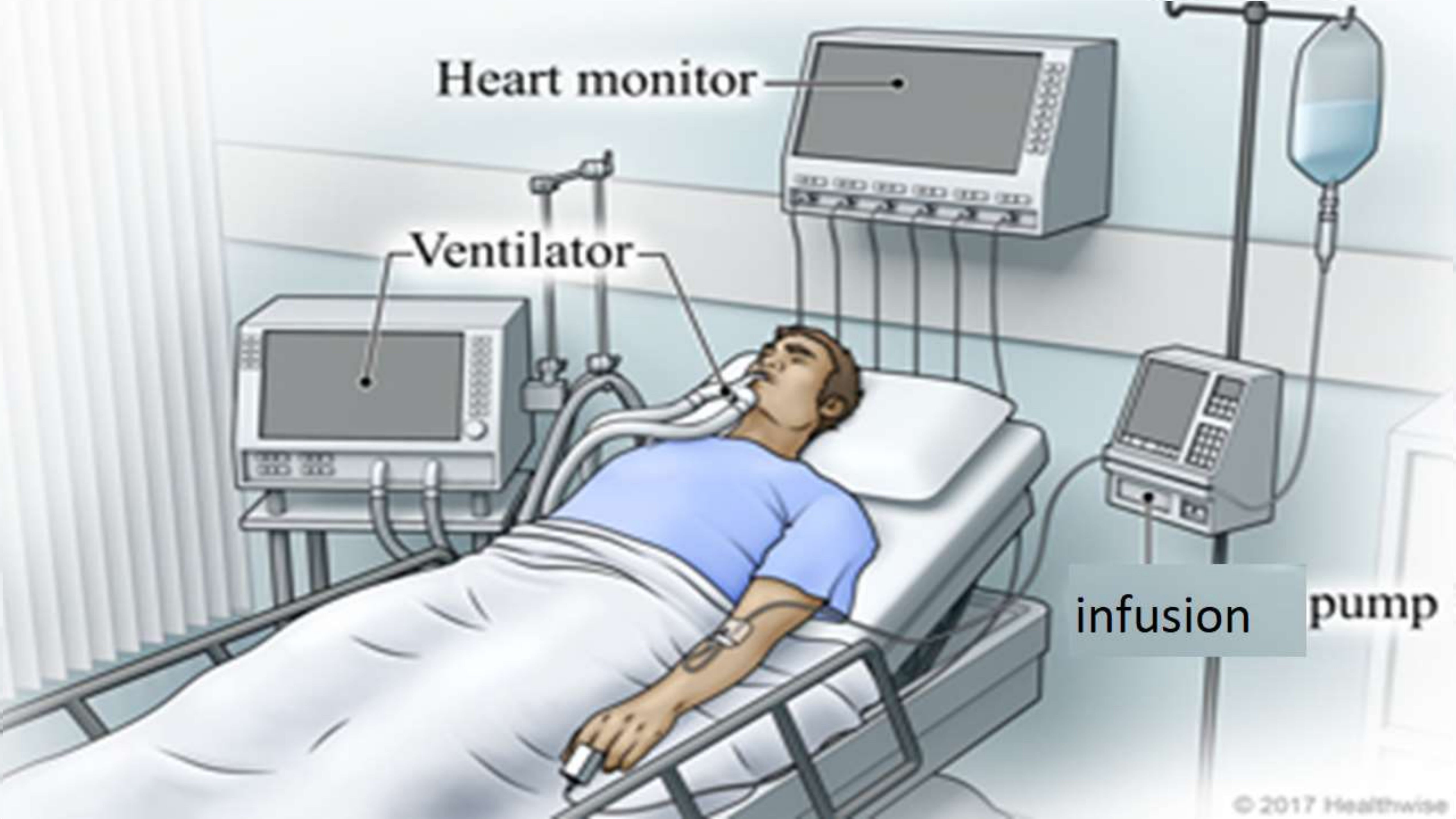

THANK YOU FOR ATTENTION!
Have a nice day!!!

Intensive care unit

L 2

Equipment and systems

Common equipment in an ICU includes mechanical ventilators to assist breathing through an endotracheal tube or a tracheostomy tube; cardiac monitors for monitoring Cardiac condition; equipment for the constant monitoring of bodily functions; a web of intravenous lines, feeding tubes, nasogastric tubes, suction, drains, and catheters, syringe pumps; and a wide array of drugs to treat the primary condition(s) of hospitalization. analgesics, and induced sedation are common ICU tools needed and used to reduce pain and prevent secondary infections.


Heart monitor
Ventilator
infusion
pump
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Mechanical ventilation

The most basic monitors show your heart rate, blood pressure, and body temperature. More advanced models show respiratory rate and how much carbon dioxide you're breathing out.

HR

The hearts of healthy adults typically beat 60 to 100 times a minute. People who are more active can have slower heart rates

- What are the causes of an increased heart rate?

Respiratory Rate (**RR**)

Respiratory Rate (RR): Look for the patient's respiratory rate under "RR" on the patient monitor. It is reported in breaths per minute, with normal values between 12 and 20. However, this number isn't very accurate, especially as the patient's breathing goes faster or slower.

- What are the causes of an increased RR?

Blood pressure

This is a measure of the force on your arteries when your heart is beating (known as systolic pressure) and when it's at rest (diastolic pressure). The first number (systolic) should be between 100 and 130, and the second number (diastolic) should be between 60 and 80.

Oxygen saturation

This number measures how much oxygen is in your blood, on a scale up to 100. The number is normally 95 or higher, and anything below 90 means your body may not be getting enough oxygen.

- If one of your vital signs rises or falls outside healthy levels, the monitor will sound a warning. This usually involves a beeping noise and a flashing color. Many will highlight the problem reading in some way
- If one or more vital signs spikes or drops sharply, the alarm may get louder, faster, or change in pitch. This is designed to let a caregiver know to check on you, so the alarm may also show up on a monitor in another room.
- But one of the most common reasons an alarm goes off is because a sensor isn't getting any information. This might happen if one comes loose when you move or isn't working the way it should.

ETCO2

The capnogram is a direct monitor of the inhaled and exhaled concentration or partial pressure of CO_2, and an indirect monitor of the CO_2 partial pressure in the arterial blood. In healthy individuals, the difference between arterial blood and expired gas CO_2, partial pressures is very small. the difference between arterial blood and expired gas can exceed 7 mmHg in some disease

- Capnography directly reflects the elimination of CO_2 by the lungs to the anesthesia device. Indirectly, it reflects the production of CO_2 by tissues and the circulatory trans
- Carbon dioxide is produced continuously as the body's cells respire, and this CO_2 will accumulate rapidly if the lungs do not adequately expel it through alveolar ventilation. Alveolar hypoventilation thus leads to an increased $PaCO_2$(a condition called hypercapnia). The increase in $PaCO_2$ in turn decrease the pH.

Hypoventilation:

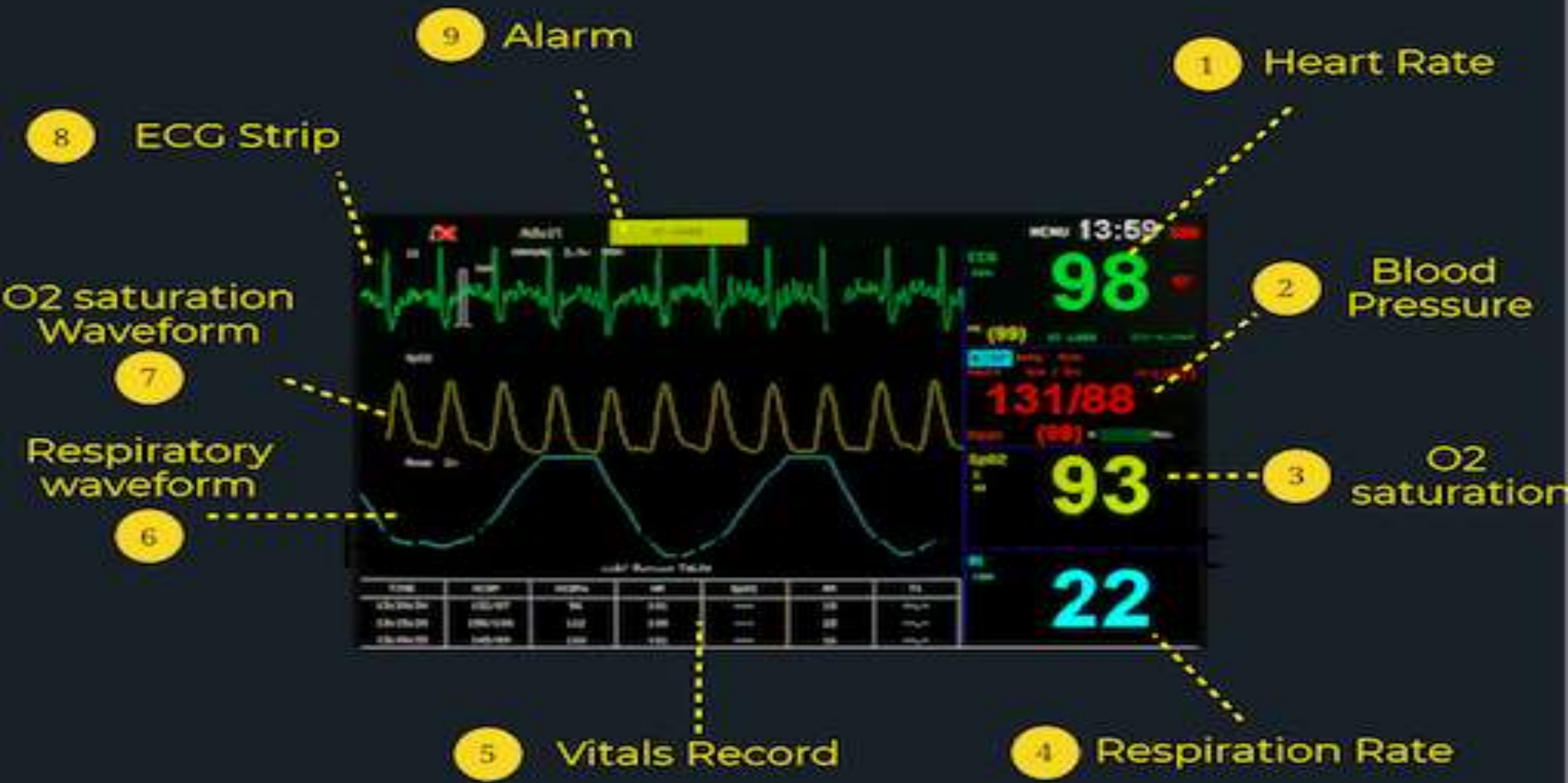
$PaCO_2 \uparrow$

$\Uparrow CO_2 + H_2O \rightarrow H_2CO_3^- \rightarrow HCO_3^- + H^+ \uparrow$

$HCO_3^- \uparrow$

Respiratory acidosis

$H^+ \uparrow$



9 Alarm
1 Heart Rate
8 ECG Strip
2 Blood Pressure
O2 saturation Waveform
7
Respiratory waveform
6
3 O2 saturatio
5 Vitals Record
4 Respiration Rate
13:59
98
131/88
93
22

DC shock used for patients with VT, VF, SVT ....

suction machine

suction machine

- Suction machines create a vacuum effect to remove obstructions such as blood, saliva, mucus, vomit, or other liquids from the respiratory tract.
- Suction of the endotracheal tube (ETT) is routine and common procedure in intensive care unit to clear secretions and to keep the airway patent so that oxygenation and ventilation in an intubated patient can be optimized. ETT suction can cause hypoxia due to oxygen suction from the lung and alveoli collapse.

The following are recommendations for endotracheal suctioning from the American Association of Respiratory Care:

- Saw tooth pattern on flow-volume loop on ventilator monitor
- Coarse crackles auscultated over trachea
- Increased peak inspiratory pressure during volume control ventilation
- Decreased tidal volume during pressure-controlled ventilation
- Deterioration in oxygen saturation and/or arterial blood gas values
- Visible secretions in airway
- Patient's inability to generate an effective cough
  Acute respiratory distress
- Suspected aspiration of gastric or upper airway secretions

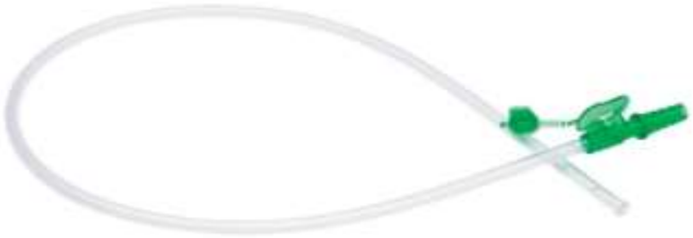
procedure

- hyperoxygenate the patient by giving them a few breaths with 100% oxygen
- Insert the catheter through the nose, tracheostomy tube or endotracheal tube. Do not be aggressive when inserting the tube through the nose.
- Once the catheter has been inserted to the appropriate depth, apply intermittent suction and slowly withdraw the catheter
- If suctioning more than once, allow the patient time to recover between suctioning attempts
- ❖During the procedure, monitor oxygen levels and heart rate to make sure the patient is tolerating the procedure well. Suctioning attempts should be limited to 10 seconds

Tips

- Apply suction for no longer than 10 seconds. Applying suction for longer periods of time can cause injury, hypoxia and bradycardia.
- Do not apply suction while inserting the catheter. This can increase the chances of injuring the mucus membranes.
- Use a clean **suction** catheter when **suctioning** the patient. Whenever the **suction** catheter is to be reused, place the catheter in a container of distilled/sterile water and apply **suction** for approximately 30 seconds to clear secretions from the inside.
- Reoxygenate between attempts. **Maximum number** of attempts should be 2 **suction passes**/episode. **Suction** catheter size should be **no** more than 1/2 (one-half) the internal diameter of the artificial airway (ETT) to avoid greater negative pressure in the airway and potentially minimize the PaO2.

Suction catheter



syringe pump used to given bolus dose (not for infusion) like 10 mg midazolam in every 6 hours

syringe pump

- A syringe pump is a small infusion device that is used to gradually administer specific amounts of fluids for use in chemical and biomedical research.
- A syringe pump is also known as Micro Infusion Pump
- The main purpose of the equipment is to supplement volumetric infusion pump in micro-administration
- It is more accurate than a typical volumetric infusion pump while administering small doses

Pump infusion used for infusion doses drugs like dopamine 10 mcg/kg/min (not for bolus dose)

Pump infusion

- Majority of the patients in ICU need these pumps. These are pumps that you will see beside the patient and they control the amount of medication or fluid that a patient receives and how fast or slow it can be given.
- used for
- Chemotherapy
- parenteral nutrition
- Anaesthesia/sedation
- Drugs like (dopamine, epinephrine, dobutamine, …)

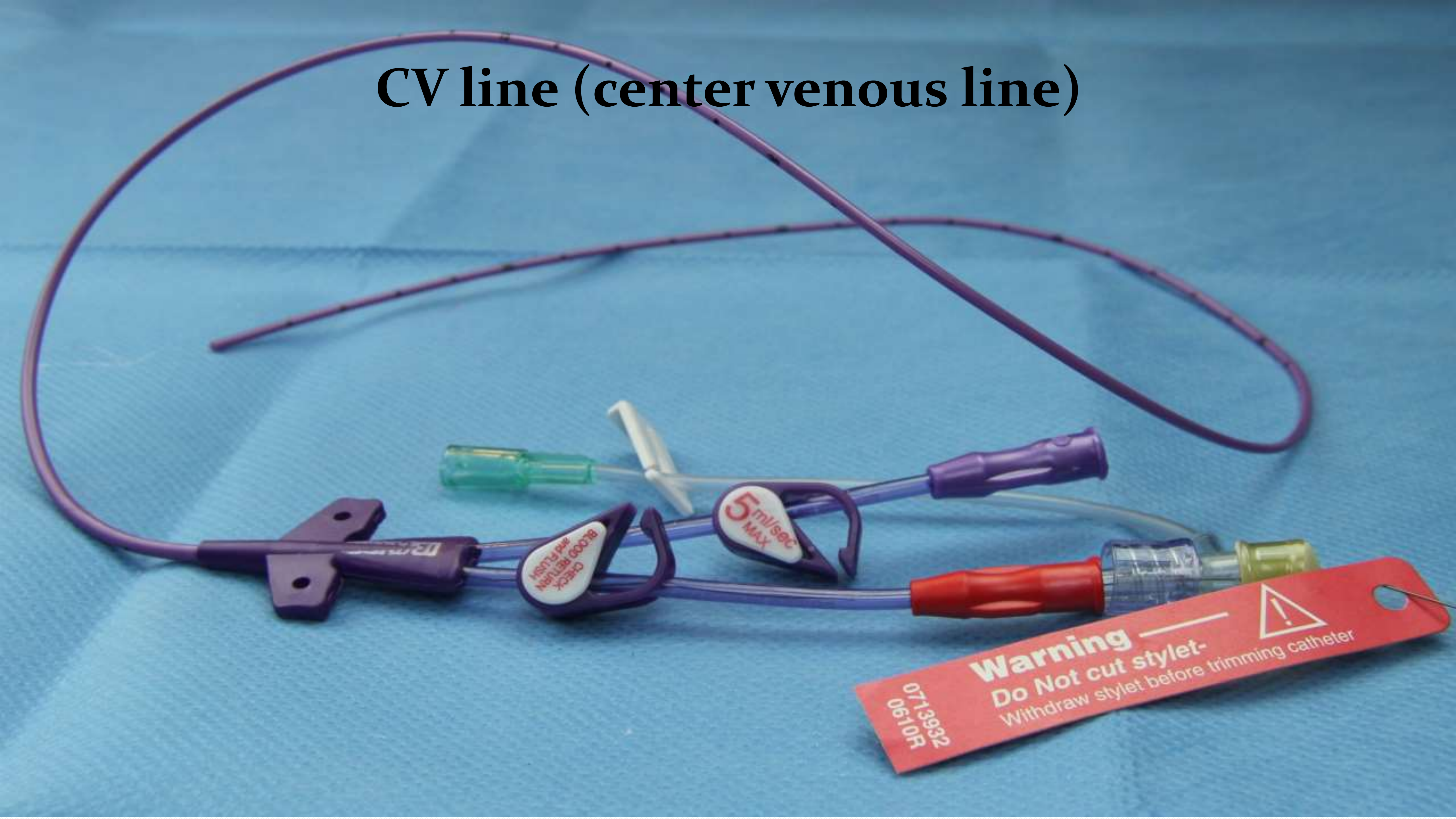
Majority of the patients in ICU need these pumps. These are pumps that you will see beside the patient and they control the amount of medication or fluid that a patient receives and how fast or slow it can be given.

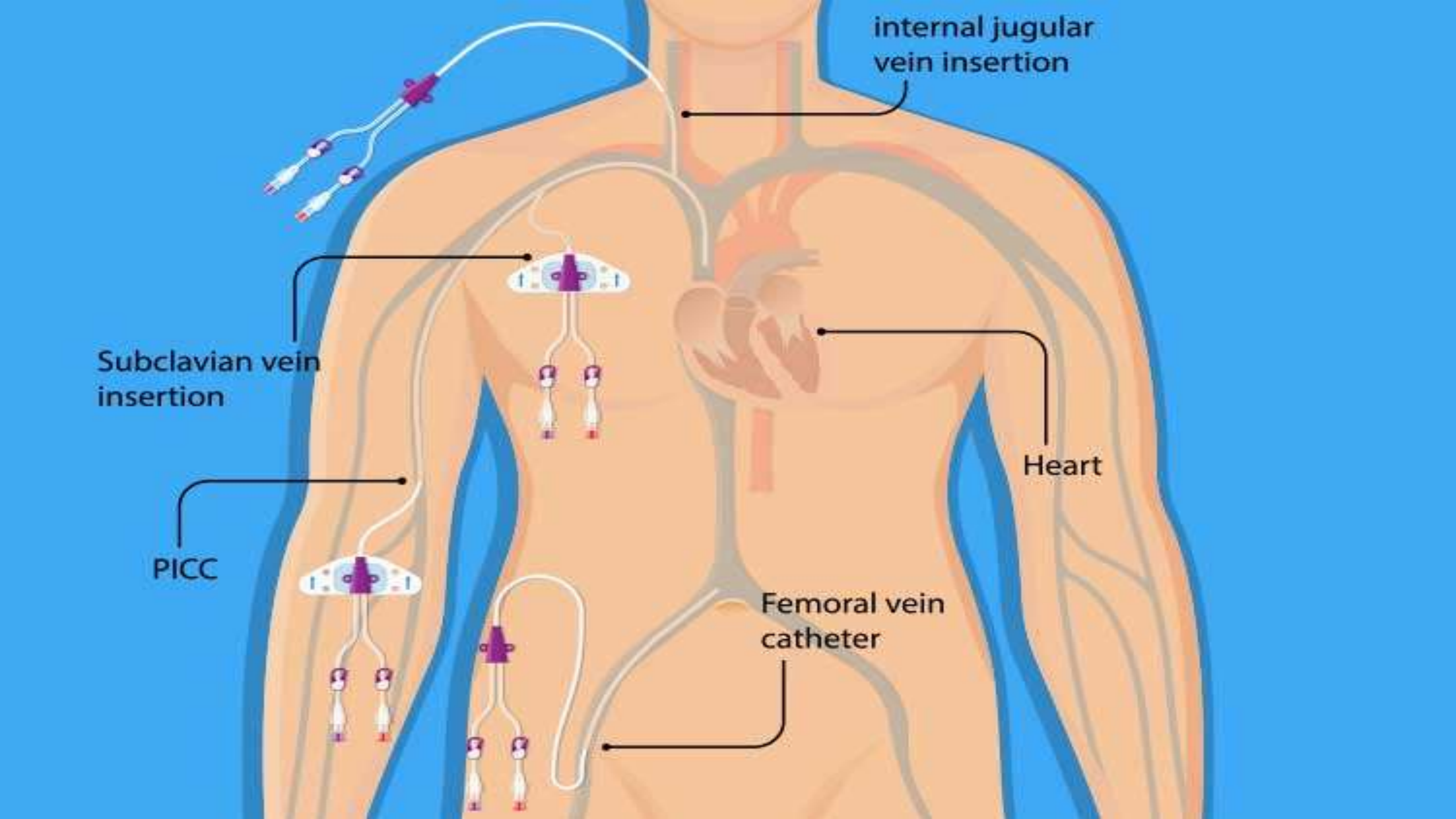
Advantages

Infusion pumps provide a high level of control, accuracy, and precision in drug delivery, thereby reducing medication errors and contributing to improvements in patient care. At the same time, infusion pumps have been associated with persistent safety problems that can result in over- or under-infusion, and missed or delayed therapy.

- Infusion pump used an unit ml/hour or mcg/hour
- You can determine the drug and dose
- You can determine the duration of administration
- An alarm for any obstruction to access and when the amount of medicine in the vial or container is running out

CV line (center venous line)




internal jugular
vein insertion
Subclavian vein
insertion
Heart
PICC
Femoral vein
catheter

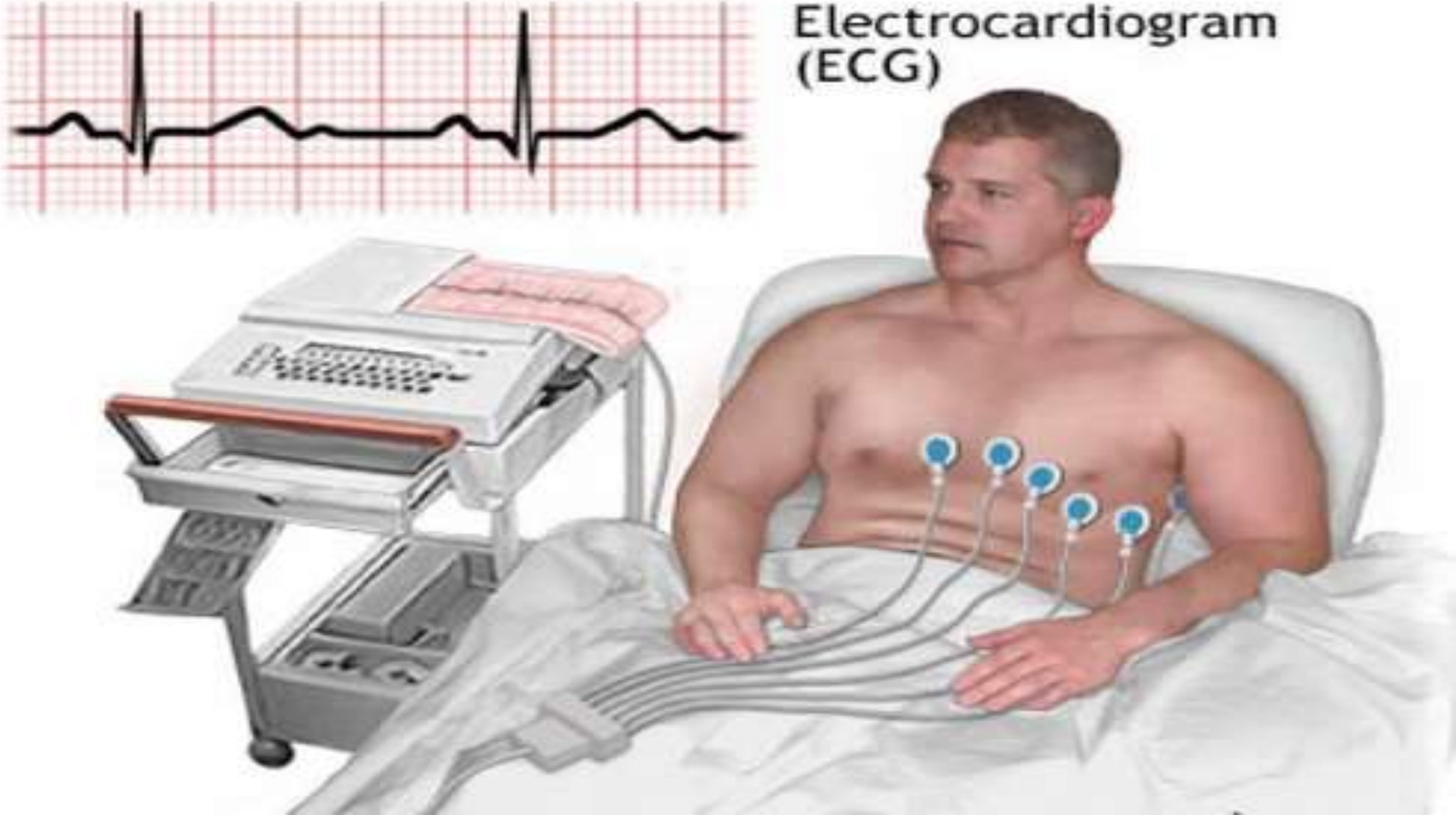
CV line (center venous line)

A central venous catheter (CVC), also known as a central line, central venous line, or central venous access catheter, is a catheter placed into a large vein. It is a form of venous access. Placement of larger catheters in more centrally located veins is often needed in critically ill patients, or in those requiring prolonged intravenous therapies, for more reliable vascular access. These catheters are commonly placed in veins in the neck (internal jugular vein), chest (subclavian vein or axillary vein), groin (femoral vein), or through veins in the arms.

ECG

The electrocardiogram (ECG) is a diagnostic tool that is routinely used to assess the electrical and muscular functions of the heart. it gives the full information about the heart beats consists of 12 leads for acquistion and a rhythm lead as an optional. it is used to analyse the heart rate and rhythm of the heart.

Electrocardiogram (ECG)



Endotracheal tube (ETT)

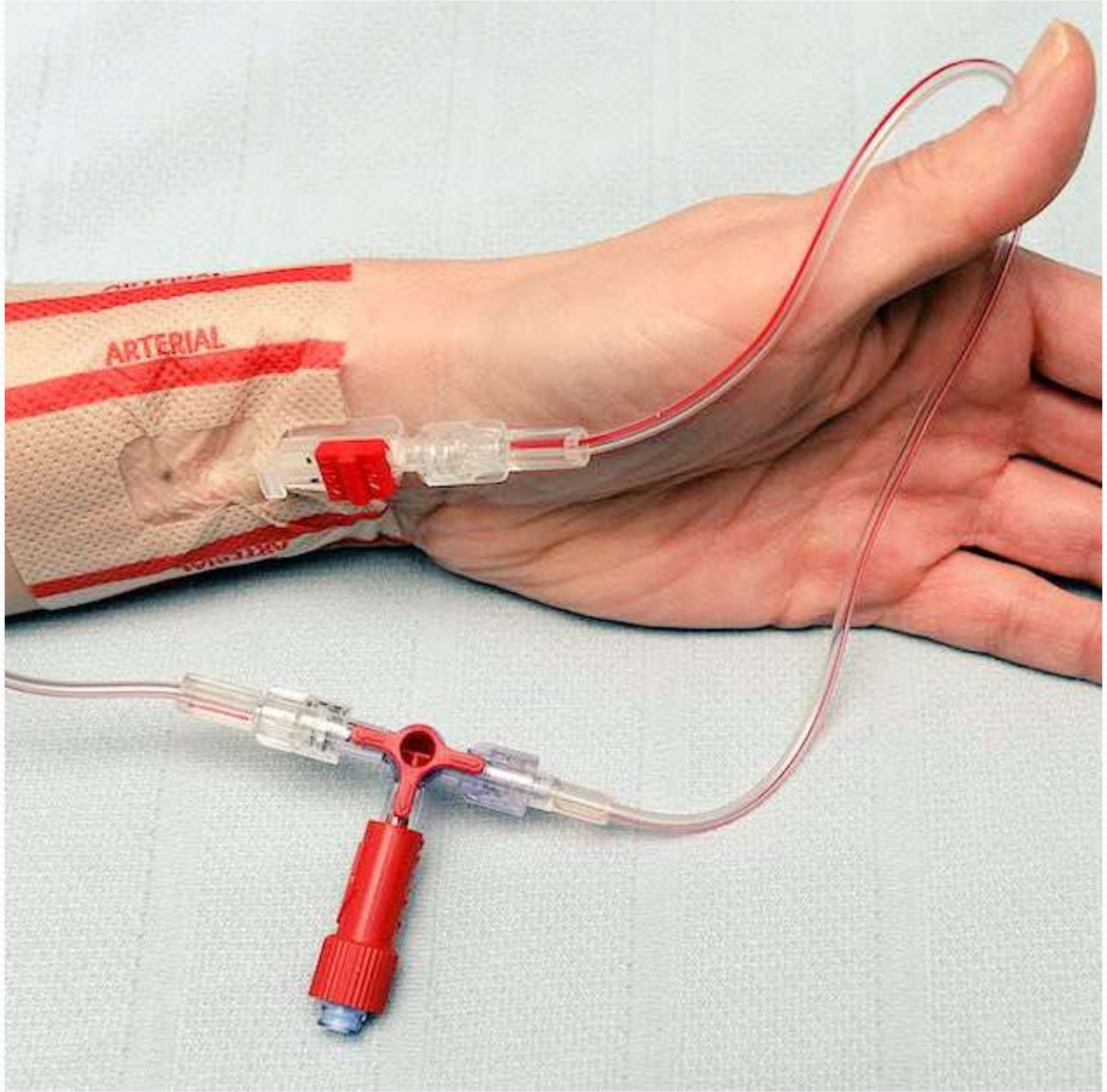
It is used in the ICU for patients who are having difficulty breathing because of a lung problem, or for patients who are not awake enough to breathe for themselves.

Tracheostomy

A tracheostomy is sometimes and option to patients who require long term ventilation, difficult weaning from the ventilator, and patients with copious secretions . When a patient no longer requires ventilator support and only needs oxygen therapy, oxygen tube can be connected to the tracheostomy.

Arterial line

It allows the nurse to see the blood pressure continuously and also allows the staff to take bloods when required



Direct current (DC) cardioversion or **defibrillation**

Defibrillation is a common treatment for life-threatening cardiac dysrhythmias, ventricular fibrillation and pulseless ventricular tachycardia. Defibrillation consists of delivering a therapeutic dose of electrical energy to the heart with a device called a defibrillator The purpose of defibrillator is to give electrical stimulation for cardiac arrest patients

Where you are can find it? what is indication for it?

AED

Pressure Relieving Mattress ('Air mattress')

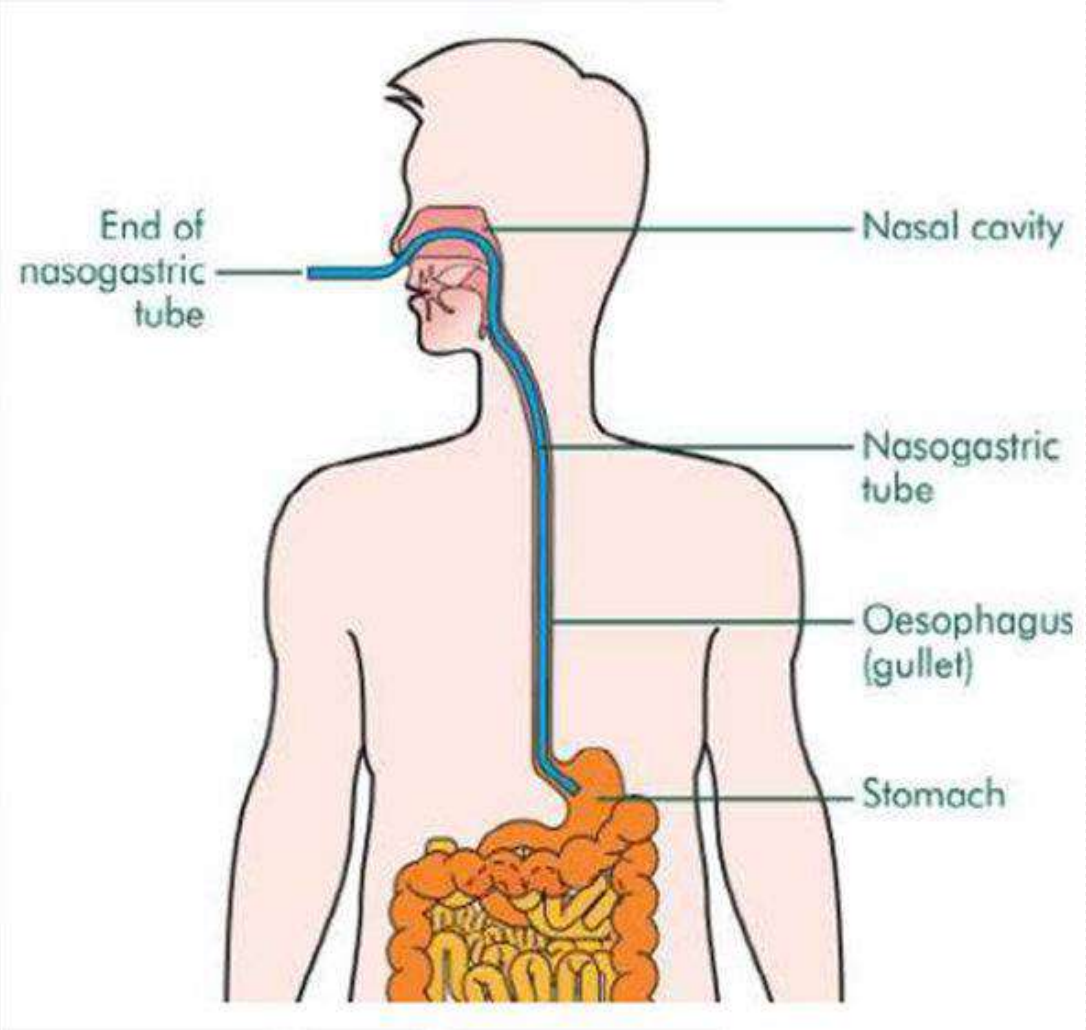
- The majority of our patients will be lying on an air mattress. This mattress is used to prevent pressure injuries or 'bed sores'
- The air mattress is constantly distributing air and alternating the pressure under the body.
- In addition to the use of an air mattress we should also turn the patients in the bed frequently

Air bed used to prevention sores

Air mattress(Air bed)

Nasogastric Tube (NG)

This tube goes through a patients nose and down into their stomach. It allows us to feed them when they are too unwell to eat and drink as they normally would or when their appetite is reduced due to illness. We can also give them medication

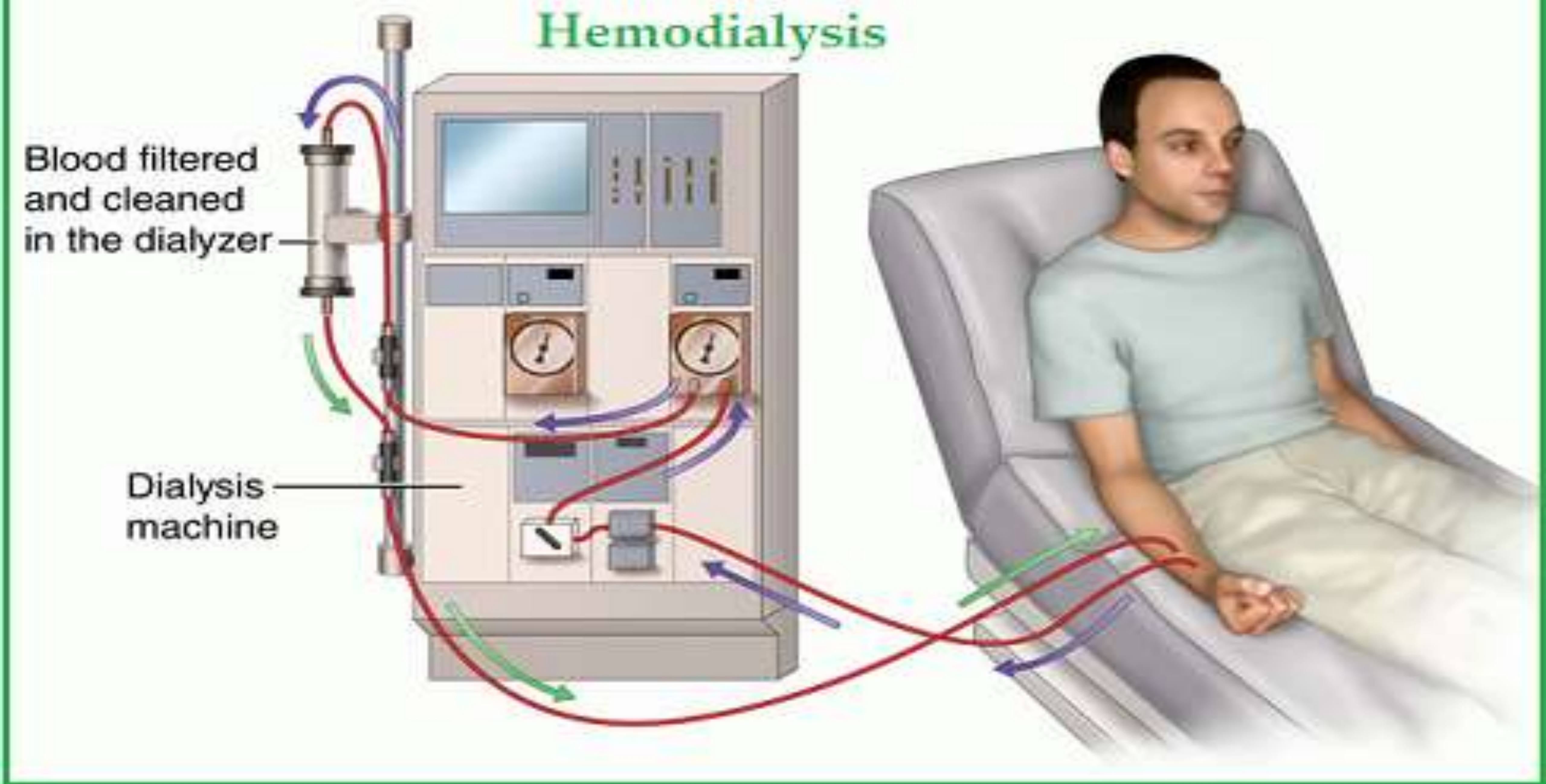


Urinary Catheter

In the ICU, a patient may have a urinary catheter put in place to monitor an hourly output. This allows us to calculate how much fluid is going in, versus how much is coming out

Kidney machines

Some patients kidneys stop working due to their illness. The kidneys work to filter the blood and remove waste products (and in doing so produce urine) so if they fail, it is important that the machines take over this job. To do this a special large tube is put into one of the big veins in the leg or neck.


Hemodialysis
Blood filtered and cleaned in the dialyzer
Dialysis machine

Bed sores

Portable X-RAY

Portable Ultra sound

THANK YOU FOR ATTENTION!

Have a nice day!!!

ventilation
Mechanical ventilation(MV)
Invasive ventilation
Non-invasive ventilation(NIV)

ICU L3

Review

Respiratory system

The main functions of respiration are to provide oxygen to the tissues and remove carbon dioxide. The four major components of respiration are

(1) Pulmonary ventilation, which means the inflow and outflow of air between the atmosphere and the lung alveoli

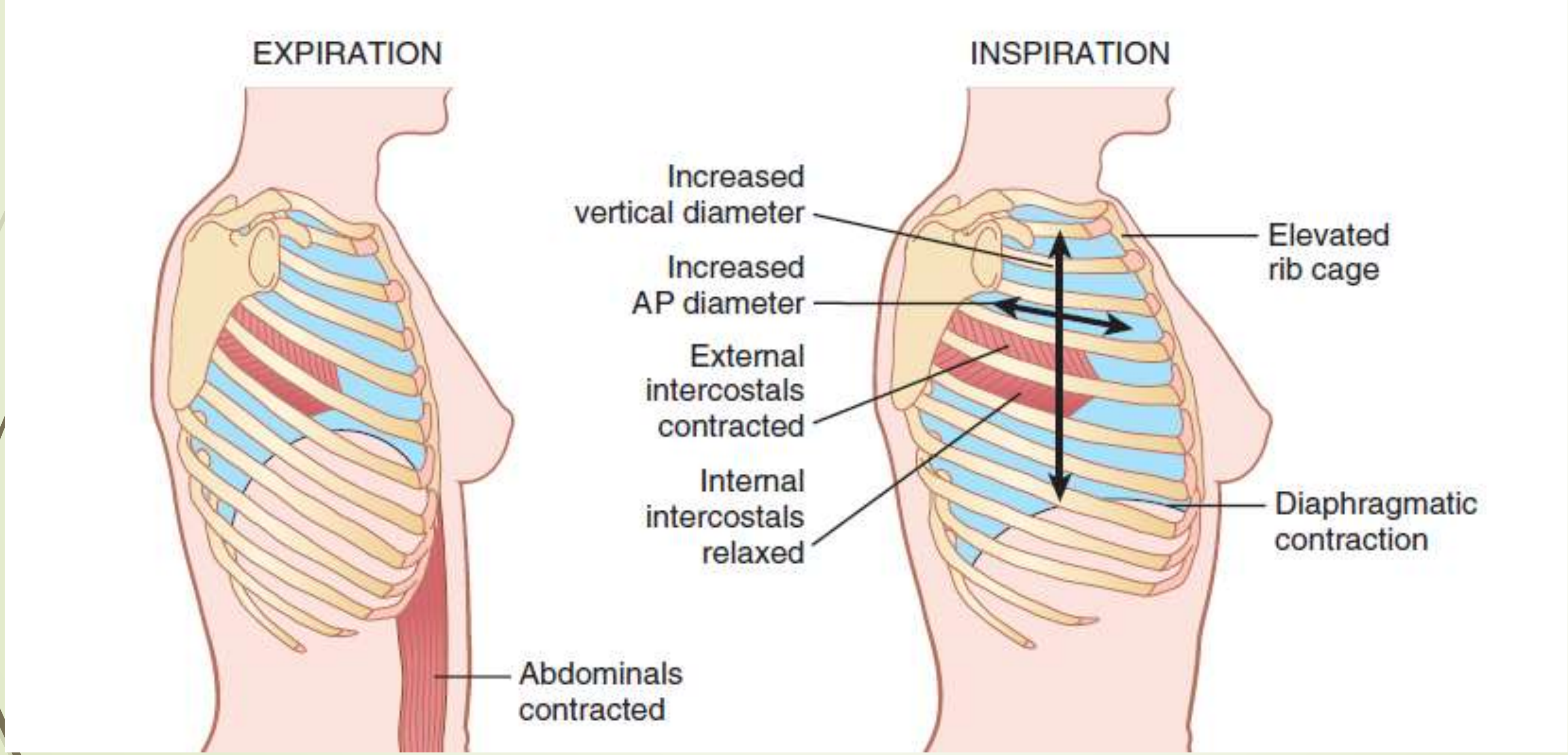
(2) Diffusion of oxygen (O_2) and carbon dioxide (CO_2) between the alveoli and the blood

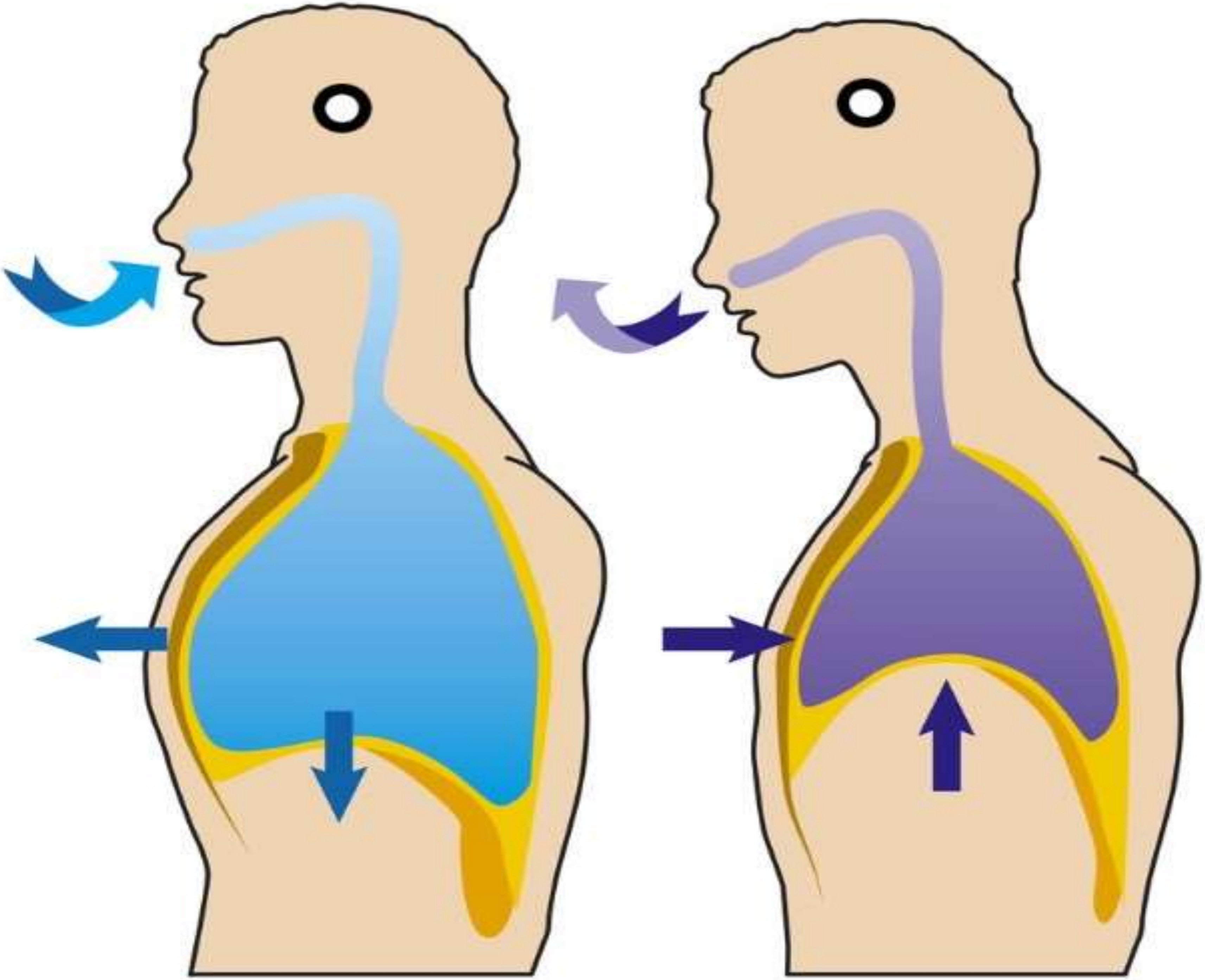
(3) Transport of oxygen and carbon dioxide in the blood and body fluids to and from the body's tissue cells

(4) Regulation of ventilation and other facets of respiration.

Lungs expansion and contraction

The lungs can be expanded and contracted in two ways: (1) by downward and upward movement of the diaphragm to lengthen or shorten the chest cavity, and (2) by elevation and depression of the ribs to increase and decrease the anteroposterior diameter of the chest cavity





❖ Important information

Pleural pressure is the pressure of the fluid in the thin space between the lung pleura and the chest wall pleura. As noted earlier, this pressure is normally a slight suction, which means a slightly negative pressure. The normal pleural pressure at the beginning of inspiration is about −5 centimeters of water, which is the amount of suction required to hold the lungs open to their resting level. During normal inspiration, expansion of the chest cage pulls outward on the lungs with greater force and creates more negative pressure, to an average of about −7.5 centimeters of water.

Respiration is defined as movement of gas molecules across a membrane

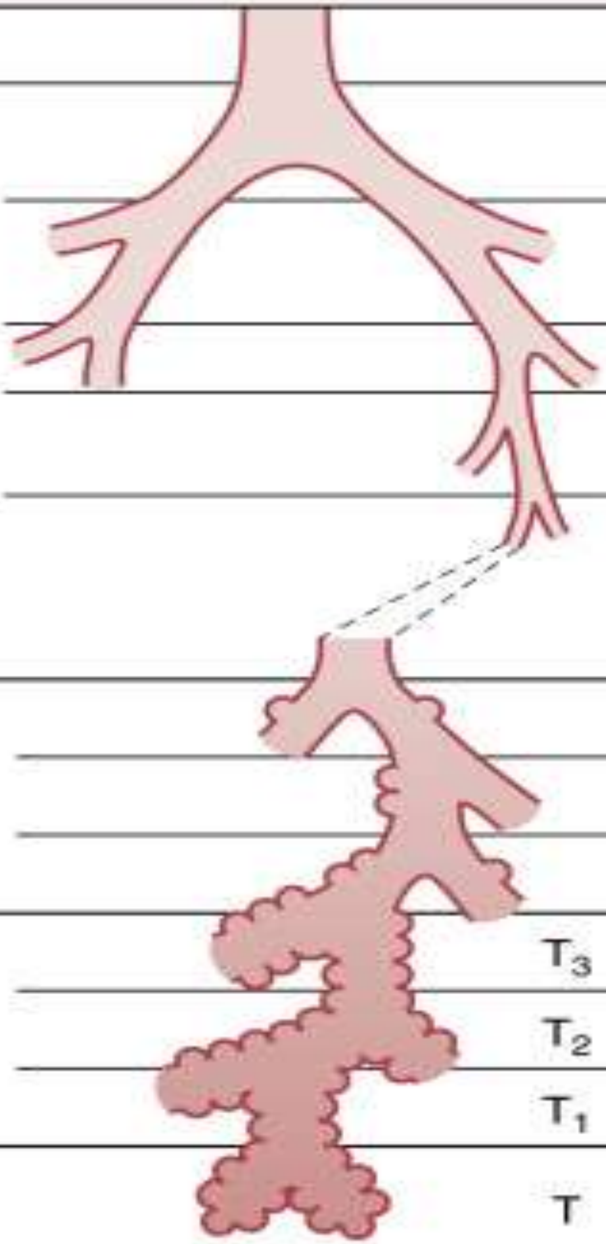
External respiration is movement of O_2 from the lungs into bloodstream and of CO_2 from bloodstream into alveoli.

Internal respiration is movement of CO_2 from the cells into the blood and movement of O_2 from the blood into cells.

❖ Important information

- During normal inspiration, alveolar pressure decreases to about −1 centimeters of water. This slight negative pressure is enough to pull 0.5 liter of air into the lungs in the 2 seconds required for normal quiet inspiration.
- During expiration, alveolar pressure rises to about +1 centimeter of water, which forces the 0.5 liter of inspired air out of the lungs during the 2 to 3 seconds of expiration.
- **Alveolar ventilation**

The ultimate importance of pulmonary ventilation is to continually renew the air in the gas exchange areas of the lungs, where air is in proximity to the pulmonary blood. These areas include the alveoli, alveolar sacs, alveolar ducts, and respiratory bronchioles. The rate at which new air reaches these areas is called alveolar ventilation



Zone	Generation			Diameter, cm	Length, cm	Number	Total cross sectional area, cm^2
Conducting zone	Trachea		0	1.80	12.0	1	2.54
	Bronchi		1	1.22	4.8	2	2.33
	↓		2	0.83	1.9	4	2.13
			3	0.56	0.8	8	2.00
	Bronchioles		4	0.45	1.3	16	2.48
	↓		5	0.35	1.07	32	3.11
			↓	↓	↓	↓	↓
	Terminal bronchioles		16	0.06	0.17	6×10^4	180.0
Transitional and respiratory zones	Respiratory bronchioles		17	↓	↓	↓	↓
			18				
			19	0.05	0.10	5×10^5	10^3
	Alveolar ducts	T_3	20	↓	↓	↓	↓
		T_2	21				
		T_1	22				
	Alveolar sacs	T	23	0.04	0.05	8×10^6	10^4

Causes of disturbances of alveolar ventilation

Extra pulmonary causes like

- **Central nervous system dysfunction:** like **d**rug induced inhibition of respiratory center (morphine and barbiturates); trauma.
- **Peripheral nervous system:** like Guillain-Barré syndrome

Pulmonary causes like

- **Obstruction of airways:** like Obstructive sleep apnea**,** Inflammation of the airway mucosa
- **Lung parenchyma:** like Emphysema
- **Pleural:** like pleural effusions, inflammations

What are the causes of abnormal V̇ /Q̇ ratio?

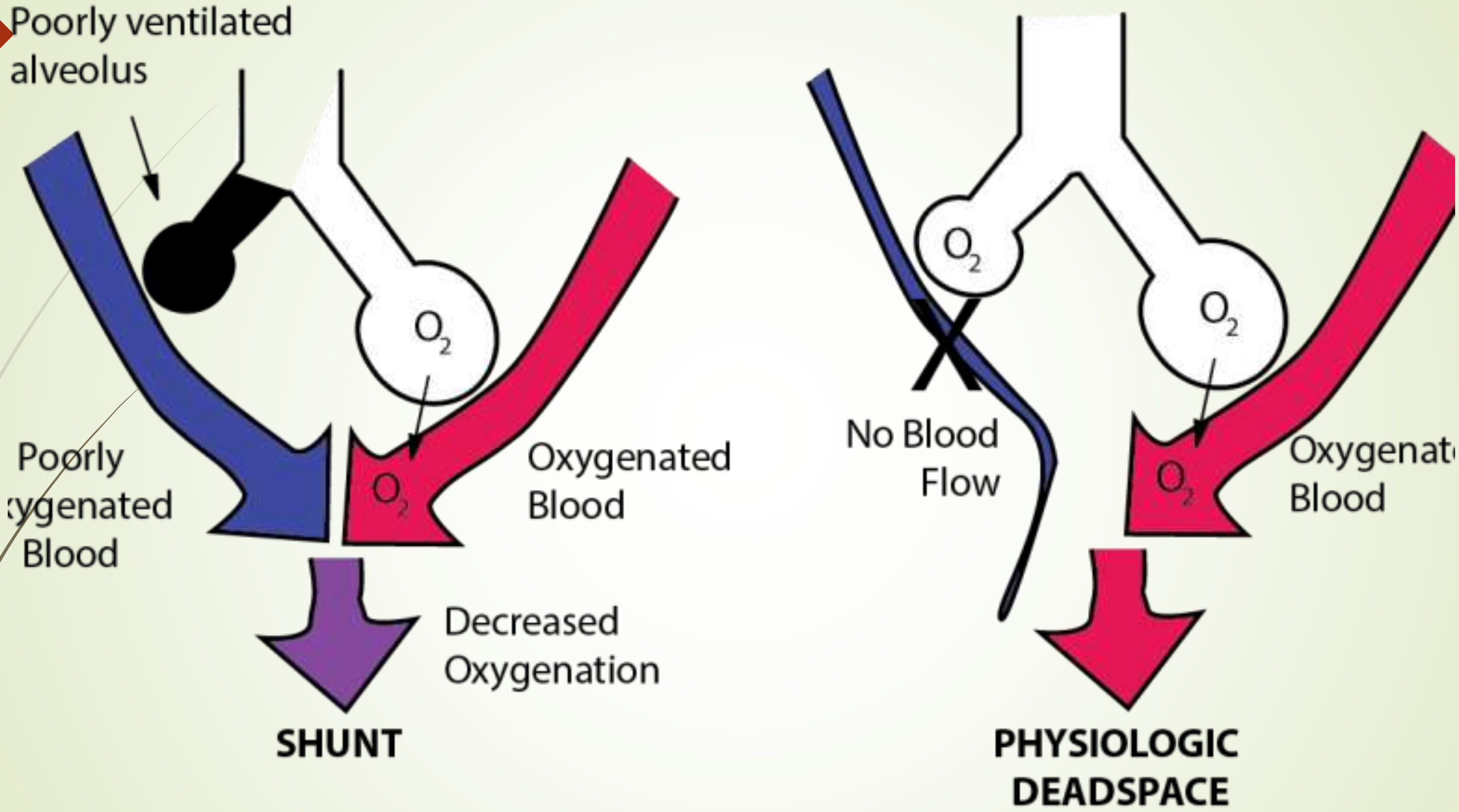
There are many pathological causes of V̇ /Q̇ mismatch. These are broadly grouped into:

- Problems with lung ventilation, resulting in low V̇ /Q̇ ratio. This is the most common cause of hypoxemia. Causes include:

- Upper airway obstruction
- Foreign body aspiration
- Pneumonia
- Pneumothorax
- Atelectasis
- ARDS
- Emphysema
- One-lung ventilation
- Normal ageing
- Increased closing capacity associated with obesity.

❑ Problems with lung perfusion, resulting in high $\dot{V}/\dot{Q}$ ratio. Causes include:

- PE
- Reduced right ventricular stroke volume (SV), due to hypovolemia, right ventricular infarction or pericardial tamponade.


Poorly ventilated
alveolus
O2
Poorly
xygenated
Blood
O2
Oxygenated
Blood
Decreased
Oxygenation
SHUNT
O2
No Blood
Flow
O2
O2
Oxygenat
Blood
PHYSIOLOGIC
DEADSPACE


LET'S START!

Manual ventilation

- Bag-mask ventilation (by Ambu bag)

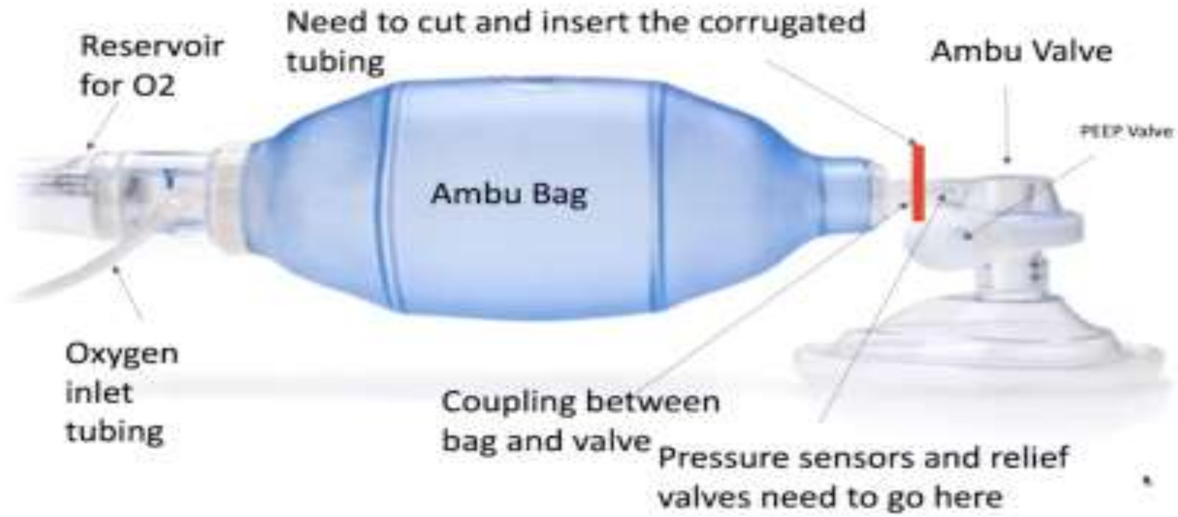
Artificial ventilation

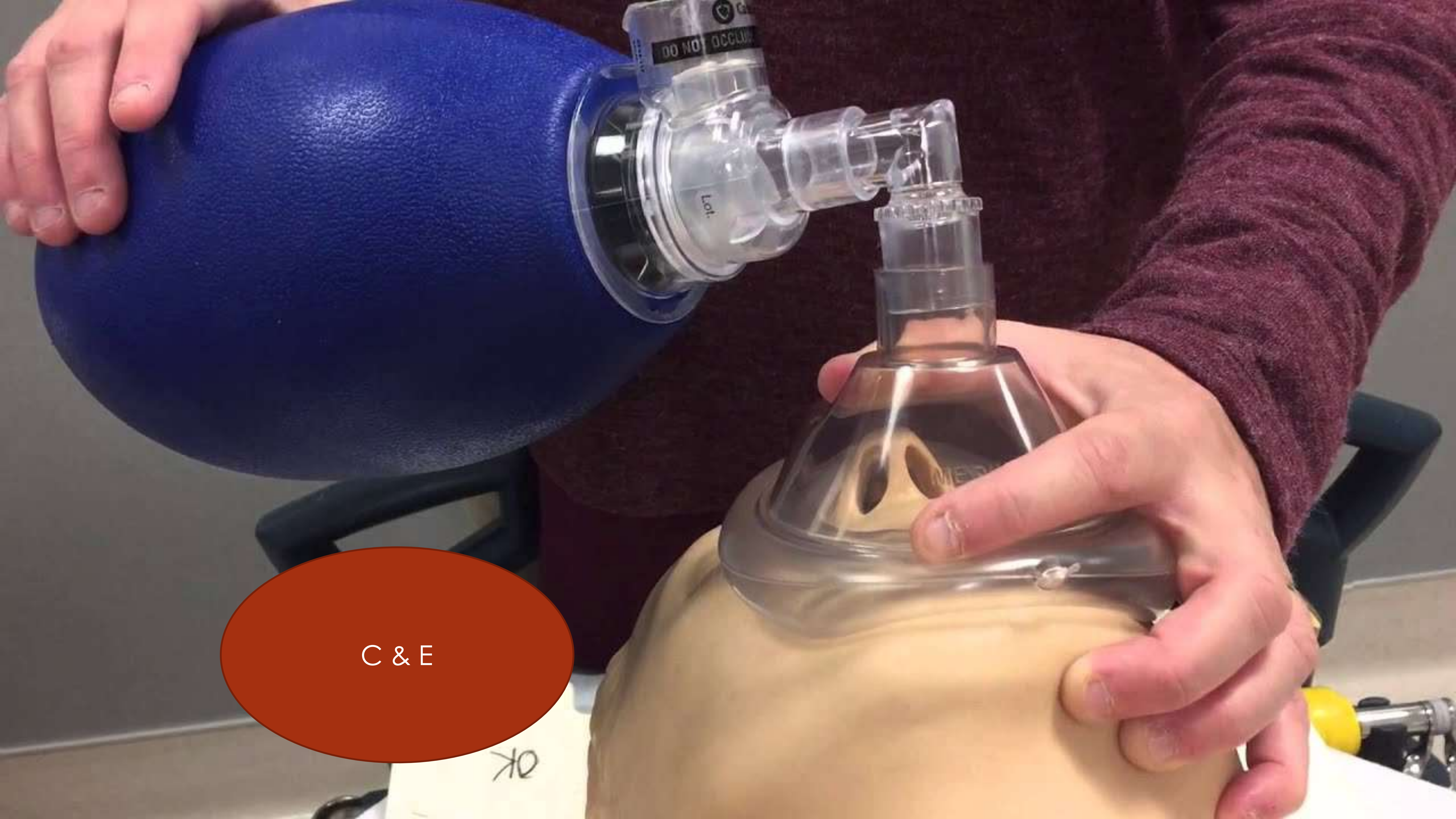
- Non Invasive
- Invasive

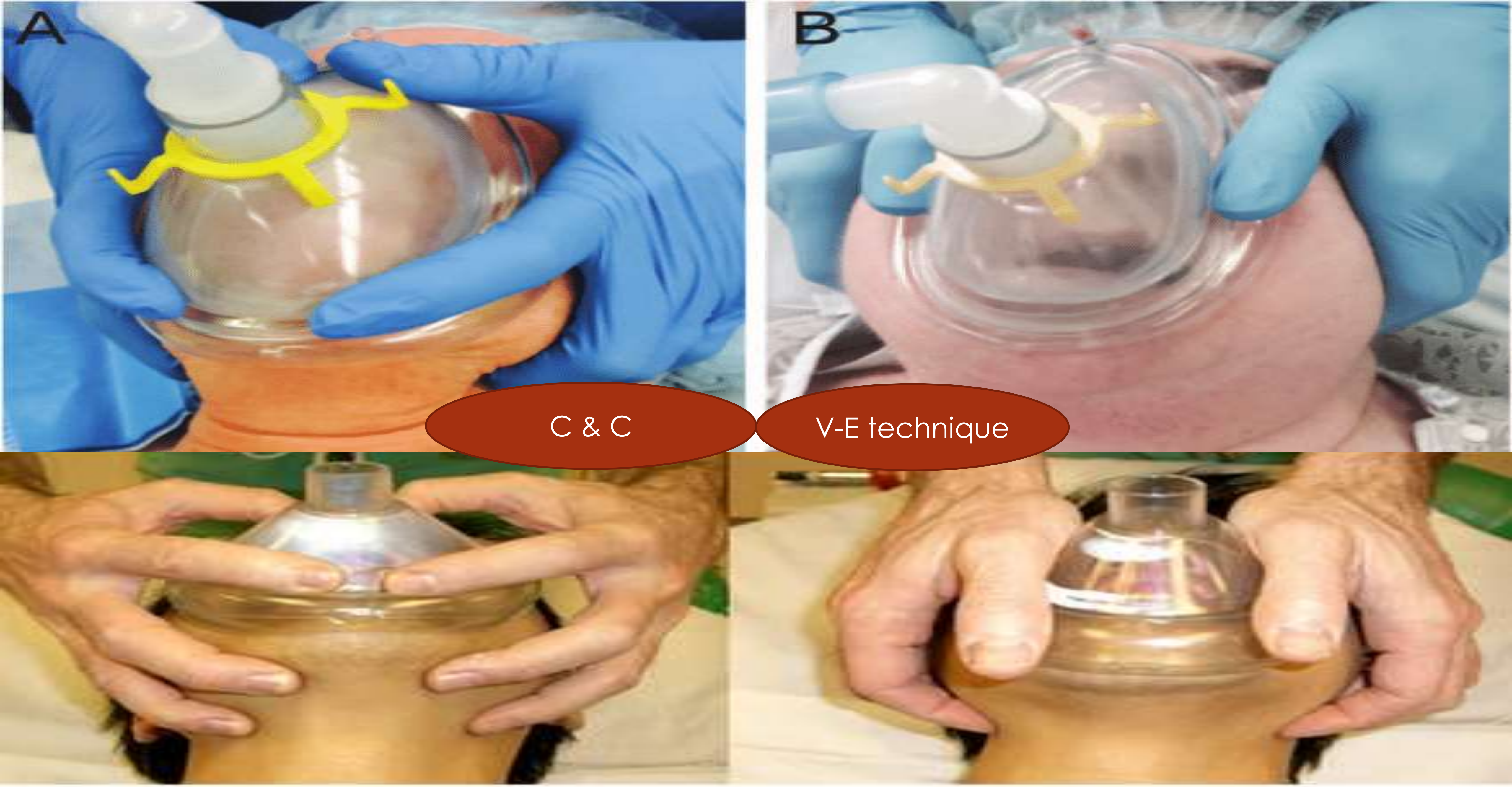
Bag-Valve-Mask with Oxygen Reservoir

- An oxygen reservoir is required in order to give the patient oxygen concentrations greater than 60 %

Design Idea: Basic Ambu Bag parts and modifications:




C & E
Lot.

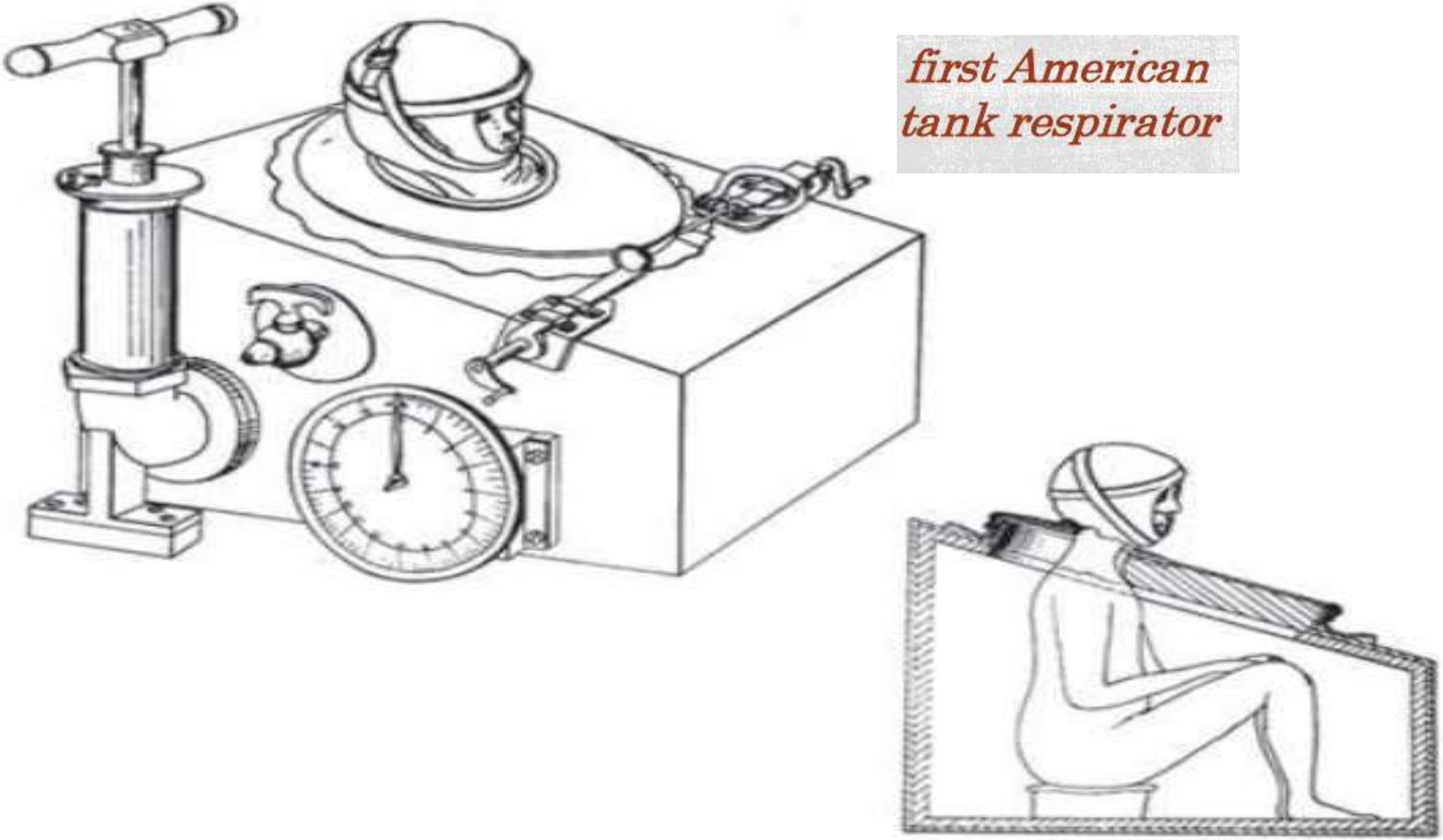

A
B
C & C
V-E technique

Artificial ventilation

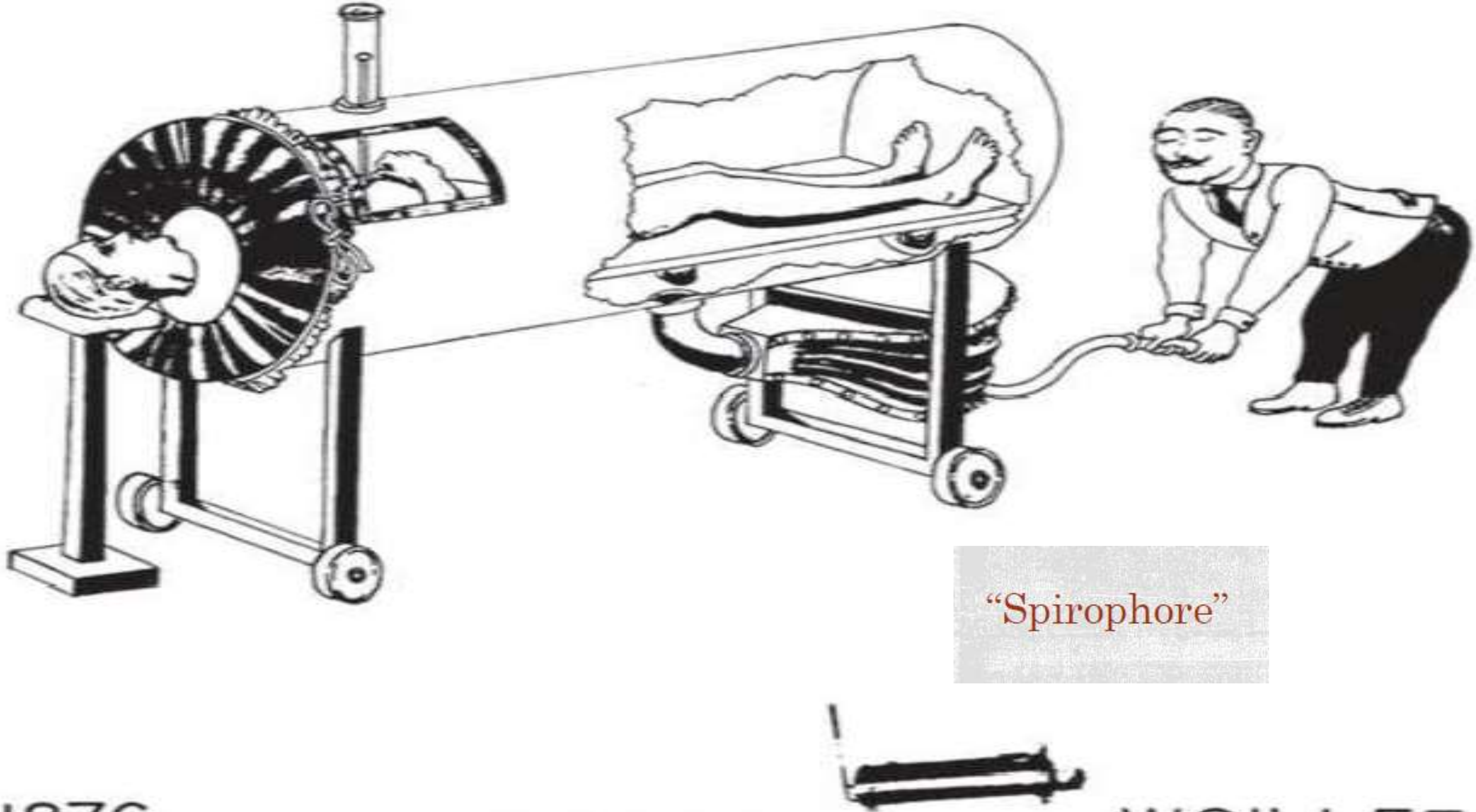
History of mechanical ventilation

- An unknown philosopher stated "The lungs are the center of the universe and the seat of the soul".
- The earliest reference for attempts to restore breathing was about 3150 BC when Egyptian physicians tried to save drowned victims by placing a reed in the throat and blowing into the lungs . The Chinese in 2000 BC described lien ch'i, as a transfer of inspired air into the "soul" (life): mouth positive pressure.

first American tank respirator



1864 NO. 1 — EMERSON EXHIBIT JONES



"Spirophore"

1876 NO. 2 – EMERSON EXHIBIT WOILLEZ

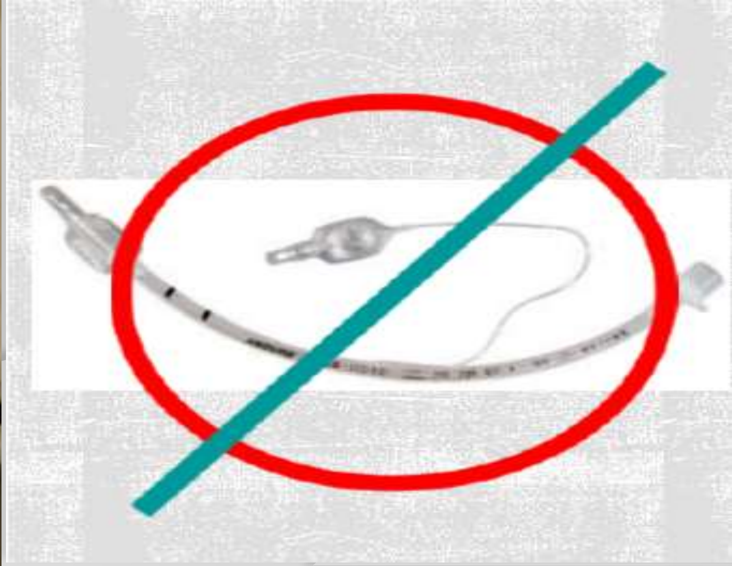

Thank You
For Your
Attention

Non-invasive ventilation(NIV)

ICU L4

NIV

- Non-invasive ventilation (NIV) refers to the administration of ventilatory support without using an invasive artificial airway (endotracheal tube or tracheostomy tube).
- Non-invasive ventilation (NIV) augments spontaneous ventilation using the tight-fitting nasal or oronasal mask without endotracheal intubation. This can be used in a large number of conditions if there is no contraindication. The application of NIV should not delay clinically indicated endotracheal intubation.



Advantages and disadvantages

- the advantages of being readily taken on and off to facilitate weaning, maintaining some ability to communicate, and avoids the complications of sedation and ventilator-associated pneumonia.
- The main disadvantages of NIV are no direct protection of the airway, no deep suctioning below the vocal cords, limited ability to apply high pressures and development of intolerance to the mask over time.

NIV

Interfaces

- There are 6 types of interfaces that can be used during NIV therapy in the acute setting. Choosing the appropriate interface for patients with ARF involves consideration of patient preferences and tolerance, and determining the correct size and fit is essential to successful ventilation.

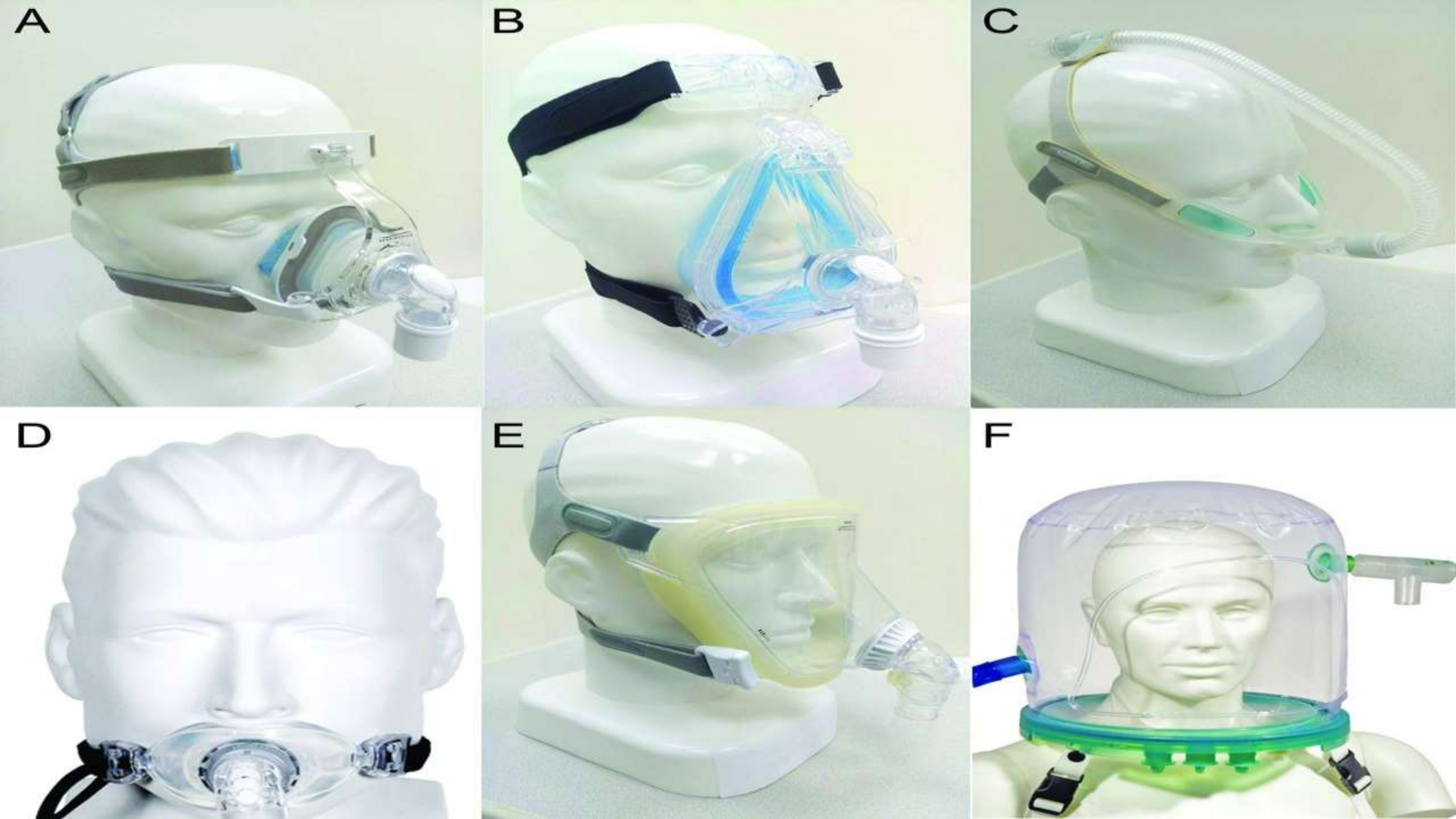
- Although interfaces are constructed from a variety of materials, the most commonly used material is silicone, although gel masks are available from some manufacturers as well.

Types of interfaces

- **Nasal mask:** this mask covers the nose only and rests on the upper lip, the sides of the nose, and the nasal bridge (fig. A).
- **Oro-nasal mask** (also referred to as a face mask): this mask covers the nose and mouth and rests on the chin, the sides of the nose and mouth, and the nasal bridge (fig. B).
- **Nasal pillow mask**: this mask fits on the rim of the nostrils. This type of mask is usually recommended for individuals who find nasal or oro-nasal masks uncomfortable or experience skin breakdown on the nasal bridge. Nasal pillows are used mainly in stable patients with sleep-disordered breathing (fig. C).

Types of interfaces

- **Oral mask**: this mask fits inside the mouth between the teeth and lips and has a tongue guide to prevent the tongue from obstructing the airway passage. This type is not common in practice (fig. D).
- **Total face mask**: this mask covers the whole face and is used mainly in patients with AHF (fig. E).
- **Helmet**: the helmet is a transparent hood that covers the entire head and face of the patient and has a rubber collar neck seal. It is used as an alternative to the oro-nasal mask in patients with acute hypoxemic respiratory failure or acute cardiogenic pulmonary edema in certain countries. it was developed to improve tolerability and reduce complications in patients with ARF on NIV. it is not commonly used in patients with acute hypercapnic respiratory failure (fig. F).


A
B
C
D
E
F

NIPPV Interfaces

NIPPV
Interface
(Nasal)

Nasal masks (general advantages)

- Best suited for more cooperative patients
- Better in patients with a lower severity of illness
- Not claustrophobic
- Allows speaking, drinking, coughing, and secretion clearance
- Less aspiration risk with emesis
- Generally better tolerated

Nasal masks (cautions, disadvantages)

- More leaks possible (eg, mouth breathing or lacking teeth patients)
- Effectiveness limited in patients with nasal deformities or blocked nasal passages

Interfaces (OroNasal)

Oronasal masks (general advantages)

- Best suited for less cooperative patients
- Better in patients with a higher severity of illness
- Better for patients with mouth-breathing
- Better in edentulous patients
- Generally more effective ventilation

Oronasal masks (cautions, disadvantages)

- Claustrophobic
- Hinder speaking and coughing
- Risk of aspiration with emesis

Interfaces (Helmet)

Clinical criteria for using NIPPV

- Moderate to severe respiratory distress
- Tachypnea (respiratory rate > 25/min)
- Accessory muscle use or abdominal paradox
- Blood gas derangement pH < 7.35, $PaCO_2$ > 45 mmHg
- PaO_2/FiO_2 < 300 or SpO_2 < 92% with FiO_2 0.5

Contraindications

- Non-availability of trained medical personnel
- Inability to protect the airways—comatose patients, patients with cerebrovascular accident or bulbar involvement, confused and agitated patients, upper airway obstruction
- Hemodynamic instability—uncontrolled arrhythmia, patients on very high doses of inotropes, recent myocardial infarction
- Inability to fix the interface—facial abnormalities, facial burns, facial trauma, facial anomaly
- Severe gastrointestinal symptoms—vomiting, obstructed bowel; recent gastrointestinal surgery, upper gastrointestinal bleeding
- Life-threatening hypoxemia
- Copious secretions
- Conditions in which NIV has not been found to be effective

Monitoring

- The patient must be monitored very closely clinically (Table 1). All this must be documented every 15 min for the first hour in the clinical notes.

Table 1

Mask comfort
Tolerance of ventilator settings
Respiratory distress
Respiratory rate
Sensorium
Accessory muscle use
Abdominal paradox
Ventilator parameters
Air leaking
Adequacy of pressure support
Adequacy of PEEP
Tidal volume (5–7 mL/kg)
Patient–ventilator synchrony
Continuous oximetry (until stable)
ABG, baseline and 1–2 h, then as indicated

Complications of NIV and corrective action

Complications	Corrective action
• Mask discomfort • Excessive leaks around mask • Pressure sores	• Check mask for correct size & fit • Minimize headgear tension • Use spacers or change to a different mask • Use wound care dressing over nasal bridge
• Nasal or oral dryness or nasal congestion	• Add or increase humidification • Irrigate nasal passage with saline • Apply topical decongestants
• Aerophagia/gastric distension	• Use lowest effective pressure for adequate tidal volume • Use simethicone agents
• Aspiration	• Make sure patients are able to protect the airway
• Mucus plugging	• Ensure adequate hydration • Ensure adequate humidification • Avoid excessive O_2 flow rates (>20 L/Min) • Allow short breaks from NIV to permit directed coughing techniques
• Hypotension	• Avoid excessively high peak pressure ($\geq$20 cm H_2O)

Discontinuation of NIV

It is very important to know when to discontinue NIV and intubate and ventilate the patient.

- NIV failure.
  - Worsening mental status
  - Deterioration of pH and $PaCO_2$ after 1–3 h of therapy
  - Refractory hypoxemia—when even a brief discontinuation of NIV leads to significant fall in oxygen saturation
- Intolerance to NIV.
- Hemodynamic instability.
- Inability to clear secretions

Modes of NIV

- NIV is divided into two main types, negative-pressure ventilation (NPV) and noninvasive positive-pressure ventilation (NIPPV); the latter is further subdivided into several subtypes, including continuous positive airway pressure (CPAP), bilevel positive airway pressure (BiPAP), and volume-assured pressure support (VAPS).
- Choosing the initial mode of ventilation is based in part on past experience, in part on the capability of ventilators available to provide support, and in part on the condition being treated.

NIV-CPAP

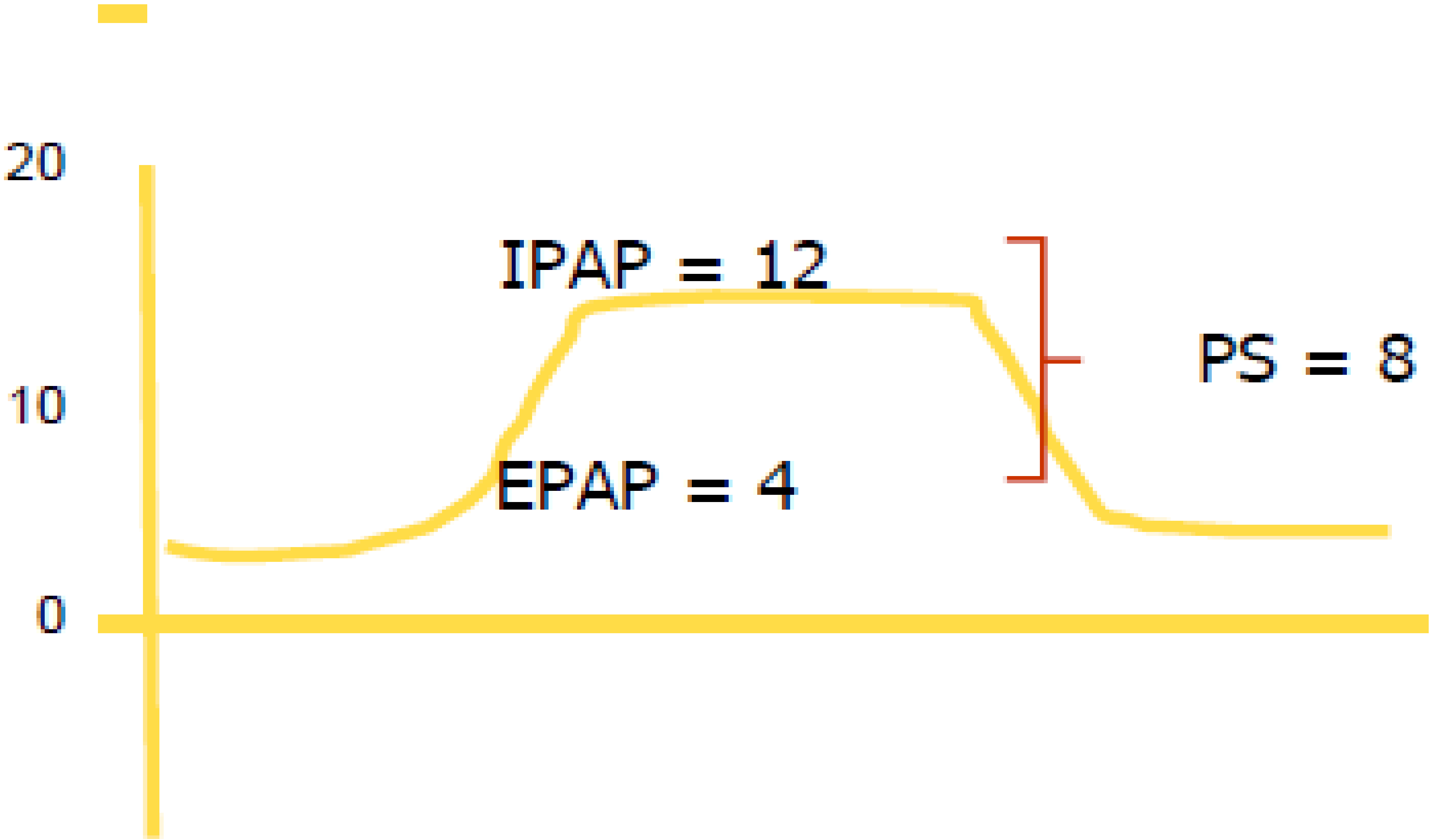
- Improve oxygenation by increasing FRC and recruiting collapsed alveoli
- It provides certain positive airway pressure throughout all phases of spontaneous ventilation
- It is similar to breathing with your head stuck out of a moving car
- CPAP » PEEP

- CPAP reduces preload and afterload. Hence it is a very effective for treatment of pulmonary oedema with low work of breathing.
- Pressures are usually limited to 5-12 cm of H2O, since higher pressure tends to result in gastric distension requiring continual aspiration through a nasogastric tube.

Pressure Waveform
CPAP

NIV- BiPAP

- IPAP + EPAP(CPAP)
- The higher pressure augments alveolar ventilation and CO_2 clearance
- The lower pressure maintains alveolar recruitment
- *IPAP:* assists in improving tidal volume, thus decreasing CO_2
- *EPAP : improve FRC,* helps recruit more alveoli, thus increasing O_2. may reduce work of breathing associated with autopeep


20
10
0
IPAP = 12
EPAP = 4
PS = 8

- Differential in pressure between inspiration and expiration allows for better patient-ventilator synchrony and thus more comfort
- EPAP » PEEP
- IPAP –EPAP » PS
- Augments TV
- Reduces Atelectasis
- Reduces WOB

NIPPV for acute exacerbation of COPD

The largest amount of supportive evidence for the use of NIPPV (particularly bilevel) is in the management of COPD exacerbation. Complications arising from dynamic hyperinflation in this population lead to excessive elastic and resistive forces that increase respiratory muscle workload and ultimately lead to respiratory failure. Intubation and invasive mechanical ventilation become difficult because of the complicated lung mechanics associated withCOPD.

- The use of NIPPV in these patients results in lower failure rates compared to standard medical therapy, lower requirement for intubation, lower mortality and decreased length of stay in hospital.
- The level of applied EPAP helps to splint open airways at risk of collapsing, and the delivered pressure (IPAP) assists with the increased respiratory muscle workload.

NIPPV for acute cardiogenic pulmonary edema

The use of NIPPV for acute cardiogenic pulmonary edema (ACPE) is aimed at treating the respiratory complications related to the presence of pulmonary edema.

- The use of CPAP alone may increase the functional residual capacity, reduce atelectasis, improve respiratory system compliance, reduce right-to-left intrapulmonary shunting and improve cardiac output.
- However, because there is often an associated increased respiratory workload with ACPE, the use of bilevel NIPPV may be more appropriate for the patient to reduce the amount of respiratory distress.
- The patient presentation and response to therapy should therefore influence the choice of mode and pressures used.

NIPPV for ARDS

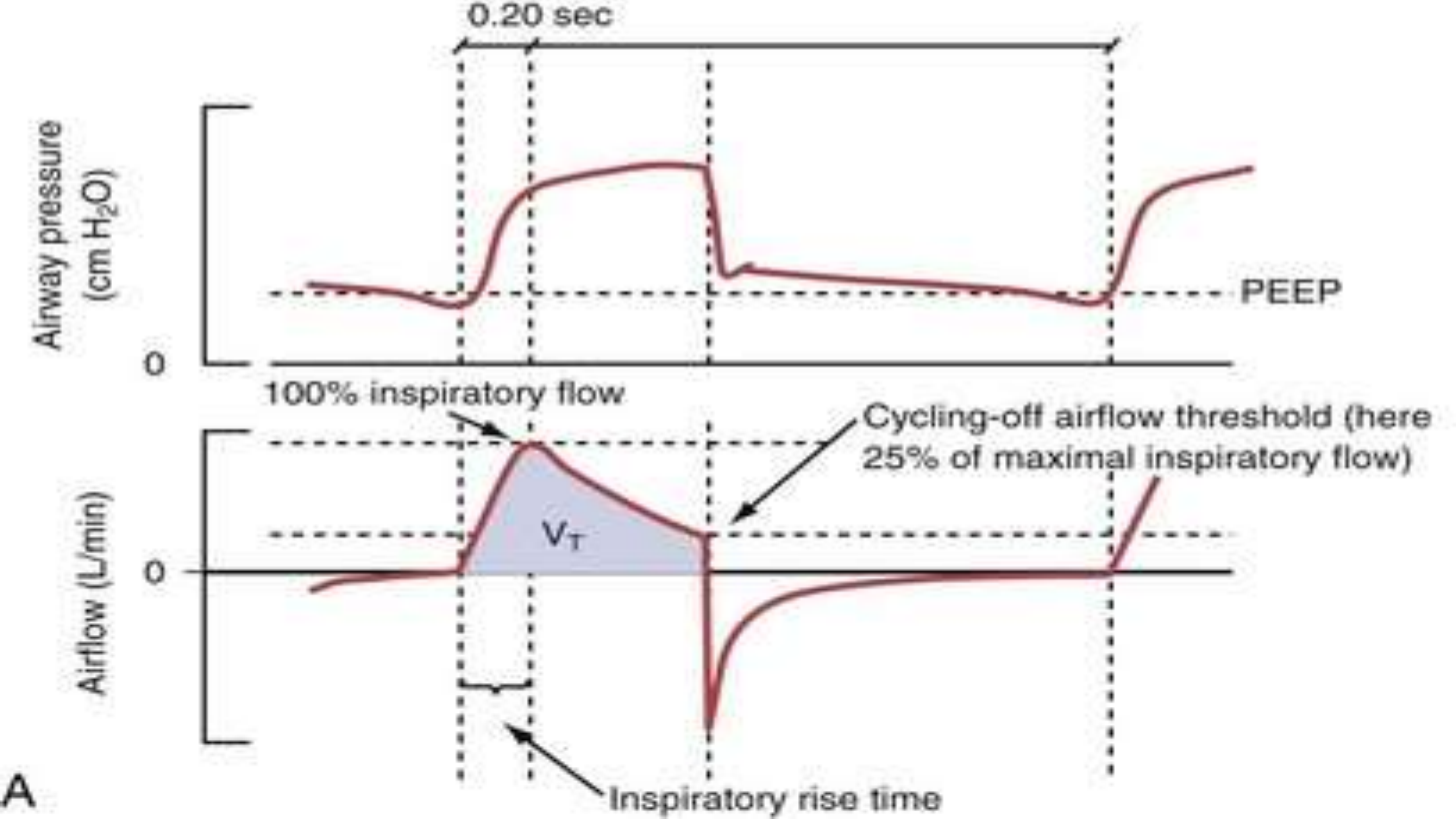
Acute respiratory distress syndrome (ARDS) is not a good candidate disease for NIPPV, since it is slow to resolve and patients have very severe pulmonary dysfunction, and the literature has been discouraging.

- While CPAP and NIPPV have been shown to improve gas exchange, they do not reduce the eventual need for intubation or mortality.
- Patients with ARDS are also prone to the effects of stress placed on the lungs by positive pressure ventilation and a controlled ventilatory approach targeting small lung volumes is more appropriate.

Fraction of inspired oxygen (FIO2)

- For all supplemental oxygen delivery devices, the patient is not just breathing the direct oxygen, but rather is breathing a **combination** of room air plus the oxygen from the supplemental device.
- The concentration of oxygen in the air that we breathe is called the **FiO2 (Fraction of inspired oxygen).** If a patient is not receiving any additional oxygen, we often say that the patient is on an FiO2 of .21 (21%) or ***"Room Air"***

- The I:E ratio is the ratio of the duration of inspiratory and expiratory phases
- A normal I:E ratio at rest is about 1:2, and so the default duration of the expiratory phase in mechanical ventilation is approximately twice the duration of the inspiratory phase.
- The **inspiratory** rise **time** determines the rate at which the **ventilator** achieves a target pressure (in pressure control and pressure support modes) or flow rate (in volume control modes).



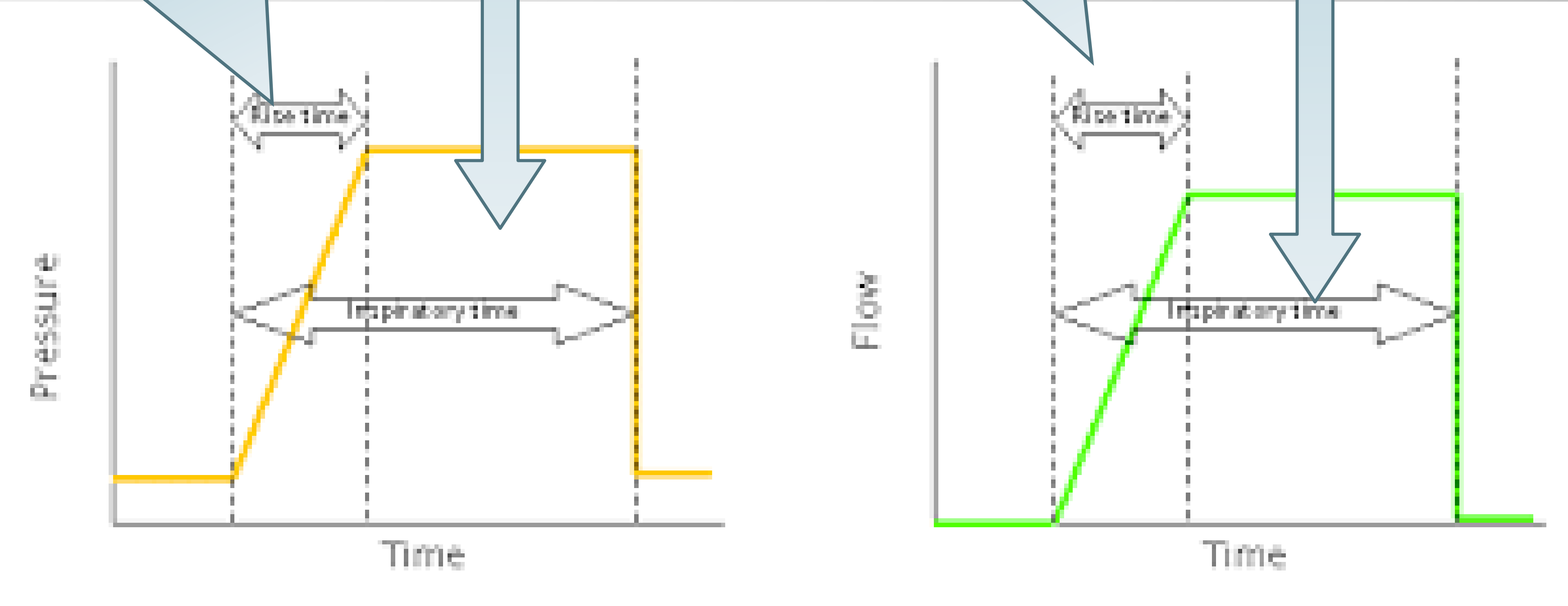
0.20 sec
Airway pressure (cm H_2O)
0
PEEP
100% inspiratory flow
Cycling-off airflow threshold (here 25% of maximal inspiratory flow)
Airflow (L/min)
0
V_T
Inspiratory rise time
A

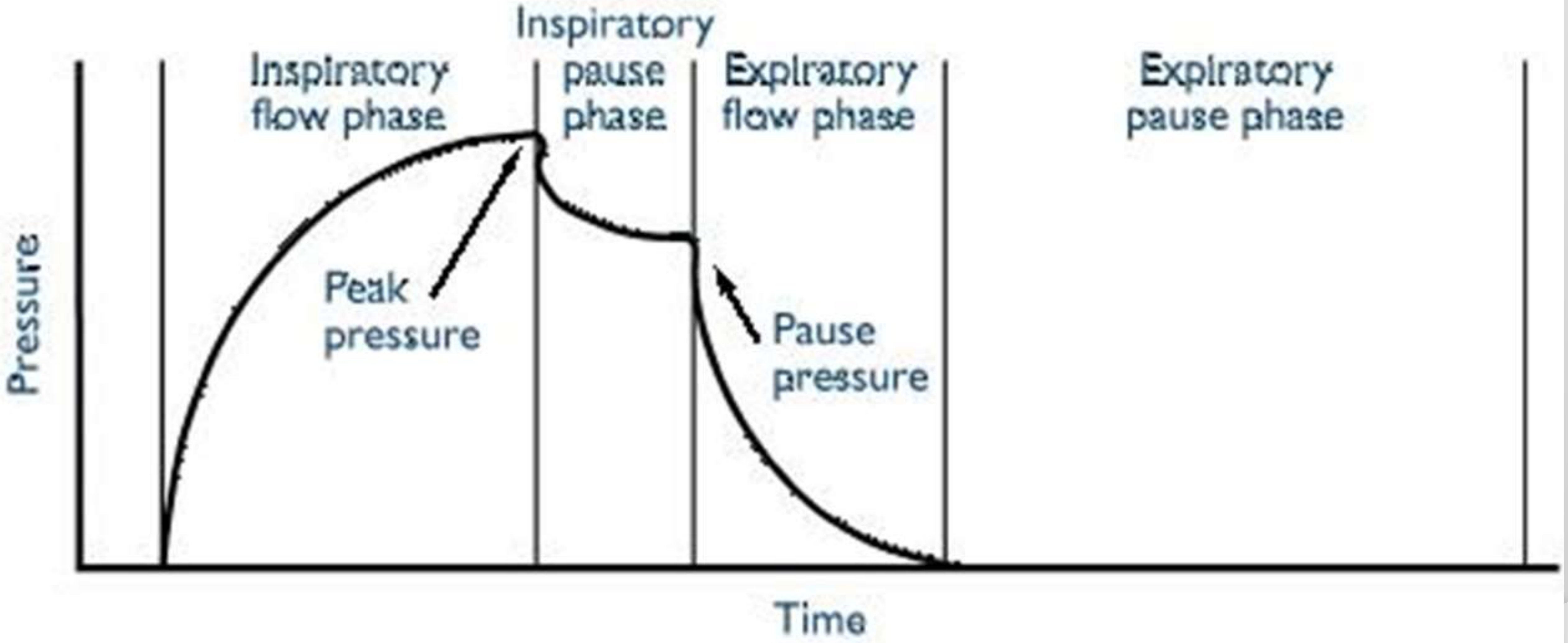
Inspiratory time
Tinsp (Inspiratory Time) seconds or ms

Ramp
Rise
time
ms

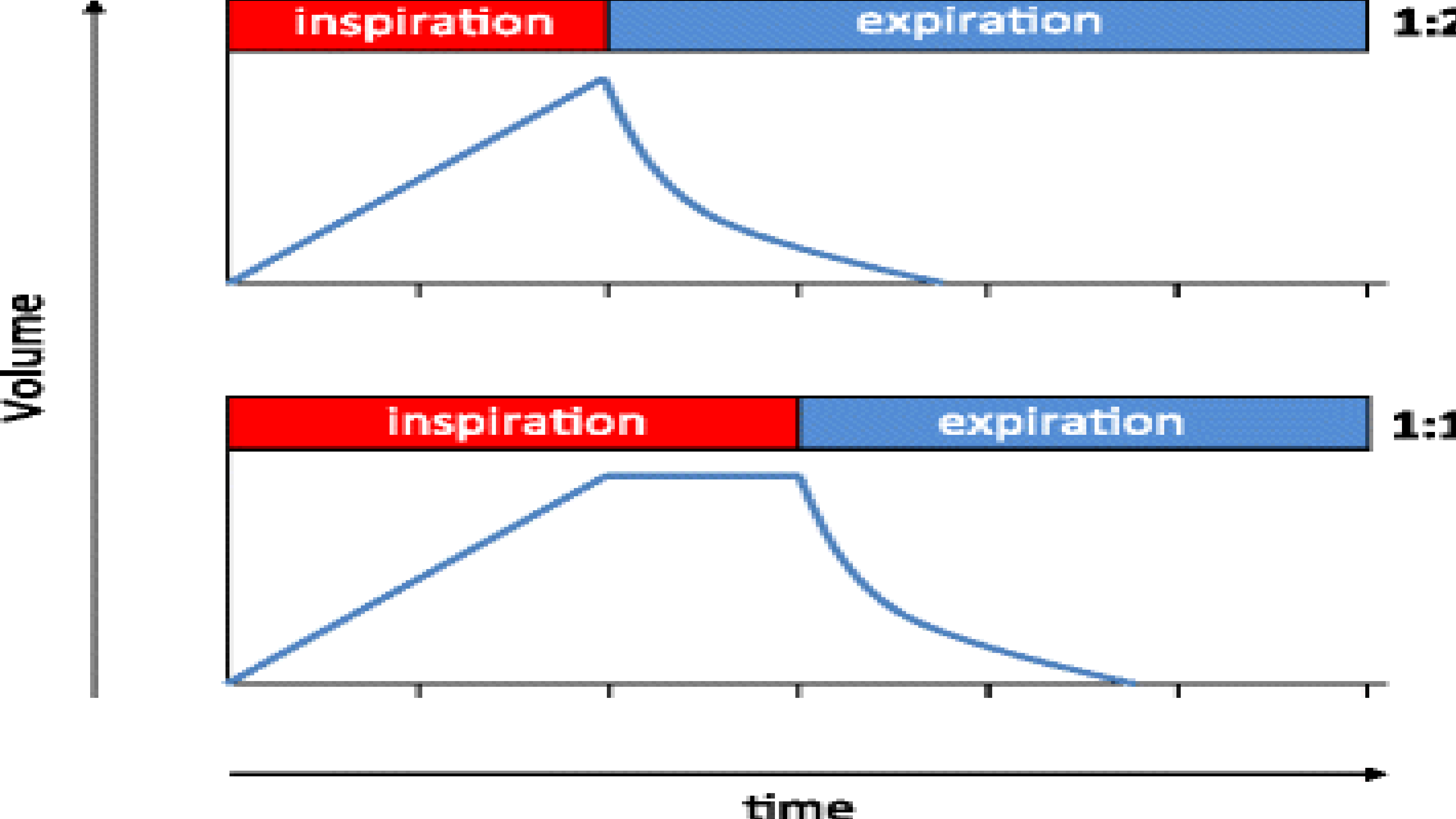
Rise
time

Inspiratory time





Phases of the respiratory cycle.[3]


inspiration
expiration
1:2
inspiration
expiration
1:1
Volume
time


Thank You
For Your
Attention

MECHANICAL VENTILATION(MV)

INVASIVE VENTILATION

L5

Introduction About Mechanical Ventilation

Mechanical ventilation is typically used after an invasive intubation, a procedure wherein an endotracheal or tracheostomy tube is inserted into the airway. It is used in acute settings such as in the ICU for a period of time during a serious illness. It may be used at home or in a nursing or rehabilitation institution if patients have chronic illnesses that require long-term ventilation assistance

Meaning of Mechanical Ventilation

In medicine, mechanical ventilation is a method to mechanically assist or replace spontaneous breathing

Main goal of mechanical ventilation

Reduce the work of breathing to allow for respiratory muscle rest and recovery

Indication of mechanical ventilation

- Respiratory failure: An inability of the heart and lungs to provide adequate tissue oxygenation or removal of carbon dioxide.
- Hypoxemic respiratory failure - lung failure just decrease in PaO_2
- Hypercapnic respiratory failure - pump failure decrease in PaO_2 and $PaCO_2$
- Neuromuscular diseases: Myasthenia Gravis, Guillain-Barre Syndrome
- Musculoskeletal abnormalities Such as chest wall trauma.
- Infectious diseases of the lung such as pneumonia, tuberculosis

- Obstructive lung disease in the form of asthma, chronic bronchitis or emphysema.
- Conditions such as pulmonary edema, atelectasis, pulmonary fibrosis.
- Patients who has received general anesthesia as well as post cardiac arrest patients requires ventilatory support until they have recovered from the effects of the anesthesia or out from a Dange

EFFECTS OF POSITIVE PRESSURE VENTILATION

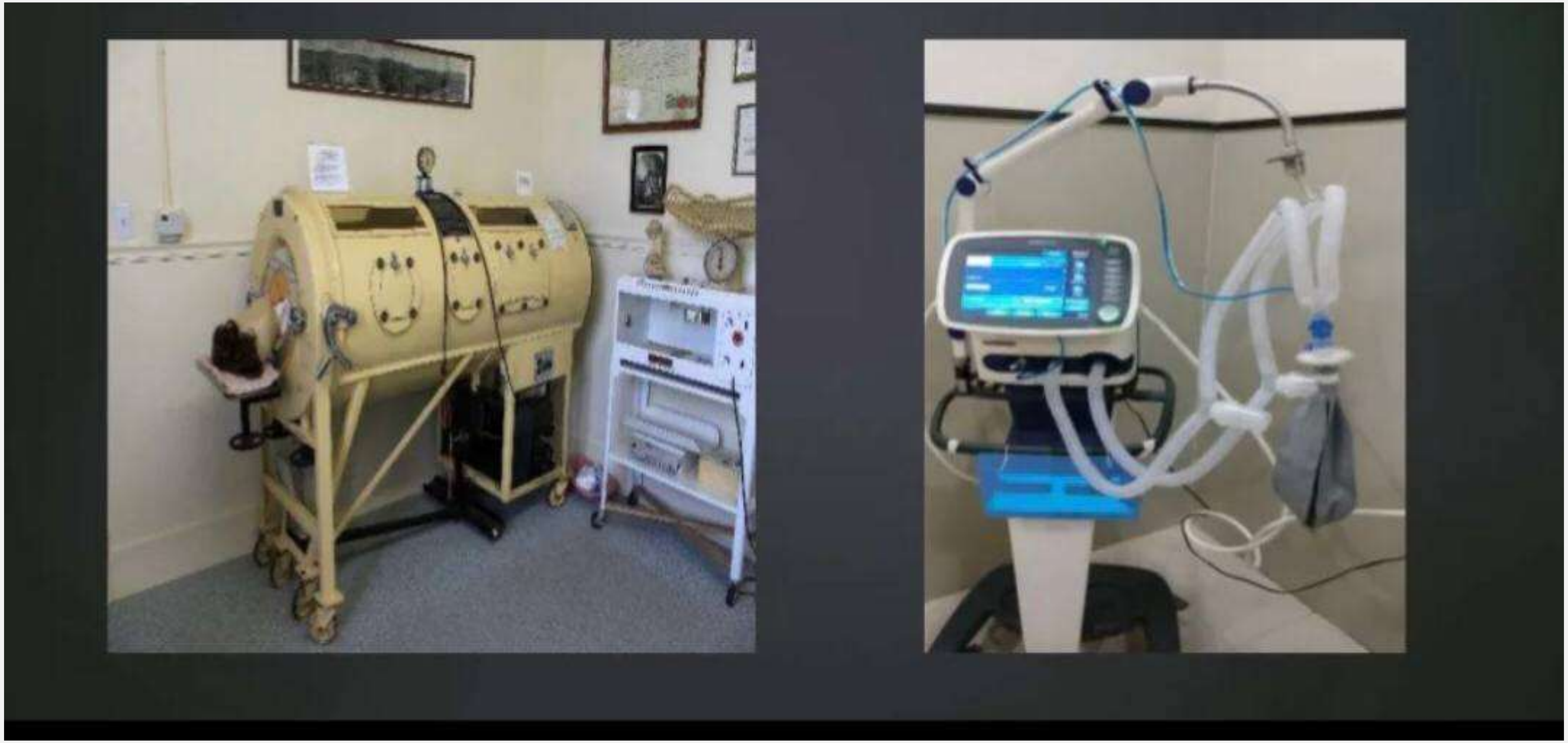
System	Effect
Respiratory / Pulmonary	↑ mPaw, alveolar and pleural pressures
Cardiovascular	• ↑ intrathoracic pressure -↓venous return - ↓ CO and SV • CVP is increased with PEEP • Effects are more pronounced with use of PEEP
Renal	Decreased CO – Decreased GFR – Reduced filtration and urine output
Hepatic	Reduced hepatic blood flow with PEEP (32% decrease with PEEP of 20 cm H2O
Gastrointestinal/ Abdominal	•Increase in Intra abdominal pressure – impaired circulation •Erosive oesophagitis, stress related mucosal damage

Basic information mechanical ventilation

- Respiratory rate (R.R) or frequency (F): is a number of breath per minute or 60 seconds.
- Tidal Volume (Vt): the volume of air that enter the lung in each breath for example 0.5 L or 500 ml.
- If we give 10 breath/min (60 second) that mean each breath will take (6 second).
- If we give 15 breath/min (60 second) that mean each breath will take (? Second).
- Minute ventilation (MV) = R.R * Tv

Types or forms of mechanical ventilation

Negative pressure ventilator positive pressure ventilator



Some important topics

1. Airway resistance physiology:

*Flow

* Airway size

*Airway length

2. Total cycle time (TCT):

It’s the time of inspiratory phase and expiratory phase (I time + E time = TCT).

What is the TCT if the R.R equal to 10b/min on A/C mode?

60s÷10b= 6 second and this equal to TCT.

Or if the rate is 20b/min the TCT is 3 second

But if we are in **pressure control** and the I time was 1 second and I: E ratio is 1:2 it mean the E time equal to 2 second and TCT is 3 second, in this case the rate is 20b/min.

Settings of Mechanical Ventilation

Mechanical Ventilator Settings regulates the rate, depth and other characteristics of ventilation.

Settings are based on the patient's status (ABGS, Body weight, level of consciousness and muscle strength)

phase variables

- There are four distinct phases of ventilator breath

Phase	Variable
Expiration – Inspiration	• Trigger
Inspiration	• Limit, Control
Inspiration - Expiration	• Cycle
Expiration	• Baseline

- Four parameters can be controlled or manipulated during each phase: Volume, Pressure, Flow, Time.

TRIGGER

TRIGGERING

- The ventilator needs to know when to start a breath. This is known as triggering. A ventilator breath may be triggered (initiated) by the patient (when breathing spontaneously) or triggered by the ventilator (after a set time)
- Ventilators use signals from various sites from within the ventilator circuit. The trigger signal can be sensed at the proximal endotracheal tube, in the inspiratory limb, and in the expiratory limb of the circuit. The trigger signal can be pressure, flow, time and neural signal.

- *Pressure triggering*: This requires the patient to generate a small negative inspiratory pressure (generally negative 1–3 cm H_2O). This negative pressure is sensed by the ventilator, causing the ventilator to start inspiration and deliver the next breath.
- *Flow triggering*: In this a minimum of flow around 10 L/m is always present in the ventilator circuit (Bias Flow). Flow triggering occurs when a flow transducer in the patient/ventilator systems senses a change in flow i.e. flow moves in to airway opening. Usually flow trigger is kept at 2 L/m. This is the preferable triggering mode in spontaneously breathing patient.

- *Time triggering*: A breath is time triggered when the patient does not initiate a breath and ventilator delivers a breath after a set time (depends on the set respiratory rate).This is the default setting in patient who do not have spontaneous breathing effort (e.g. on neuromuscular blocker).
- *Neural triggering*: It is currently developed to minimise the delay interval between the generation of the signal to breathe in the brain (sensed by diaphragmatic muscle signals) and the actual delivery of flow from the ventilator.

LIMIT OR INSPIRATORY PHASE

This is the phase of the ventilator delivered breath that begins with the initiation of the breath, and ends when the ventilator stops inspiratory flow. Inspiratory valve is open and the expiratory valve is closed. During the inspiratory phase, air flow is determined by variables called limit variables which could be either pressure or flow. The limit variable does not terminate the inspiration; it allows inspiration to continue till the cycling criterion is reached.

CYCLING: CHANGEOVER FROM INSPIRATION TO EXPIRATION

This is known as ‘cycling.’ Cycling defines how the ventilator recognizes that the inspiratory phase is over, and expiration starts with opening of the expiratory valve. Ventilators may cycle (changeover to expiration) when a certain tidal volume (set inspiratory tidal volume, volume cycled), inspiratory time (time cycled), flow rate (flow cycled). Pressure controlled ventilation is time cycled, volume controlled ventilation without pause is volume cycled and Pressure support mode is flow cycled.

PARAMETERS OF MECHANICAL VENTILATION

- RESPIRATORY RATE (F) :-NORMALLY 10-20B/M
- TIDAL VOLUME (VT) :-5-15ML/KG
- OXYGEN CONCENTRATION (FIO2):-21-90%
- I:E RATIO:-1:2
- FLOW RATE:-40-100L/MIN
- SENSITIVITY/TRIGGER:- Such as 0.5-1.5 CM H2O
- PRESSURE LIMIT:-10-25CM H2O
- PEEP - USUALLY, 5-10 CMH2O
- PRESSURE MAX : USUALLY 40 H2O

Modes of Mechanical Ventilation

- Controlled Mandatory Ventilation (CMV)
- Asst-Control Mandatory Ventilation (ACV)
- Synchronized Intermittent Mandatory Ventilation(SIMV)
- Continuous Positive Airway Pressure (CPAP)
- Pressure Support Ventilation (PSV)

Controlled mandatory ventilation(CMV)

the ventilator delivers

► preset tidal volume (or pressure) at a time triggered (preset) respiratory rate.

► As the ventilator controls both tidal volume (pressure) and respiratory rate, the ventilator "controls" the patients minute volume

Controlled mandatory ventilation(CMV)

- Patient can not breath spontaneously
- Patient can not change the ventilator respiratory rate
- Suitable only when patient has no breathing efforts
    - Disease or
    - Under heavy sedation and muscle relaxants

Controlled mandatory ventilation (CMV)

- ►Asynchrony and increased work of breathing.
- ► Not suitable for patient who is awake or has own respiratory efforts
- ► Can not be used during weaning

VOLUME CONTROL

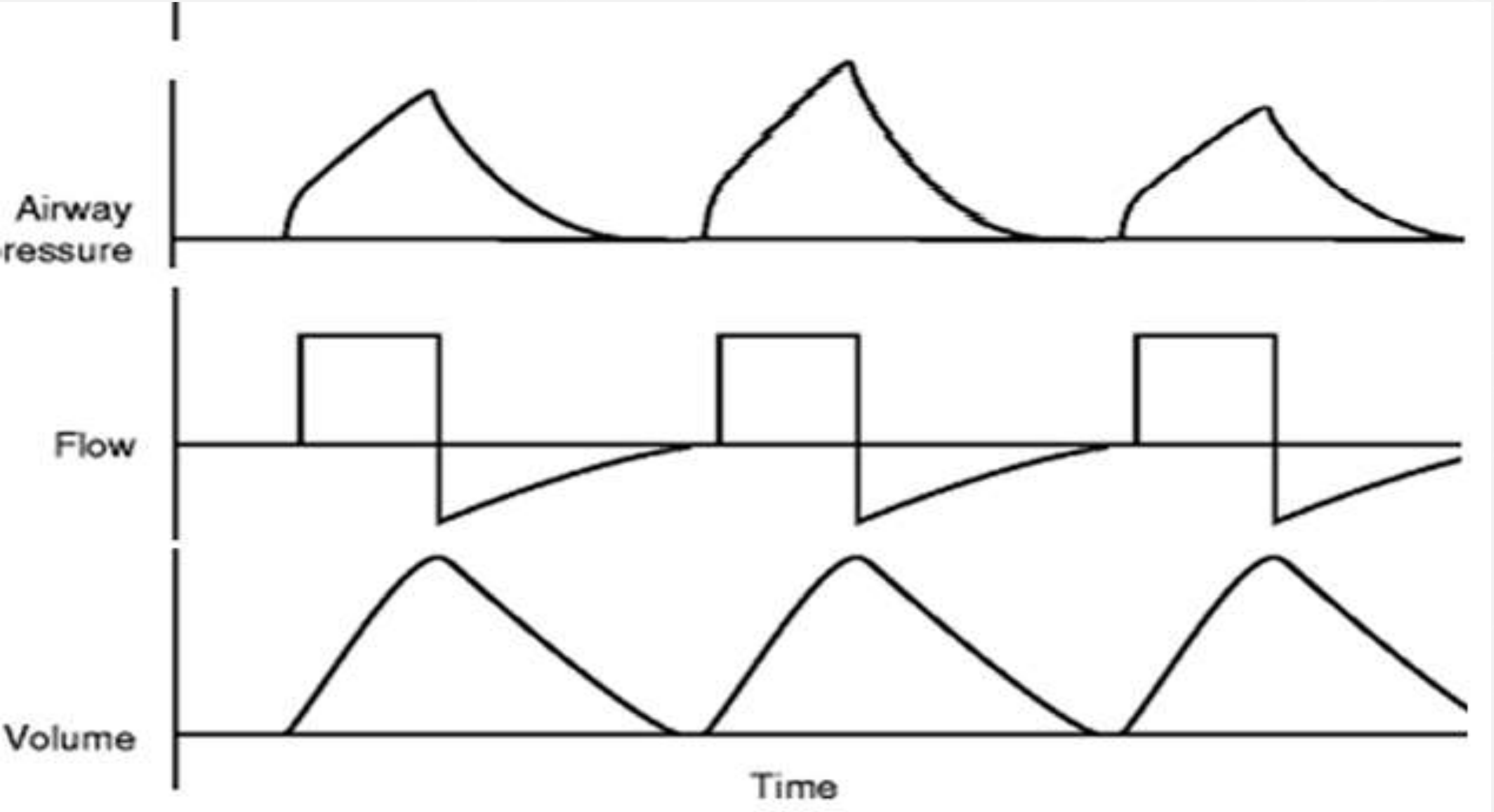
Advantages	Disadvantages
Predictable regulation of TV, MV	Higher incidence of barotrauma, volutrauma and VILI esp in ARDS and ALI
Better control over PaCO2 than PC	During assisted breath, flow rates may be insufficient leading to dys- synchrony and auto PEEP

- ❖ Ventilator-induced lung injury (VILI)
- ❖ Acute respiratory distress syndrome (ARDS)
- ❖ Acute lung injury (ALI)
- ❖ Positive end-expiratory pressure (PEEP)

- Settings:
  - V_T , RR, Flow/ Time and FiO2.
  - V_T set at 6 – 12 ml/kg IBW
- RR = 10 – 15 bpm
  - FiO2 lowest possible to achieve oxygenation
- I:E – 1:2 – 1:4
  - Flow rate is a measure of I:E, can be set separately in some models.

Monitoring and alarms:

- PIP relates to resistance and P_{Plat} relates to compliance.
- High pressure alarm
- Low pressure alarm 5 – 10 cm H20 below ventilating pres.
- Low pressure and volume alarms signify leak in system.


Airway
ressure
Flow
Volume
Time

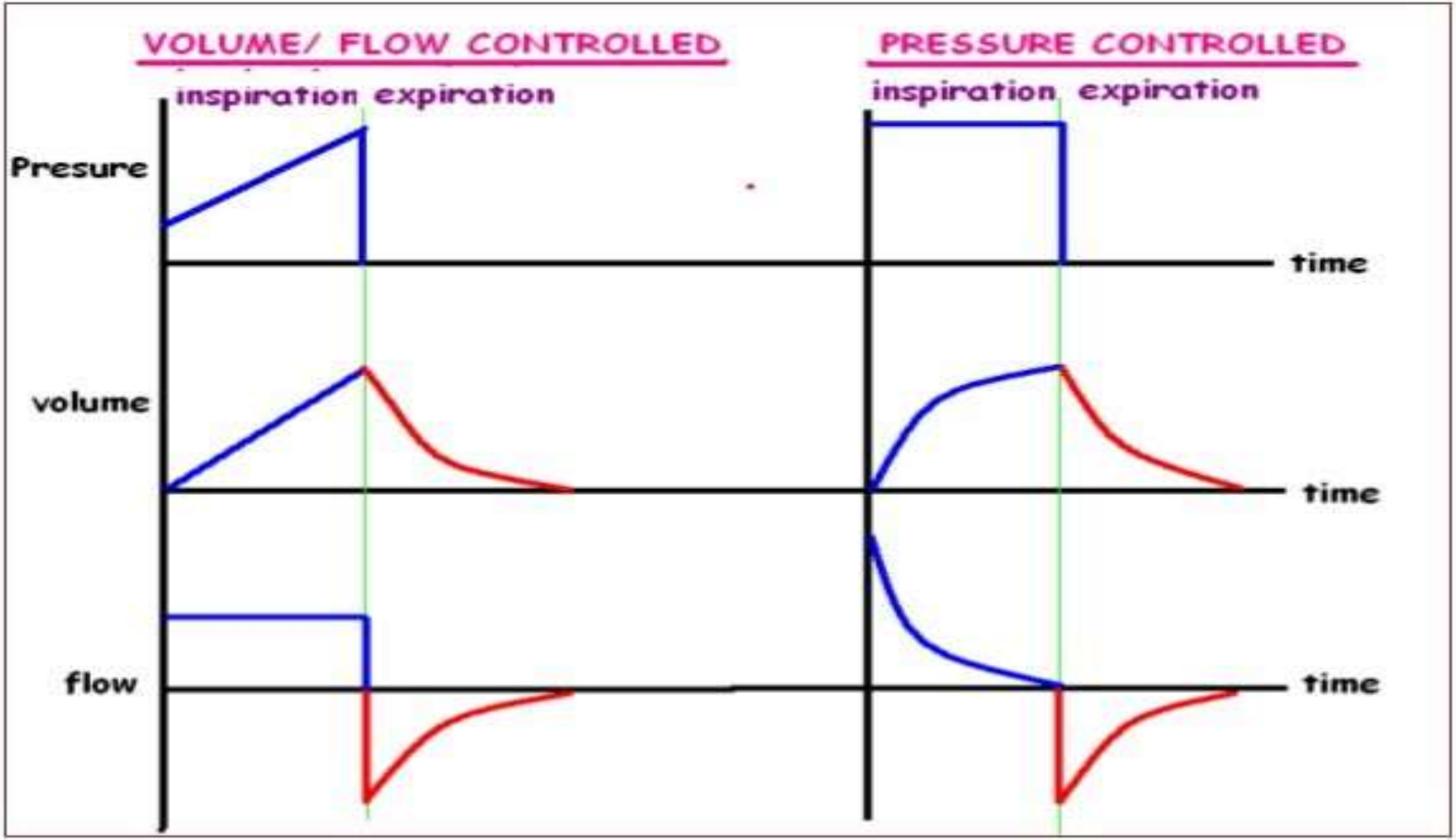
PRESSURE CONTROL

- Settings
  - Pressure - <30 cm H2O
  - RR – 10-15 bpm
  - I:E ratio: 1:2 - 1:4
  - Inspiratory time and flow rate depend on I:E ratio and RR

Advantages	Disadvantages
Avoids over distention and VILI, especially in ALI/ARDS	V_T and MV are variable, decrease in worsening conditions
Adequate flow: less flow dys- synchrony & auto PEEP	May promote hypoventilation
Time cycled: recruitment of alveoli	May cause increase in PaCO2

•Monitoring and alarms:

- Low Volume alarm: Set at the minimum acceptable V_T for the patient, signifies increased resistance or decreased compliance
- Low pressure alarm: Set at ~10 cm H2O below patients ventilation pressure, signifies leak in the system.



VOLUME/ FLOW CONTROLLED
inspiration expiration
Presure
volume
flow
PRESSURE CONTROLLED
inspiration expiration
time
time
time

Important definitions:

Barotrauma: injury resulting from high airway pressure.

Volume trauma: injury resulting from high volume inside the lungs

Exhaust valve: valve in a ventilator with a bellows that allows driving gas to exit the bellows housing when it is open.

Expiratory flow time: time between the beginning and end of expiratory gas flow.

Expiratory pause time: time from the end of expiratory gas flow to the start of inspiratory flow.

Expiratory phase time: time between the start of expiratory flow and the start of inspiratory flow. It is the sum of the expiratory flow and expiratory pause times.

Con…

Inspiratory phase time: time between the start of inspiratory flow and the beginning of expiratory flow. It is the sum of the inspiratory flow and inspiratory pause times.

Inspiratory: expiratory phase time ratio (i:e ratio): ratio of the inspiratory phase time to the expiratory phase time.

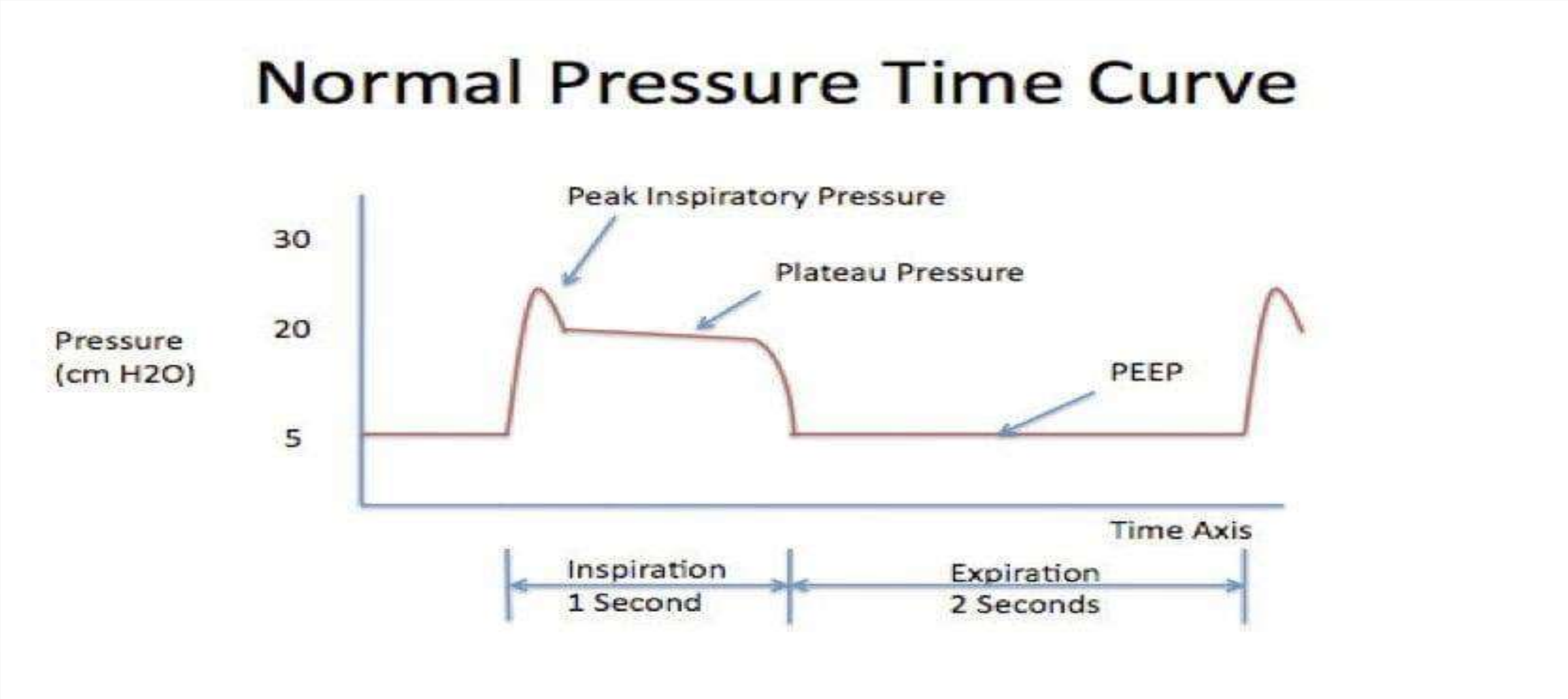
Minute volume: sum of all tidal volumes within 1 minute.

Peak pressure: maximum pressure during the inspiratory phase time.

Plateau pressure: resting pressure during the inspiratory pause. Airway pressure usually falls when there is an inspiratory pause. This lower pressure is called the plateau pressure.

Con….

Positive end-expiratory pressure (peep): airway pressure above ambient at the end of exhalation. This term is commonly used in reference to controlled ventilation.

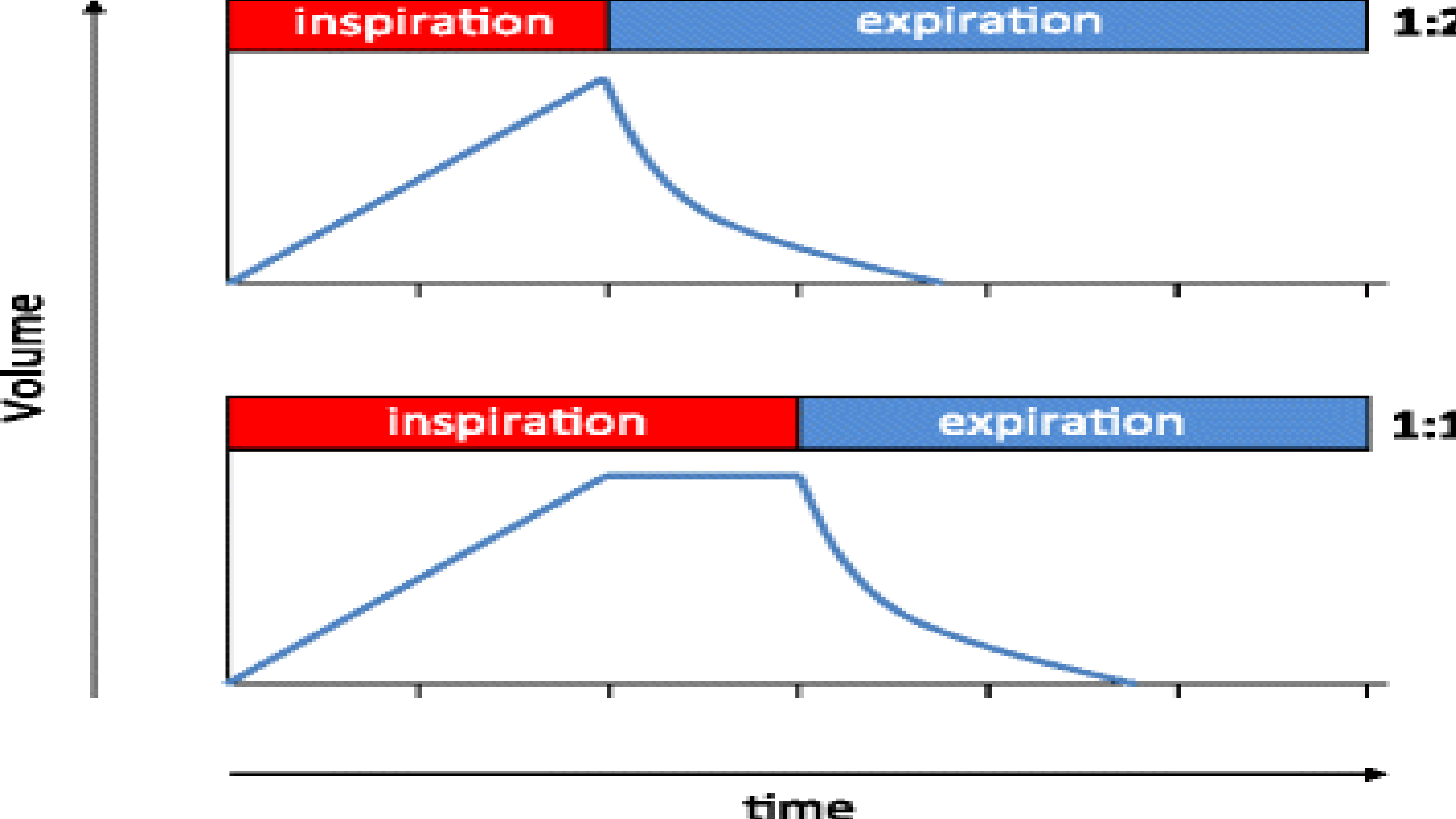


Thank you

ventilation
Mechanical ventilation(MV)
Invasive ventilation
Non-invasive ventilation(NIV)
L-6

I:E Ratio

- The I:E ratio is the ratio of the duration of inspiratory and expiratory phases
- A normal I:E ratio at rest is about 1:2, and so the default duration of the expiratory phase in mechanical ventilation is approximately twice the duration of the inspiratory phase.
- The inspiratory rise time determines the rate at which the ventilator achieves a target pressure (in pressure control and pressure support modes) or flow rate (in volume control modes).


inspiration
expiration
1:2
inspiration
expiration
1:1
Volume
time

Total cycle time (TCT) equals inspiratory time (T_I) plus expiratory time:

$$TCT = T_I + T_E$$

Respiratory rate (f) equals 1 min (60 seconds) divided by TCT.

$$f = \frac{1\ \text{min}}{TCT} = \frac{60\ \text{seconds}}{TCT\ (\text{seconds})} = \text{breaths/min}$$

a Calculate TCT from f.

$$TCT = \frac{60\ \text{sec}}{f}$$

- I:time (Inspiratory Time)
- E:time (Expiratory Time)
- I:E Ratio= 1:2 most common
- Respiratory Rate 15
  - 60 ÷ 15 = 4 (total cycle time)
  - I= 1 second, E= 3 seconds, I:E Ratio 1:3
- Respiratory Rate 12
  - 60 ÷ 12 = 5 (total cycle time)
  - I= 1 second, E= 4 seconds, I:E Ratio 1:4

Notes

Infant ReVel default I:Time= 0.3 seconds

Pediatric ReVel default I:Time= 0.7 seconds

Measured I:E ratios will have decimal points – They are actual real time measurements that change dependent on patients measured respiratory rate.

Examples= 1:3.2, 1:4.1, 1:2.7, 0.7:2.3

$$Ti = Vt(L)/flow(L/s)$$

A time cycled ventilator is set with the following parameter: Vt=500 f=12 I:E =1:4. If a constant flow waveform is used, what is the inspiratory gas flow?

Flow= 0.5L/1sec x 60sec/min=

30L/min

You are asked to ventilate a 63yr old female pt in severe CHF. Her ABG on a non-rebreather: ph 7.18, $PaCO_2$ 83, PaO_2 98 HCO_3 31. She is orally intubated with a 7.5 ETT with VT=400ML, RR=15, I:E = 1:4

Determine the following:

Ti

Ei

TCT

flow

You are asked to ventilate a 33yr old male pt in severe ARF. His ABG on a non-rebreather: ph 7.18, $PaCO_2$ 73, PaO_2 90 HCO_3 31. he is orally intubated with a 8 ETT with constant gas flow 40 L/min, RR=14, I:E = 2:3

Determine the following:

Ti(I time)

Te(E time)

TCT

VT

- Adjusting I:E Ratio

  - $\dot{V}_I$: ↑$\dot{V}_I$ → ↓T_I → smaller I:E ratio
  - $\dot{V}_I$: ↓$\dot{V}_I$ → ↑T_I → larger I:E ratio

  - VT: ↑VT → ↑TI → larger I:E ratio
  - VT: ↓VT → ↓TI → smaller I:E ratio

  - f : ↑RR → ↓T_E → larger I:E ratio
  - f : ↓RR → ↑T_E → smaller I:E ratio

VENTILATION
MECHANICAL VENTILATION(MV)
INVASIVE VENTILATION
NON-INVASIVE VENTILATION(NIV)
L-7

ASST-CONTROL MANDATORY VENTILATION (ACV)

- The ventilator provides the patient with a pre-set tidal volume at a pre-set rate.
- The patient may initiate a breath on his own, but the ventilator assists by delivering a specified tidal volume to the patient.
- Client can breathe at a higher rate than the preset number of breaths/minute

Cont..

- The total respiratory rate is determined by the number of spontaneous inspiration initiated by the patient plus the number of breaths set on the ventilator.

- If the patient want to breathe faster, he or she can trigger the ventilator and receive a full-volume breath.

- Often used as initial mode of ventilation When the patient is too weak to perform the work of breathing (e.g. when emerging from anesthesia)

Cont...

- The preset RR ensures that the patient receives adequate ventilation, regardless of spontaneous efforts.

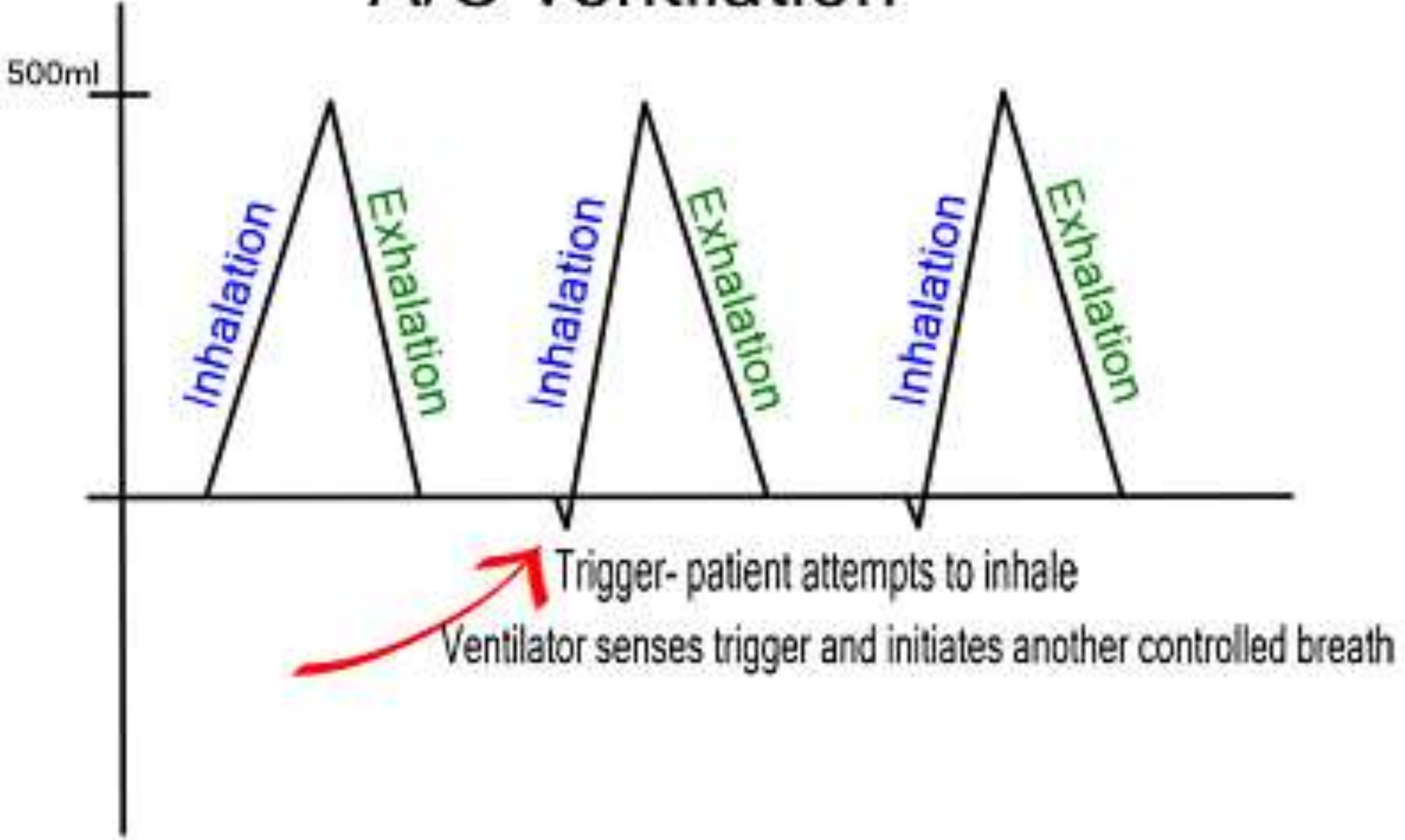
- The patient can breath faster than the preset rate but not slower
- Patient can control RR but not V_T or P_{aw}

- Advantages:
  - Very small WOB, if correct trigger sensitivity is set.
  - Allows patient to control MV (through RR) to normalise $PaCO_2$

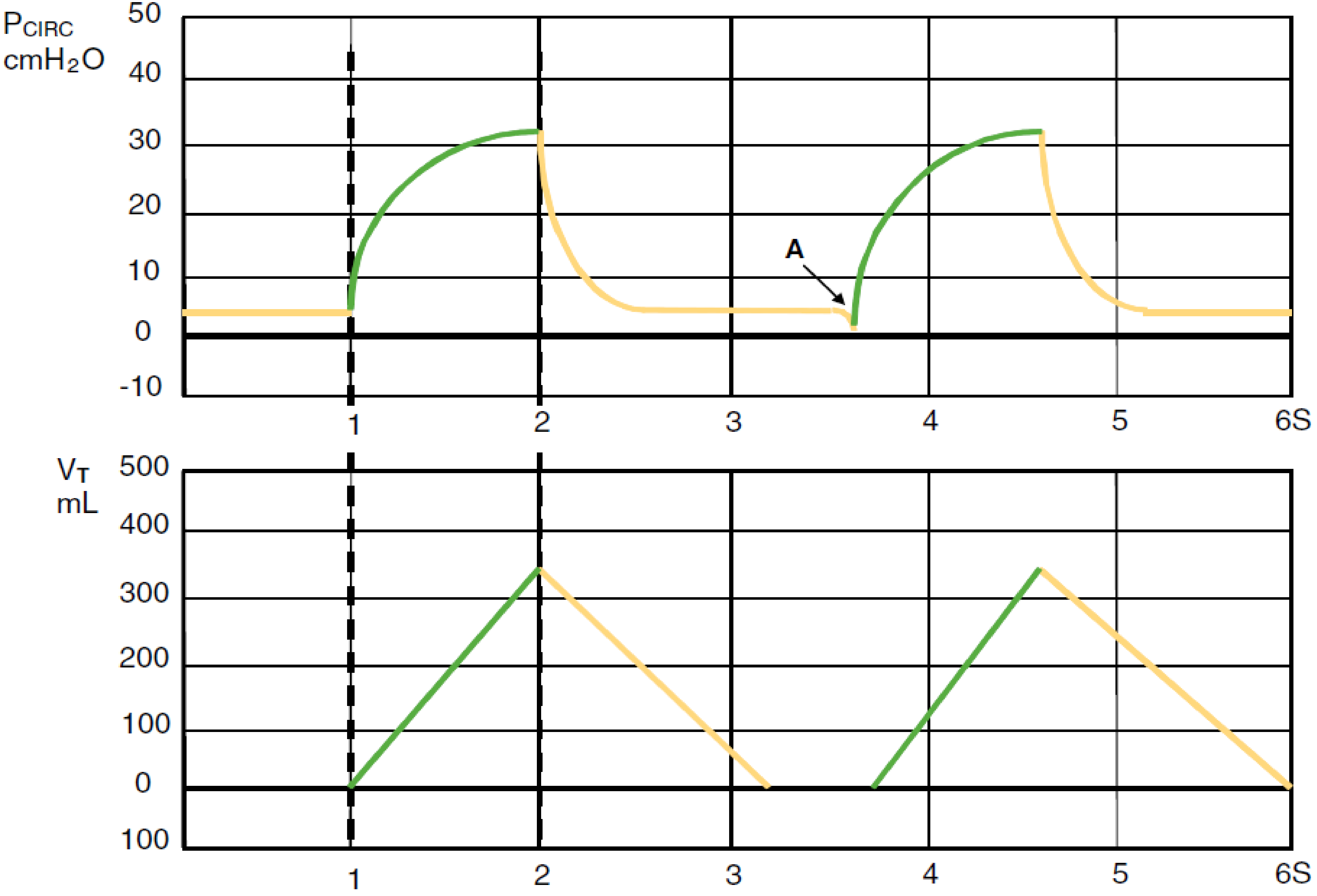
- Disadvantages:
  - Alveolar hyperventilation
  - Respiratory alkalosis
  - Higher pH and lower $PaCO_2$ compared to IMV [1]

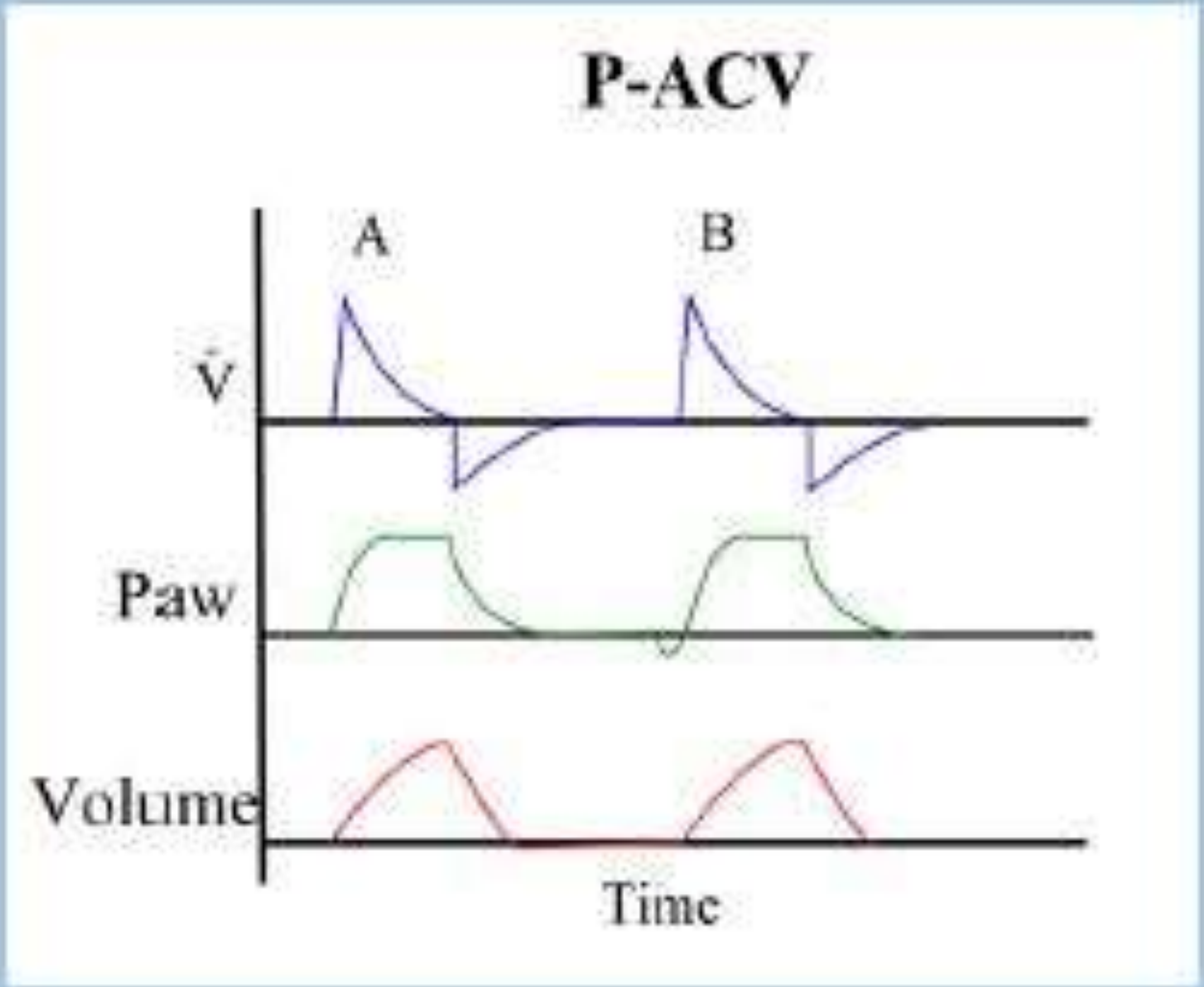
- Contraindications:
  - Irregular RR
  - Cheyne – Stokes respiration
  - Hiccoughs
  - Brainstem injury

A/C ventilation



Assist Control




P-ACV
A
B
V̇
Paw
Volume
Time

Synchronized Intermittent Mandatory Ventilation (SIMV)

- Breaths are given are given at a set minimal rate, however if the patient chooses to breath over the set rate no additional support is given
- One advantage of SIMV is that it allows patients to assume a portion of their ventilatory drive
- SIMV is usually associated with greater work of breathing than AC ventilation and therefore is less frequently used as the initial ventilator mode
- Like AC, SIMV can deliver set tidal volumes (volume control) or a set pressure and time (pressure control)
- Negative inspiratory pressure generated by spontaneous breathing leads to increased venous return, which theoretically may help cardiac output and function

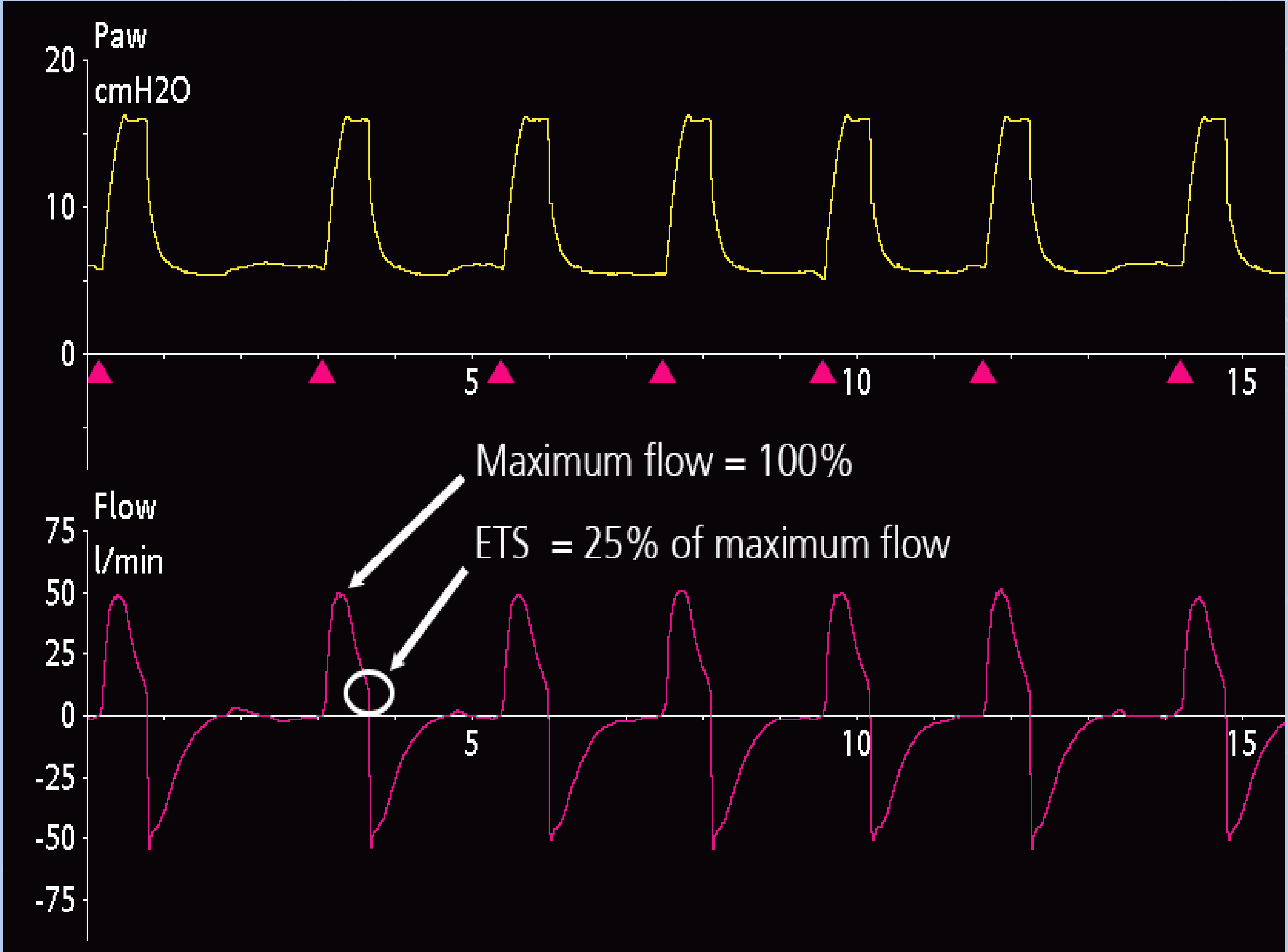
- The problem of ‘breath stacking’ and dys-synchrony was addressed by SIMV.
- But, problems of WOB and R_{aw} during spontaneous breath persisted.
- This is tackled with use of **Pressure Support** as adjunct.
- Inspiratory flow is provided to maintain a pressure plateau if inspiratory effort is sensed.
- Breath is terminated once patients inspiratory flow declines below a set limit.
- Thus, patient triggered, pressure limited, flow cycled assisted ventilation.
- SIMV and spontaneous mode always used with PSV in modern practice.

- Settings:

1. SIMV + PS – VCV
   - V_T - 6-12 ml/kg IBW
- RR – 10 – 15 bpm
- I:E – 1:2 – 1:4
   - FiO2 – titrated to PaO2
   - PS: PIP – P_{plat} (min 5 cm H2O
   - High pressure alarm
   - Low pressure/ vol alarm

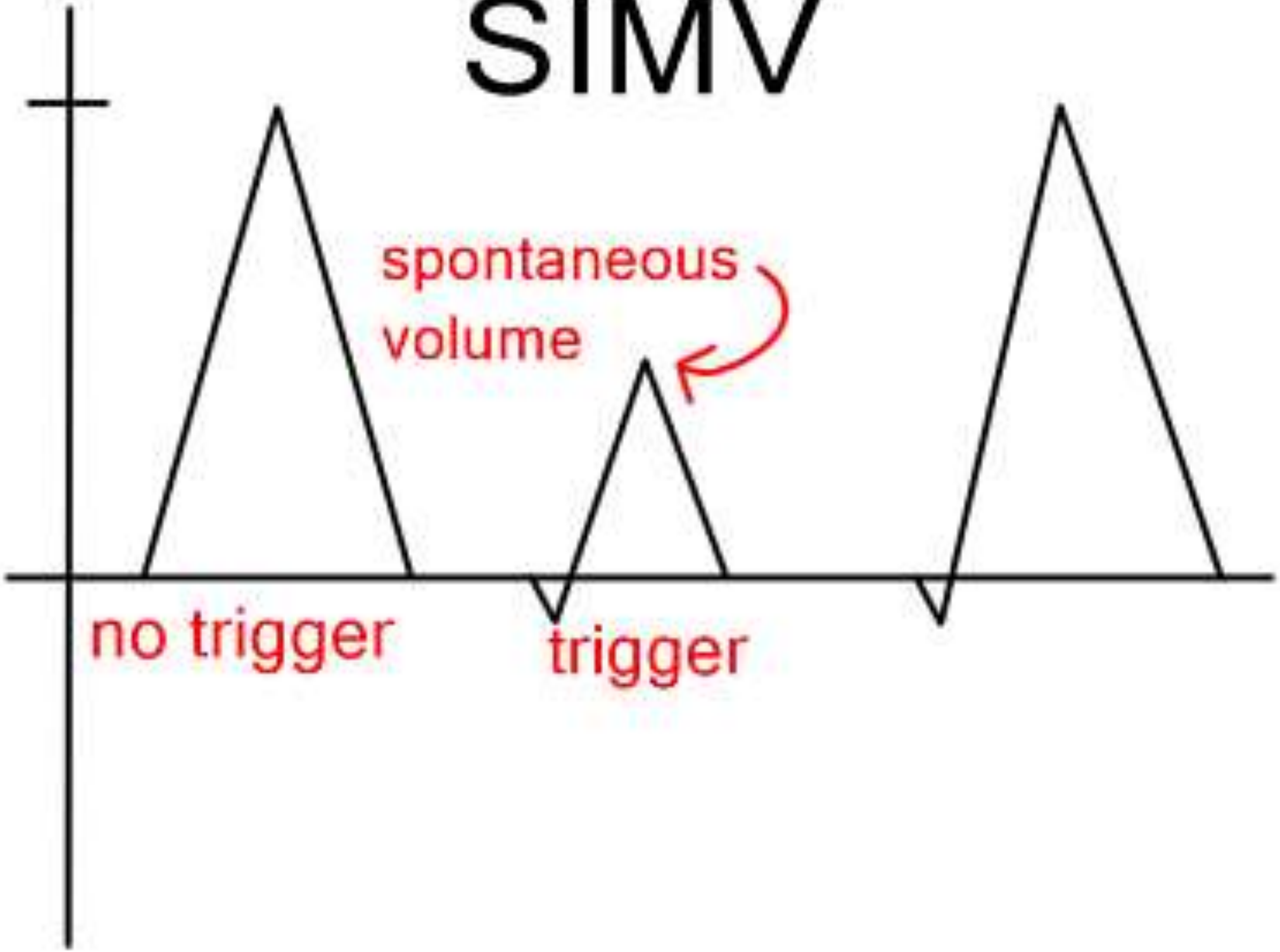
1. SIMV + PS – PCV
   - Pressure - < 30 cm H2O
   - Low pressure alarm
   - Low volume alarm

Advantages	**Disadvantages**
Maintains respiratory muscle strength/ avoids atrophy	May provide false sense of improvement of lung function
Reduces V/Q mismatch	Desire to wean too early and failed weaning.
Decreases mean airway pressure	
Facilitates weaning	
P.S: Increases V_T, decreases patients' RR, decreases WOB	



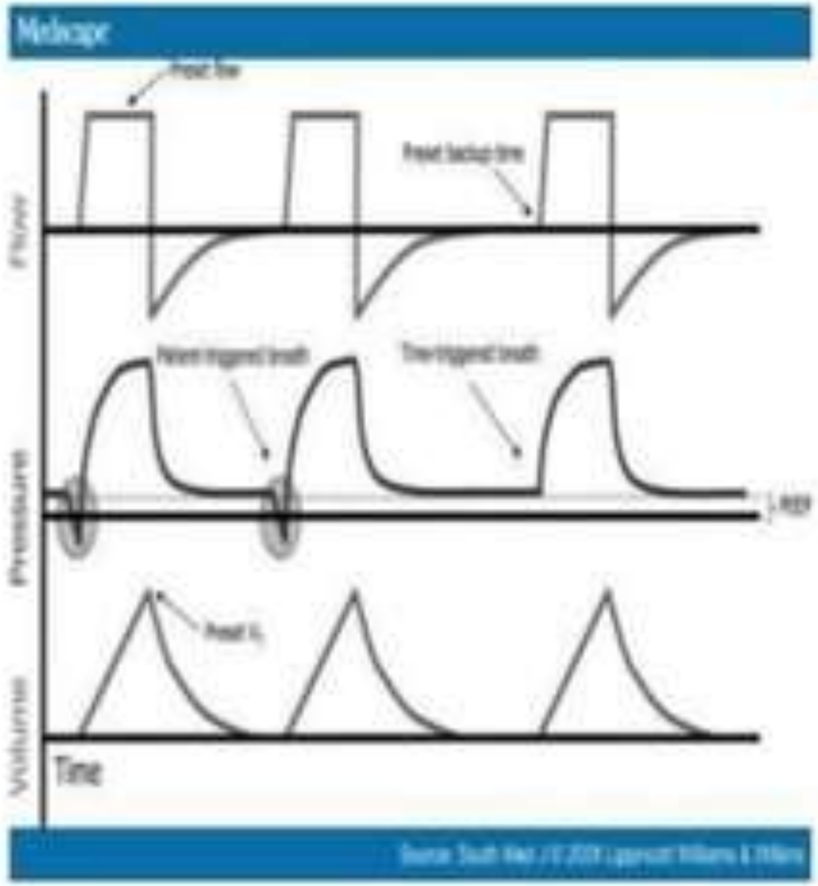
Paw
cmH2O
20
10
0
5
10
15
Maximum flow = 100%
ETS = 25% of maximum flow
Flow
l/min
75
50
25
0
-25
-50
-75
5
10
15

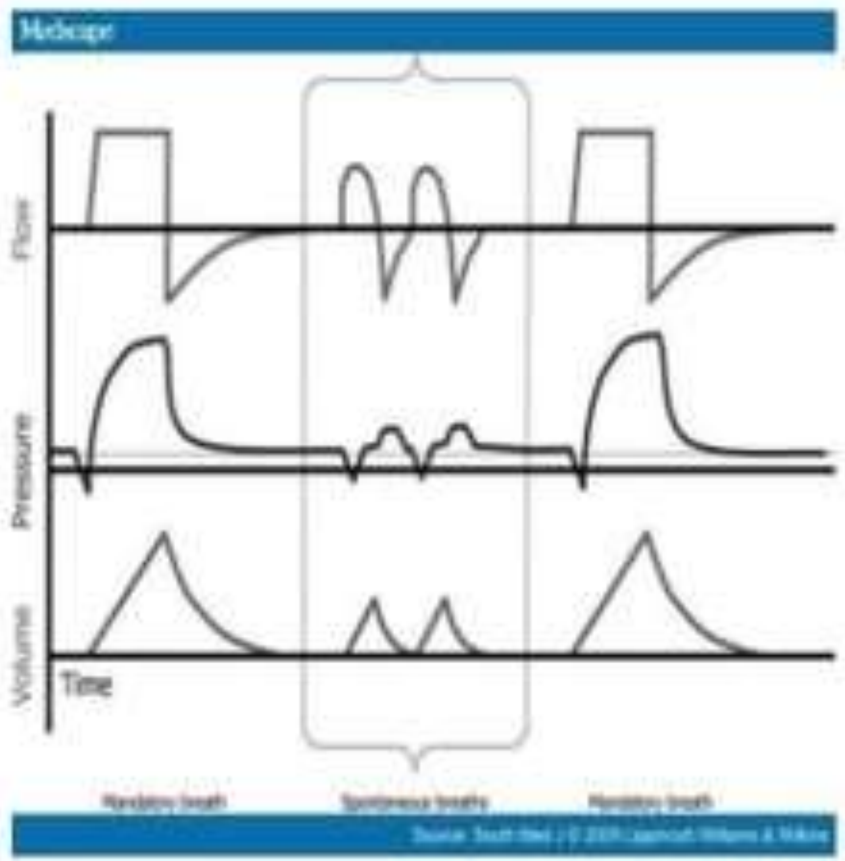
SIMV

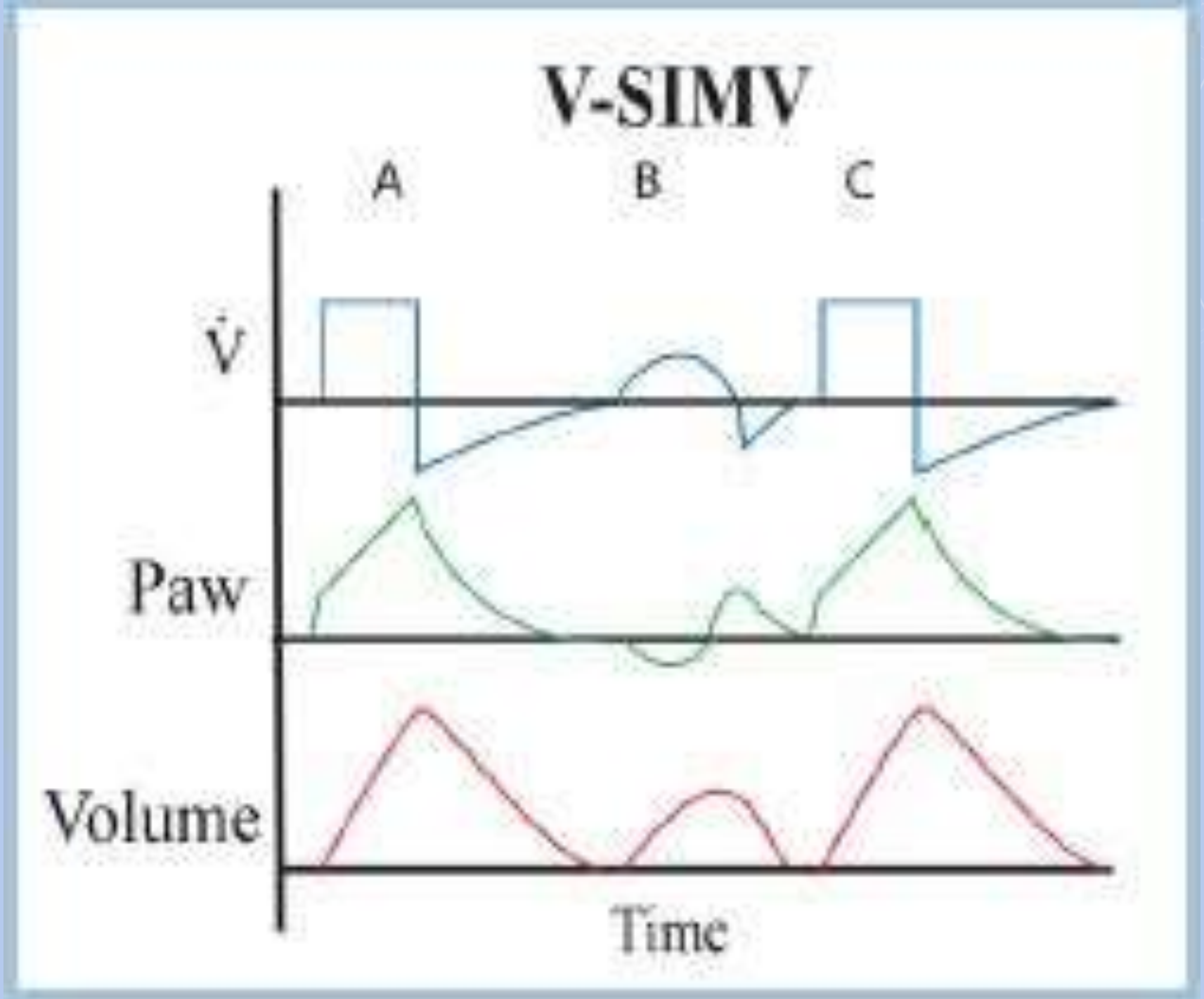


Assist Control

SIMV







V-SIMV
A
B
C
V̇
Paw
Volume
Time

Pressure Support Ventilation (PSV)

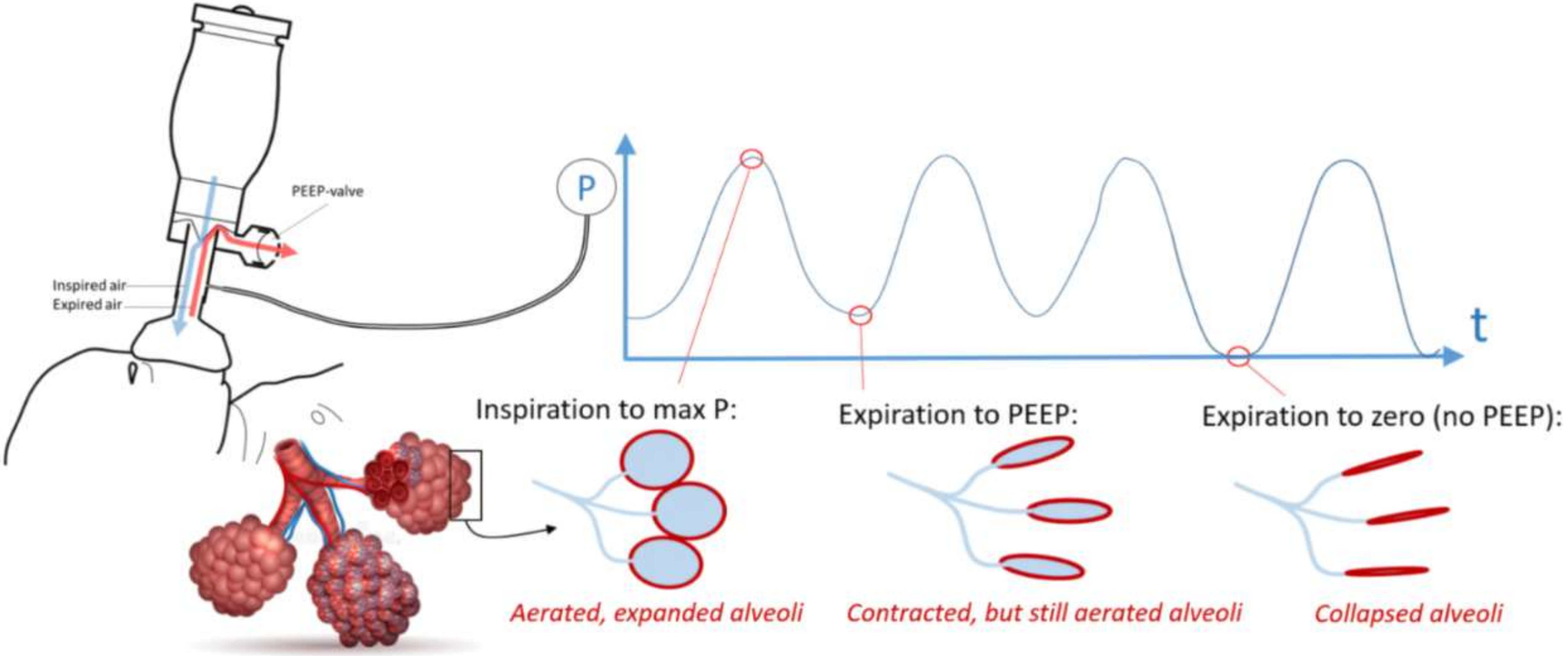
- The patient must initiate all pressure support breaths.
- During weaning using the PSV mode the level of pressure support is gradually decreased based on the patient maintaining an adequate tidal volume (8 to 12 mL/kg) and a respirator y rate of less than 25 breaths/minute.
- PSV weaning is indicated for :

  - Difficult to wean patients

  - Small spontaneous tidal volume

Positive End-expiratory Pressure PEEP

- The amount of positive pressure that is maintained at end-expiration.
- " Typical settings for PEEP are 5 to 20 cm H_2O
- PEEP increases oxygenation by preventing collapse of small airways
- It increases the functional residual capacity of the lungs
- A typical initial applied PEEP is 5 cmH20. However, up to 20 cmH20 may be used in patients undergoing low tidal volume ventilation for acute respiratory distress syndrome (ARDS)


PEEP-valve
Inspired air
Expired air
P
t
Inspiration to max P:
Expiration to PEEP:
Expiration to zero (no PEEP):
Aerated, expanded alveoli
Contracted, but still aerated alveoli
Collapsed alveoli

COMPLICATION

- Hypotension
- Pneumothorax
- Decreased Cardiac Output
- Nosocomial Pneumonia
- Increased Intracranial Pressure (ICP)
- Alarms turned off or nonfunctional
- Sinusitis and nasal injury
- Mucosal lesions Aspiration, GI bleeding, Inappropriate ventilation (respiratory acidosis or alkalosis, Thick secretions, Patient discomfort due to pulling or jarring of ETT or tracheostomy, High PaO2, Low PaO2, Anxiety and fear, Dysrhythmias or vagal reactions during or after suctioning, Incorrect PEEP setting, Inability to tolerate ventilator mode

Alarms and Common Causes

High Pressure Limit	Low Pressure	High Respiratory Rate	Low Exhaled Volume
▪Secretions in ETT/airway or condensation in tubing. ▪Kink in vent tubing ▪Patient biting on ETT ▪Patient coughing, ▪gagging, or trying to talk. ▪Increased airway pressure from bronchospasm or pneumothorax	▪Vent. tubing not connected. ▪Displaced ETT or trach tube.	▪Patient anxiety or pain ▪Secretions in ETT/airway ▪Hypoxia ▪Hypercapnia	▪Vent tubing not connected ▪Leak in cuff or inadequate cuff seal ▪Occurrence of another alarm preventing full delivery of breath

mode	trigger	limit	cycle
CMV VC			
CMV PC			
ACMV VC			
ACMV PC			
SIMV VC			
SIMV PC			
PSV			

REMEMBER TWO RULES.....

- An alarm should never be silenced until the cause has been investigated and corrected.

- If the source of the alarm cannot be determined, disconnect the client from the ventilator and use a hand-held resuscitation bag for manual ventilation with 100% oxygen until the problem can be resolved

During mechanical ventilation the oxygenation is determined by the FiO_2, PEEP and mean airway pressure and $PaCO_2$ is determined by minute

ventilation.

It is important to note that **mechanical ventilation** does **not** heal the patient. Rather, it allows the patient a chance to be stable while the medications and **treatments** help them to recover

Initial ventilator setting

Mode—assist/control (volume or pressure)	
Tidal volume	6–8 mL/Kg ideal body weight (see formula in Appendix B)
Inspiratory time	0.7–1.2 s
Inspiratory flow	Four times minute ventilation (approx)
Rate	12–20 breaths/min
PEEP	4–5 cm H_2O
FiO_2	1.0
Plateau pressure	<30 cm H_2O
Once the patient is stabilized	
FiO_2	To maintain PaO_2 more than 60 mmHg or SpO_2 more than 93–94% in normal lung and 88–92% in hypercapnic respiratory failure
PEEP	Set according to FiO_2 requirements (predetermined according to the degree of hypoxemia)
Plateau pressure	Recheck in an attempt to keep plateau pressure below 30 cm H_2O
Driving pressure (plateau-PEEP)	Keep below 13 cm H_2O

THANK YOU FOR ATTENTION!

Have a nice day!!!