Collage of Health and Medical Technology / AL_Kufa

Department of Anesthesia

Anesthetic Equipments

Third stage

BY :

B.M.T of Anesthesia and ICU

Anesthetic Breathing system (breathing circuit)

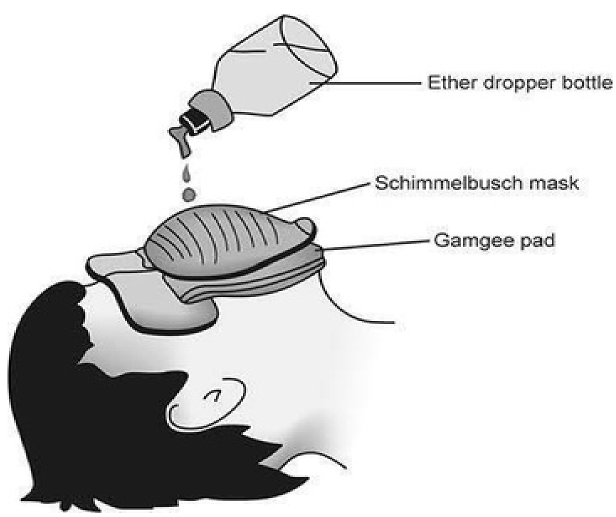
Abreathing system is defined as an assemblyofcomponents, which connect the patient's airway to the anesthetic machine creating an artificial atmosphere, from and into which the patient breathes. And Delivery O2 and inhaled An. From anesthesia machine to patient and remove CO_2 from exhaled gases. ***Breathing systems must fulfil three objectives:*** 1. Delivery of oxygen. 2. Removal of carbon dioxide from the patient. 3. Delivery of inhaled anaesthetic agents.

Properties of the ideal breathing system

1. Simple and safe to use.
2. Delivers the intended inspired gas mixture.
3. Permits spontaneous, manual and controlled ventilation in all age groups
4. Efficient, requiring low FGF rates.
5. Protects the patient from barotrauma.
6. Sturdy, compact and lightweight in design.
7. Permits the easy removal of waste exhaled gases.
8. Easy to maintain with minimal running costs.

Classification Of Breathing Systems (*McMohan in 1951*) *:*

- Open: No ***rebreathing*** (Nasal cannula and gauze with drop of anesthesia agent and allow venting)
- Semiclosed: Partial ***rebreathing*** (Mapleson)
- Closed: Total ***rebreathing*** (circle system) with CO_2 absorber



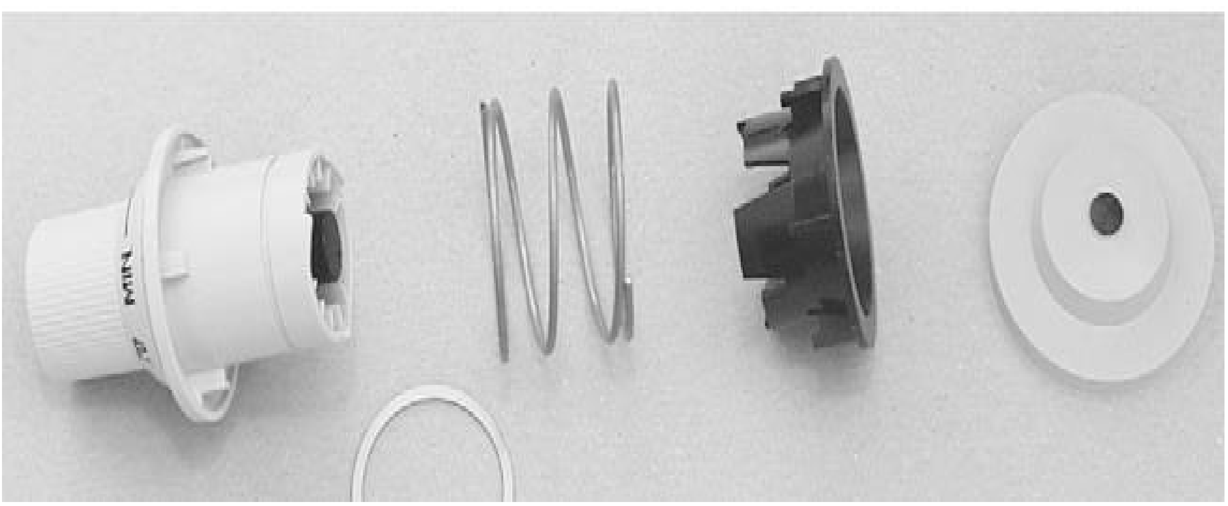
functional classification (***Conway2***) ***:***
classified according to the method used for CO2 elimination as:
- Breathing systems with CO2 absorber
- Breathing systems without CO2 absorber

Componentsofthe breathingsystems

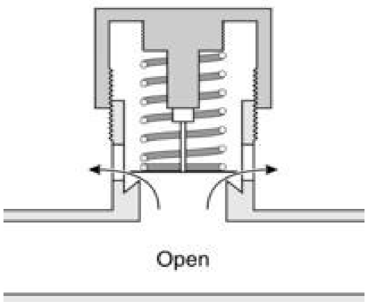
1. Adjustable Pressure Limiting (APL) Valve 2. Reservoir Bag 3. Tubings

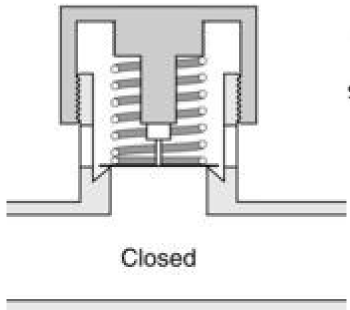
1. Adjustable Pressure Limiting (APL) Valve

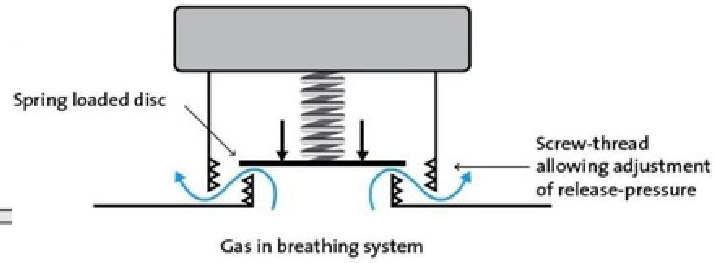
This is a valve which allowsthe exhaled gases and excess FGF to leave the breathing system . It does not allow room air to enter the breathing system. Synonymous terms for the APL valve are expiratory valve, spill valve and relief valve.



Components 1. Three ports: the inlet, the patient and the exhaust ports. The latter can be open to the atmosphere or connected to the scavenging system using a shroud 2. A lightweight disc rests on a knife-edge seating. The disc is held onto its seating by a spring. The tension in the spring, and therefore the valve's opening pressure, are controlled by the valve dial.

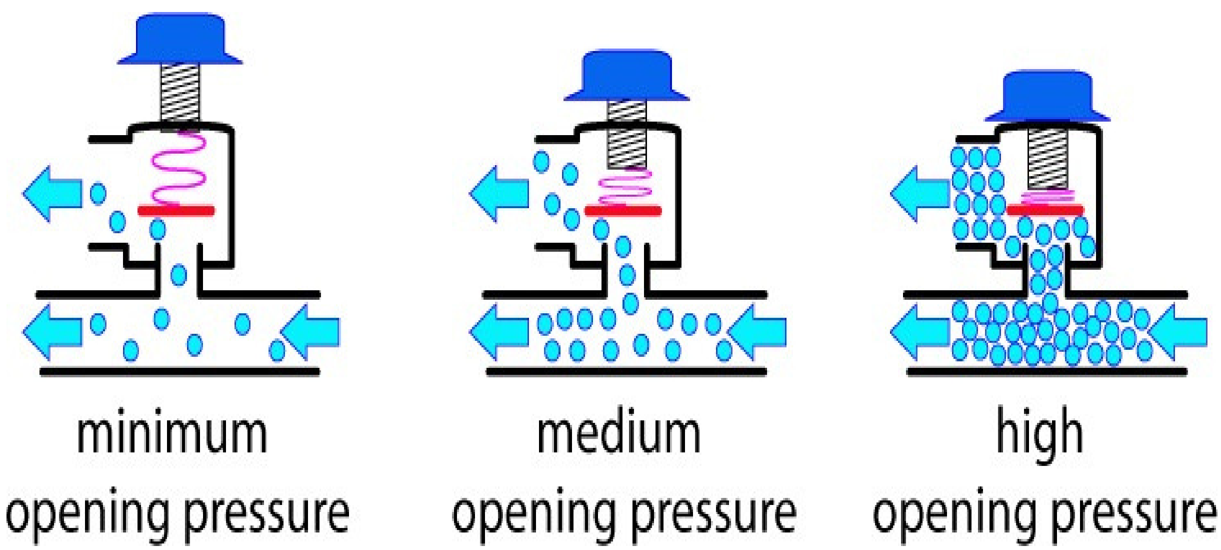






Mechanism of action

1. This is a ***one-way, adjustable, spring-loaded valve***. The ***spring*** is used to ***adjust*** the ***pressure*** required to ***open the valve***. The disc rests on a knife-edge seating in order to minimize its area of contact.
2. The ***valve allows gases to escape when the pressure in the breathing system exceeds the valve's opening pressure.***
3. During ***spontaneous*** ventilation, the ***patient generates a positive pressure*** in the system during expiration, causing the valve to ***open***. A pressure of less than 1 cm H2O (0.1 kPa) is needed to actuate the valve when it is in the open position.
4. During ***positive pressure ventilation***, a controlled leak is produced by adjusting the valve dial during inspiration. This allows control of the patient's airway pressure.



Problems in practice and safety features 1. Malfunction of the scavenging system may cause excessive negative pressure. This can lead to the APL valve remaining open throughout respiration. This leads to an unwanted enormous increase in the breathing system's dead space 2. The patient may be exposed to excessive positive pressure if the valve is closed during assisted ventilation. A pressure relief safety mechanism actuated at a pressure of about 60 cm H2O is present in some designs 3. Water vapour in exhaled gas may condense on the valve. The surface tension of the condensed water may cause the valve to stick. The disc is usually made of a hydrophobic (water repelling) material, which prevents water condensing on the disc.

2. Reservoir Bag

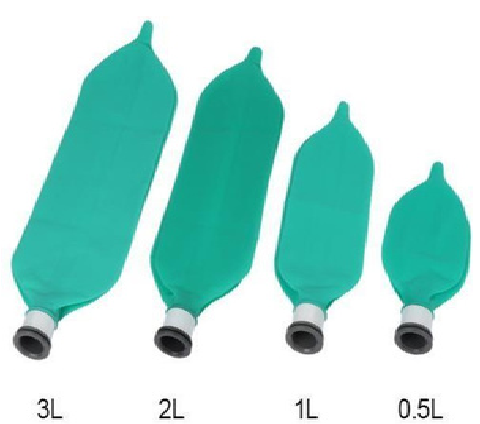
The reservoir bag is an important component of most breathing systems.

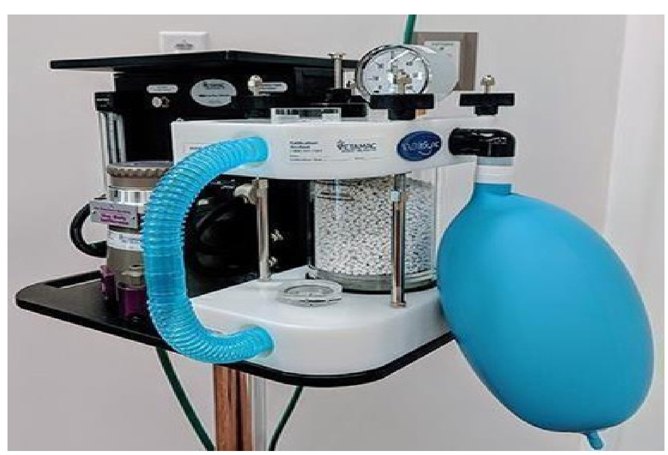
Components

1. It is made of anti-static rubber or plastic. Latex-free versions also exist. Designs tend to be ellipsoidal in shape
2. The standard adult size is 2 L. The smallest size for pediatric use is 0.5 L. Volumes from 0.5 to 6 L exist. Bigger size reservoir bags are useful during inhalational induction, e.g. adult induction with sevoflurane.

Uses

1. ***Accommodates the FGF during expiration acting as a reservoir*** available for the following inspiration.
2. It acts as a ***monitor of the patient's ventilatory pattern during spontaneous breathing***. It serves as a very inaccurate guide to the patient's tidal volume
3. It can be used ***to assist or control ventilation***.

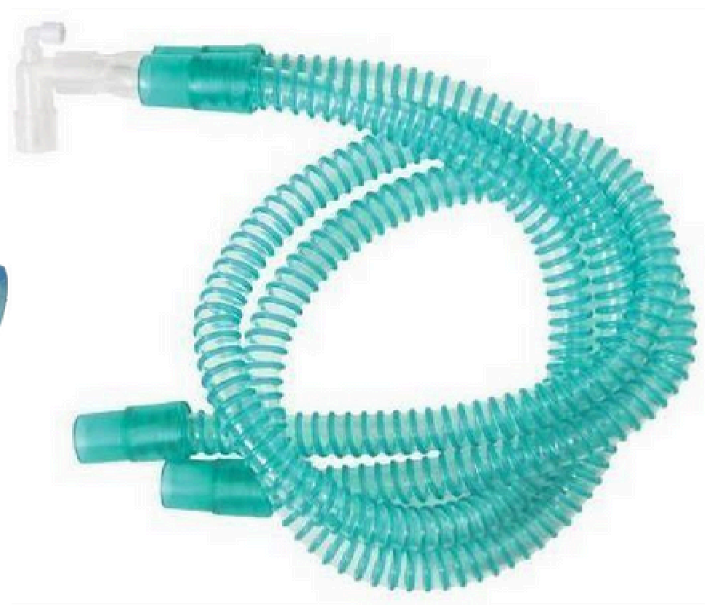




Problems in practice and safety features 1. Because of its compliance, the reservoir bag can accommodate rises in pressure in the breathing system better than other parts. When grossly overinflated, the rubber reservoir bag can limit 2. The size of the bag depends on the breathing system and the patient. A small bag may not be large enough to provide a sufficient reservoir for a large tidal volume 3. Too large a reservoir bag makes it difficult for it to act as a respiratory monitor.

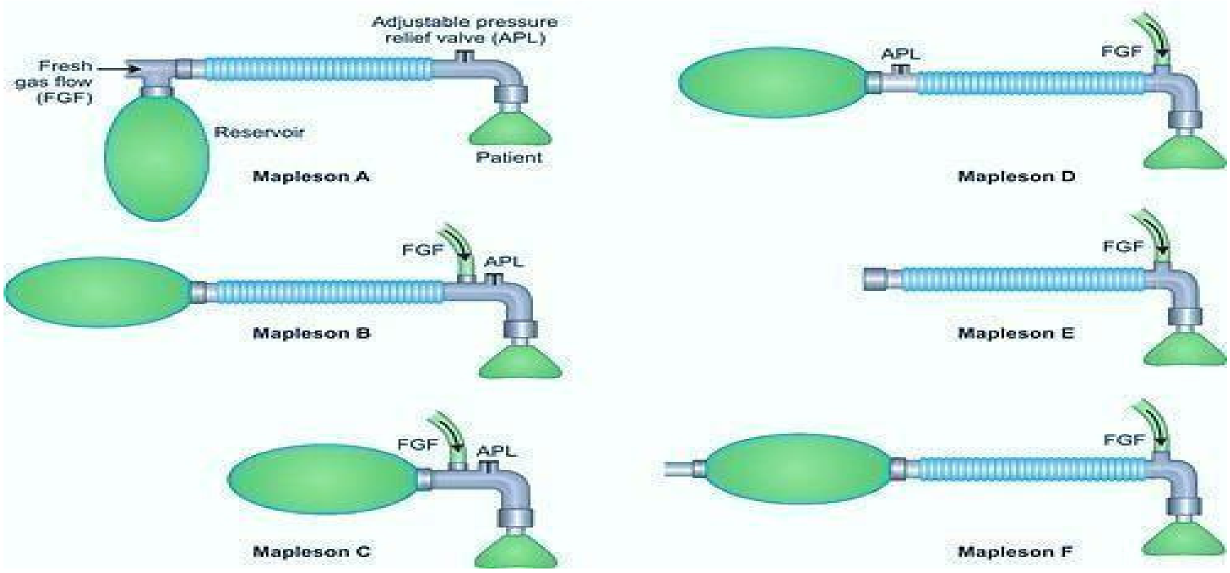
3. Tubings

These connect one part of a breathing system to another. They also act as a reservoir for gases in certain systems. They tend to be made of plastic, but other materials such as silicone rubber and silver impregnated bactericidal plastics are available. The length of the breathing tubing is variable depending on the configuration of the breathing system used.. The size for adults is 22 mm wide. However, pediatric tubing is 15 mm wide, to reduce bulk. The corrugations resist kinking and increase flexibility



Mapleson classification (Semiclosed Partial rebreathing)

In 1954, Mapleson classified the breathing systems into five configurations (A to E) and a sixth (F) was added later. The classification is according to the relative positions of the APL valve, reservoir bag and FGF. Mapleson systems need significantly higher FGF to prevent rebreathing compared to the circle breathing system and therefore the expensive use of volatile agents. Their use in modern anesthesia is very limited with the wide spread of the circle breathing system.



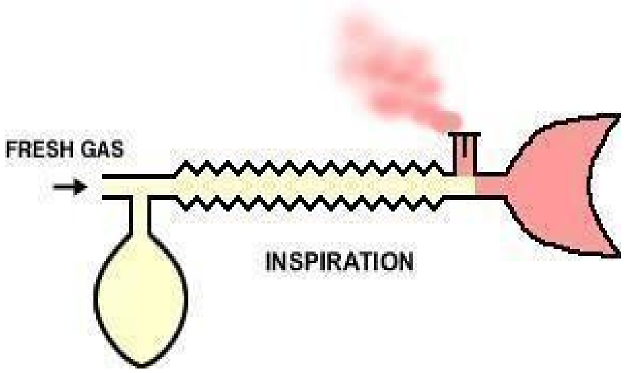
Magill system (Mapleson A)

Components

1. Corrugated rubber or plastic ***tubing*** (usually 110–180 cm in length) and an internal volume of at least 550 mL.

2. A ***reservoir bag***, mounted at the ***machine end***.

3. ***APL valve*** situated at the ***patient end***.



Uses of magill system It is a ***very efficient system for spontaneous*** breathing.

Because there is no gas
exchange in the anatomical dead space, the FGF requirements to prevent rebreathing of alveolar gases are theoretically equal to the patient's alveolar minute volume (about 70 mL/kg/min).
The Magill system is ***not*** an ***efficient system for controlled ventilation***. An FGF rate of three times the alveolar minute volume is required to prevent rebreathing.

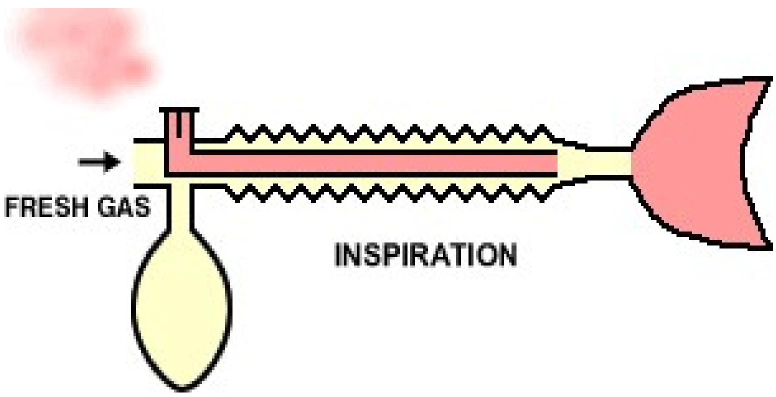
Problems in practice and safety features

1- The Magill system is ***not suitable for use with children of less than 25–30 kg*** body weight. This is because of the increased dead space caused by the system's geometry at the patient end. Dead space is further increased by the angle piece and face mask.

2- One of its disadvantages is the ***heaviness of the APL valve*** at the patient's end (***Not suitable for paediatric practice***). especially if connected to a scavenging system.

Lack system (Mapleson A)

This is a ***coaxial*** modification of the ***Magill Mapleson A system***.



Components

1. 1.8-m length coaxial tubing (tube inside a tube). The FGF is through the outside tube, and the exhaled gases flow through the inside tube.

2. The reservoir bag and APL valve is mounted at the machine end.

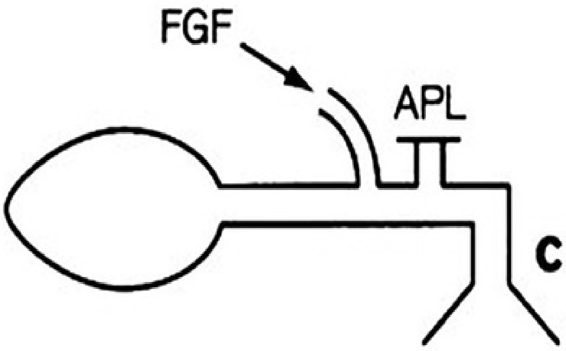
Uses A FGF rate of about 70 mL/kg/min is required in order to prevent rebreathing.

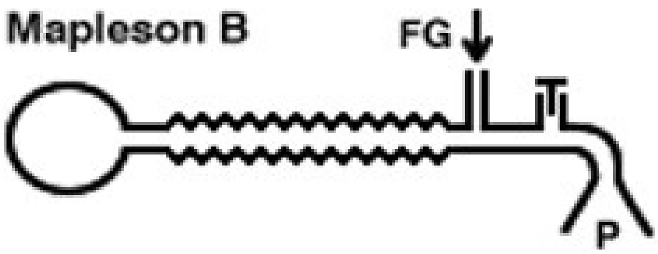
This
makes it an ***efficient breathing system for spontaneous ventilation.***
Since it is based on the Magill system, it is ***not suitable for controlled ventilation***.
Instead of the coaxial design, a ***parallel*** tubing version of the system exists This has separate inspiratory and expiratory tubing, and retains the same flow characteristics as the coaxial version.

Mapleson B and C systems

Components

1. A reservoir bag. In the B system, corrugated tubing is attached to the bag and both act as a reservoir.
2. An APL valve at the patient's end.
3. FGF is added just proximal to the APL.

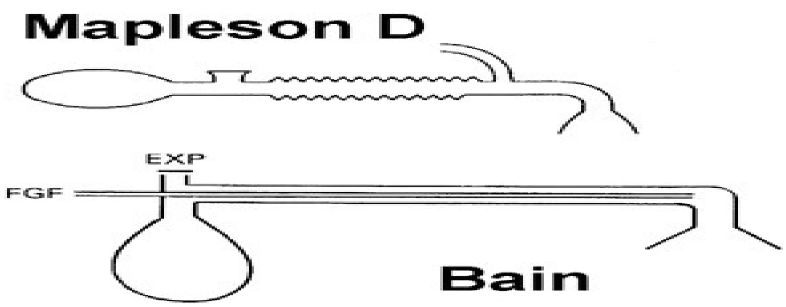




Mapleson D System

1- It consists of fresh gas inlet near the patient end

2-a corrugated rubber tubing one end which is connected with expiratory valve and then reservoir bag.
3. It is mainly used for assisted or controlled ventilation.



Bain system (Mapleson D) 1- Bain system is a coaxial version (tube inside a tube) of the Mapleson D system. 2- It is lightweight and compact at the patient end.

Components

The usual length of coaxial tubing is 180 cm, but it can be supplied at 270 cm , (for dental or ophthalmic surgery) and 540 cm (for [MRI] scans where the anaesthetic machine needs to be kept outside the scanner's magnetic field).

Problems in practice and safety features

1. The ***internal tube can kink***, preventing fresh gas being delivered to the patient.

2. The internal tube can become ***disconnected*** at the machine end, causing a large increase in the dead space and resulting in ***hypoxaemia*** and ***hypercapnia***.

Mapelson E sys (Ayre's T-Piece)

Components

1. A T-shaped tubing with three open ports

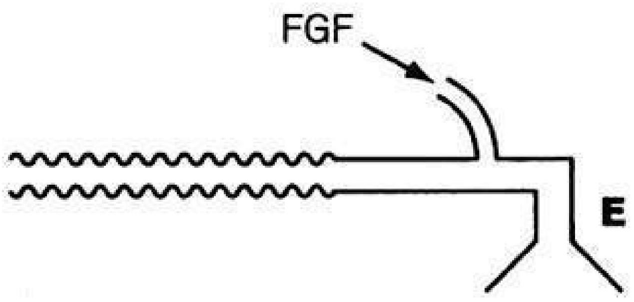
2. The first port to Fresh gas from the ***anesthetic machine*** is delivered via a tube

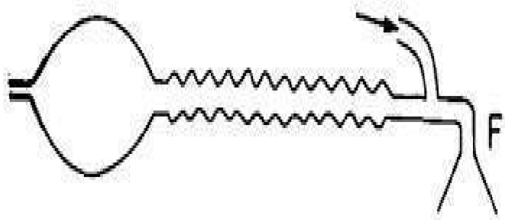
3. The second port leads to the ***patient*** .

4. The third port leads to ***reservoir tubing***.

A recent modification exists where an APL valve is included before a closed ended 500 mL reservoir bag. A pressure relief safety mechanism in the APL valve is actuated at a pressure of 30 cm H_2O.
*No bag, no valve, used in children (low resistance to breathing and minimal dead space) .

Not:To prevent respiration of room air, the reservoir limb should exceed the VT & to prevent rebreathing, FGF (2-3 MV) .





Mapelson F sys (Jackson Rees modification of the Ayer s T piece)

A small bag (0.5L) with an open end is attached to the outlet of the reservoir limb. The bag is visual monitor FGF (2-3 MV) in both spontaneous and controlled.

The Humphrey ADE breathing system

This is a very versatile breathing system which combines the advantages of the Mapleson ***A, D and E*** systems. It can therefore be used efficiently for ***spontaneous*** and ***controlled*** ventilation in both ***adults*** and ***children***. The mode of use is determined by the position of one ***lever*** which is mounted on the ***Humphrey block***

Components

1. Two lengths of 15-mm smooth-bore ***tubing*** .One delivers the ***fresh gas*** and the other carries away the ***exhaled gas***. Distally they are connected to a ***Y-connection*** leading to the patient. Proximally they are ***connected to the Humphrey block.***

2. The ***Humphrey block is at the machine end*** and consists of

an ***APL valve*** featuring a visible indicator of valve performance

b.***2-L reservoir bag***

c.***lever*** to select either spontaneous or controlled ventilation

d.***port*** to which a ***ventilator*** can be connected. a ***safety pressure relief valve***

which opens at pressure in excess of ***60 cm H2O***. a modified design incorporating

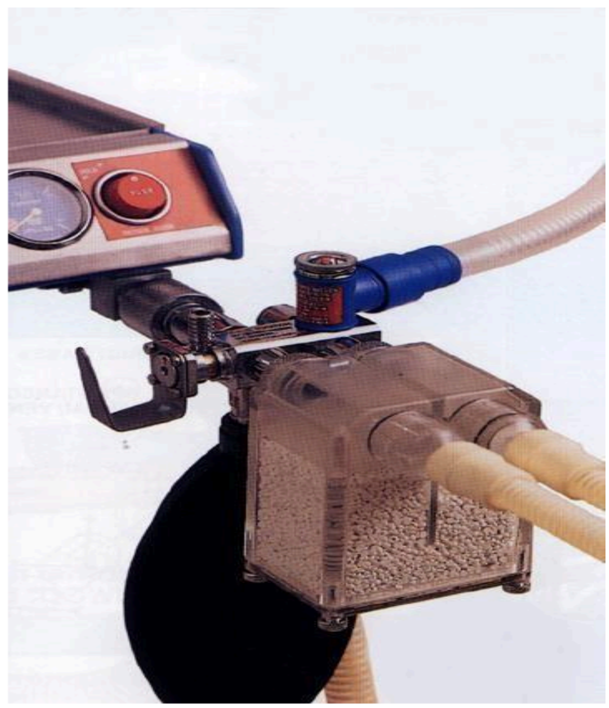
a soda lime canister.

Some important notes

1. During spontaneous ventilation With the ***lever up in the spontaneous mode***, the ***reservoir bag and APL valve are connected*** to the breathing system as in the Magill system.

2. During controlled ventilation

With the ***lever down*** in the ***ventilator mode***, the ***reservoir bag and the APL valve are isolated*** from the breathing system as in the Mapleson E system. The expiratory tubing carry the exhaled gas via the ventilator port. Scavenging occurs at the ***ventilator's expiratory valve***.



Soda lime and the circle breathing system Over 80% of the anesthetic gases are wasted when FGF of 5 L/min is used. Typically,
the reduction of FGF from 3 L/min. to 1 L/min results in a saving of about 50% of the total consumption of any volatile anesthetic agent. In this breathing system, soda lime is used to absorb the patient's exhaled carbon dioxide. FGF requirements are low, making the circle system very efficient and causing minimal pollution. As a result, there has been renewed interest in low-flow anesthesia due to the cost of new, expensive inhalational agents, together with the increased awareness of the pollution caused by the inhalational agents themselves.

Depending on the FGF, the system can be one of the following:

- ***Closed circle anesthesia.*** The FGF is just sufficient to replace the volume of gas and vapour taken up by the patient. No gas leaves via the APL valve and the exhaled gases are rebreathed after carbon dioxide is absorbed. Leaks from the breathing system should be eliminated. In practice, this is possible only if the gases sampled by the gas analyser are returned back to the system.

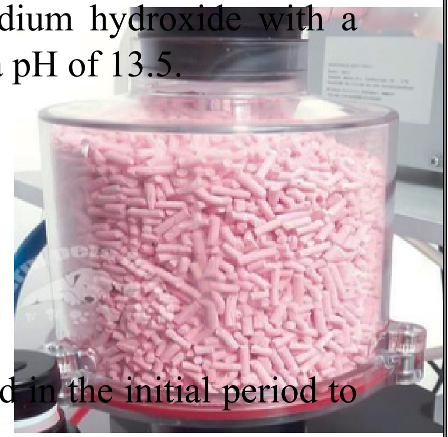
- ***Minimal-flow anesthesia.*** The FGF is reduced to 0.5 L/min.

- ***Low-flow anesthesia.*** The FGF used is less than the patient's alveolar ventilation (usually below 1.5 L/min). Excess gases leave the system via the APL valve.

Components

1. A vertically positioned ***canister*** containing ***soda lime***. The canister has two ports, one to deliver inspired gases to the patient and the other to receive exhaled gases from the patient.
2. Inspiratory and expiratory tubings connected to the canister. Each port incorporates a ***unidirectional valve*** .
3. FGF from the anaesthetic machine is positioned ***distal to the soda lime*** canister, but proximal to the inspiratory valve .
4. An ***APL valve*** is positioned ***between the expiratory valve and canister*** and connected to a 2-L reservoir bag.

5. ***Soda lime*** consists of 94%calcium hydroxide and 5%sodium hydroxide with a small amount of potassium hydroxide(less than 0.1%). It has a pH of 13.5.



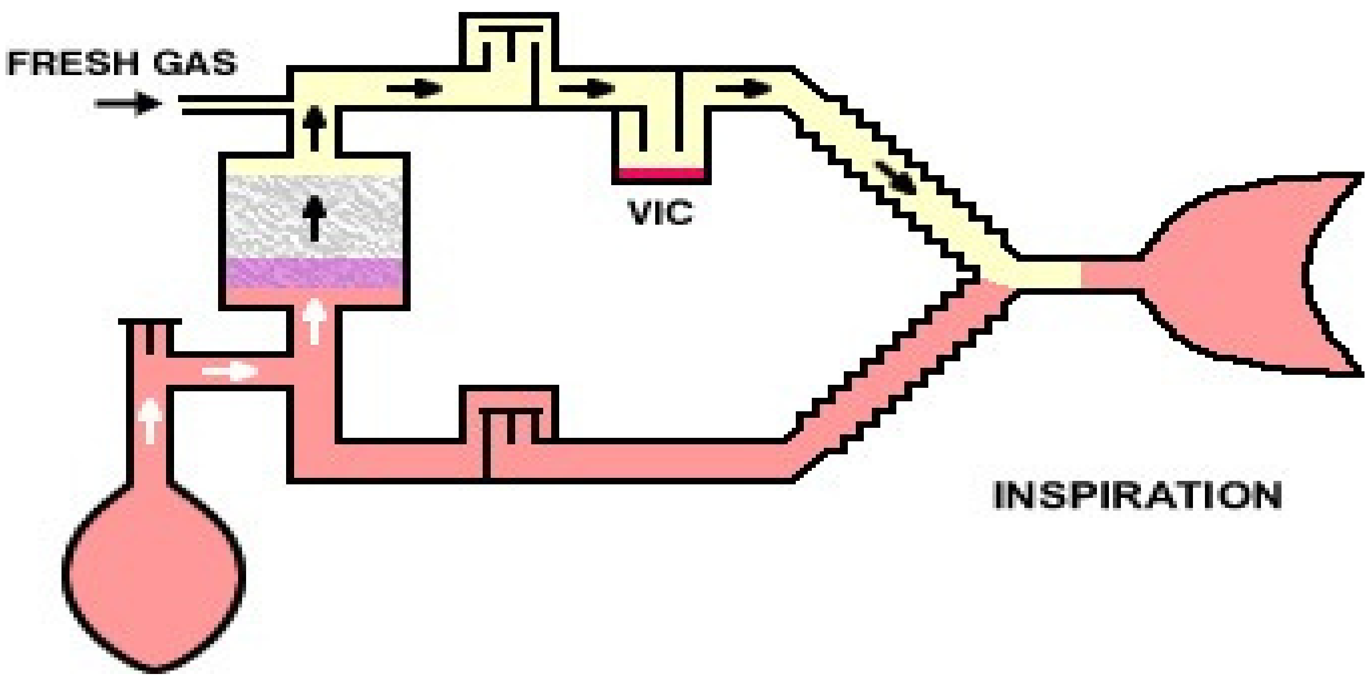
👉👉👉 A ***dye*** or ***color indicator*** is added to change the granules' color when the soda lime is ***exhausted***. Color changes can be from ***white to violet/purple***(ethyl violet dye), from ***pink to white*** (titan yellow dye) or from ***green to violet.*** Colour changes occur when the ***pH is less than 10***

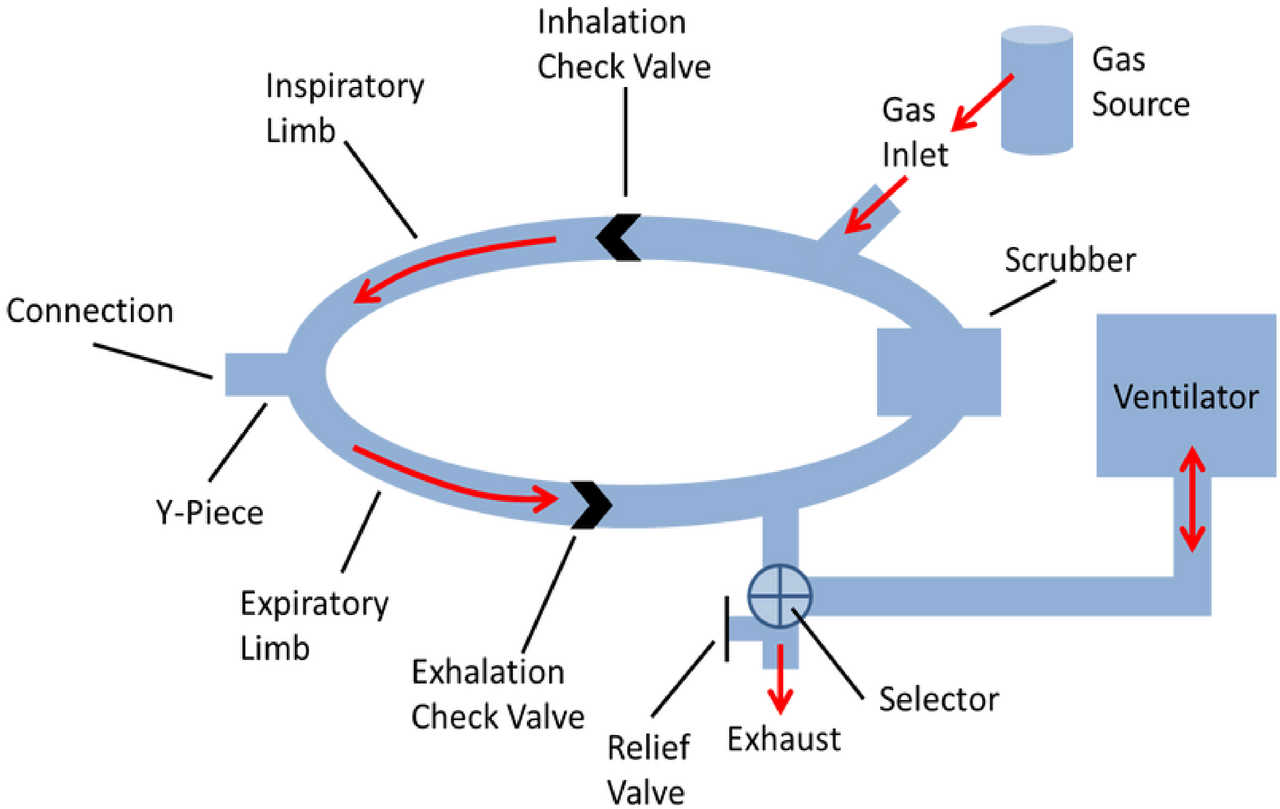
Mechanism of action 1- High FGF of several L/min is needed in the initial period to ***denitrogenate*** the circle system and the functional residual capacity (FRC). This is important to avoid the ***buildup of unacceptable levels of nitrogen*** in the system. In closed circle anesthesia, a high FGF is needed for up to 15 minutes.

2- ***Exhaled gases are circled back to the canister*** , where carbon dioxide absorption takes place and ***water*** and ***heat*** (exothermic reaction) are produced. The ***warmed*** and ***humidified*** gas joins the FGF to be delivered to the patient.

3- The canister is positioned ***vertically*** to prevent exhaled gas passaging through unfilled portions

4- The circle system can be used for both ***spontaneous*** and ***controlled*** ventilation.

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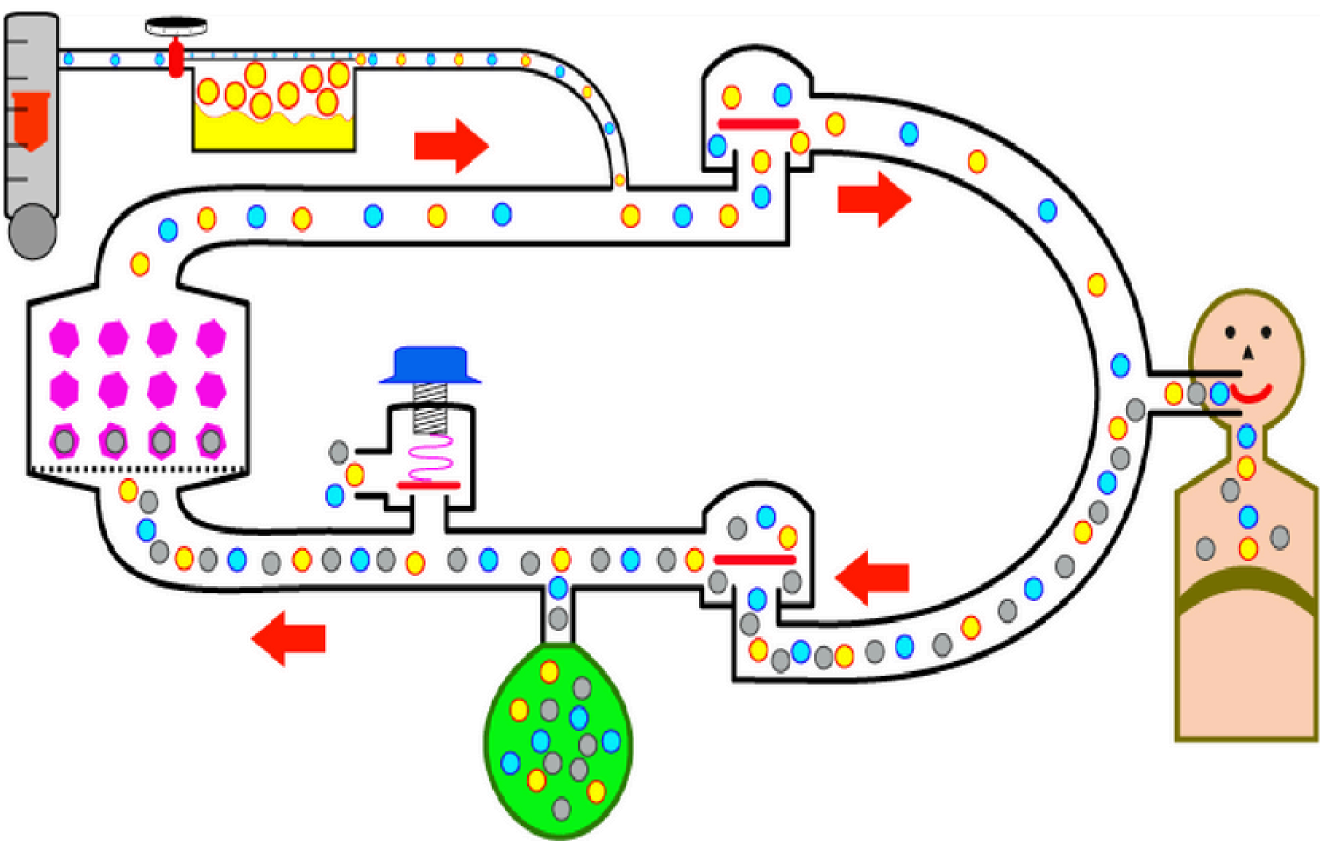


Problems in practice and safety features

1. Adequate monitoring of inspired oxygen, end-tidal carbon dioxide and inhalational agent concentrations is essential and mandatory.

2. The unidirectional valves may stick and fail to close because of water vapour condensation.

3. The resistance to breathing is increased during spontaneous ventilation due to the unidirectional valves.

4. Compound A is produced when sevoflurane is used in conjunction with soda lime. This is due to the degradation of sevoflurane.

5. Uneven filling of the canister with soda lime leads to passage of gases .

6. The circle system is big, less portable and more difficult to clean.

7. Soda lime is corrosive. So clothing, gloves and eye/face protection can be used.

8. Because of the many connections, there is an increased in leaks and disconnection.

Breathing System Check Procedure

Checking a breathing system involves a systematic approach to ensure functionality, typically starting with a high-pressure leak check and a low-pressure check.

Key steps include verifying the oxygen supply, checking the anesthetic circuit, testing the ventilator, and ensuring all valves and soda lime are functional, ideally performing these checks before every patient.

High-Pressure Leak Test:

1. Connect the oxygen pipeline or turn on the cylinder.

2. Close the APL (Adjustable Pressure Limiting) valve entirely.

3. Occlude the patient end of the circuit (e.g., with a 5ml syringe plunger or red adapter).

4. Press the oxygen flush button to fill the circuit and check for a stable pressure gauge reading (usually up to 30cmH2O).

5. Confirm the pressure holds, indicating no leaks.

Low-Pressure Check & Circuit Check:

1. Ensure the oxygen flowmeter is working and the bobbin moves freely.

2. Check all hoses for cracks, leaks, or proper connections.

3. Verify the soda lime canister (if used) is not exhausted (no color change) and check that the unidirectional valves (inspiratory/expiratory) move correctly.

Finalizing the Check:

Open the APL valve to the fully open position for spontaneous breathing and Remove the occlusion from the patient end and ensure the bag is attached and the ventilator is connected

Manual Resuscitators

Manual resuscitators are portable manual ventilating devices used for ventilating the patient during:

- Resuscitation
- Transport of the patient
- As a standby measure for the nonfunctioning of anesthesia machine
- Administering anesthesia when anesthesia machine is not available, e.g., in an infield situation.

They are known by many names, the most common being ―AMBU bag‖ i.e., artificial mandatory breathing unit or air mask bag unit. They are inflated at rest.

The devices are available in three sizes:

1. Adult: It delivers a tidal volume of 600 mL and has a capacity of 1,600 mL. It can be used in adults weighing more than 30 kg.
2. Child: It has a capacity of 500 mL and can be used in patients weighing between 7 kg and 30 kg.
3. Neonatal: It is capable of delivering the tidal volume up to 20–50 mL and can be used in infants up to 7 kg.

The various components of any ventilating system are:

- Self-inflating bag
- Nonrebreathing valve
- Bag refill valve
- Attachment for oxygen enrichment
- Pressure limiting device for pediatric bags
- Attachment to the scavenging system

Oxygen Enrichment Device:

The manual resuscitator can deliver a fraction of inspired oxygen (FiO_2) of at least 0.21.

- An oxygen reservoir can be added to increase FiO_2, up to 15 L/min

Pressure Limiting Devices:

It is also called a pressure relief valve or pop-off valve. It opens at an opening pressure of 45 cm of water for infant and pediatric bags and thus prevents lung injury because of barotrauma and gastric inflation. In adults, the opening pressure is kept at 60 cm of water.

A. Laerdal manual resuscitator B. Artificial breathing unit or air mask bag unit

**Paediatric version exists .Neonatal: ~240 mL
Paediatric: ~500–600 mL
Adult: ~1,500–1,600 mL

Ventilators

Amechanical ventilator is a machine designed to move breathable air into and out of the lungs to provide breathing for a patient who is physically unable to breathe or is breathing insufficiently, or it is a device designed to provide or augment patient ventilation.

Characteristics of the ideal ventilator

1. simple, portable, robust and economical to use.

2. It should be versatile and supply tidal volumes up to ***1500*** mL with a respiratory rate of up to 60/min and variable I:E ratio. It can be used with different breathing systems. It can deliver any gas or vapour mixture. The addition of positive end expiratory pressure (***PEEP***) should be possible.

3. It should monitor the airway pressure, inspired and exhaled minute and tidal volume, respiratory rate and inspired oxygen concentration.

4. There should be facilities to provide humidification. Drugs can be nebulized through it.

5. Disconnection, high airway pressure and power failure ***alarms*** should be present.

6. There should be the facility to provide other ventilator modes, e.g. SIMV, CPAP and pressure support.

7. It should be easy to clean and sterilize.

Different type of ventilator

Bag in bottle ventilator

Modern anaesthetic machines often incorporate a bag in bottle ventilator.

Components:

1.A ***driving unit*** consisting of:

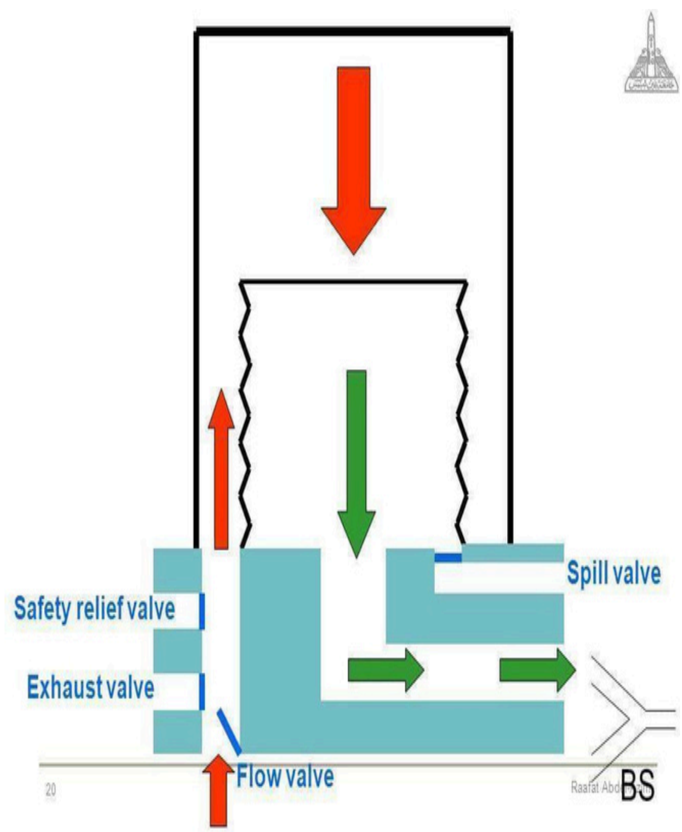
a. a chamber with a tidal volume range of 0–1500 mL (a paediatric version with a range of 0–400 mL exists)

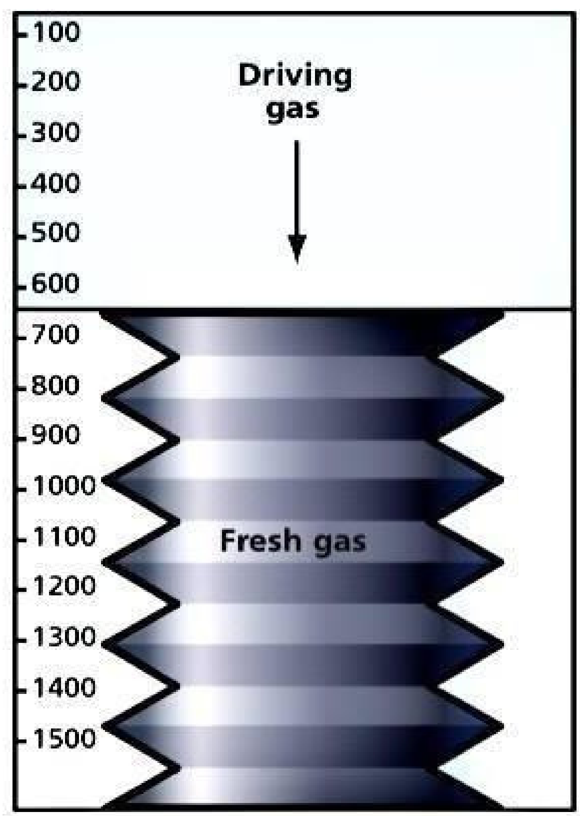
b. an ascending bellows accommodating the FGF.

2. A ***control unit*** with a variety of controls, displays and alarms: the tidal volume, respiratory rate (6–40 breaths/min), I : E ratio, airway pressure and power supply .

Mechanism of action

1. It is a time-cycled ventilator that is pneumatically powered and electronically controlled.
2. The fresh gas is accommodated in the bellows.
3. Compressed air is used as the driving gas ,On entering the chamber, the compressed air forces the bellows down, delivering the fresh gas to the patient.
4. The driving gas and the fresh gas remain separate.
5. The volume of the driving gas reaching the chamber is equal to the tidal volume.
6. Some designs feature a descending bellows instead.





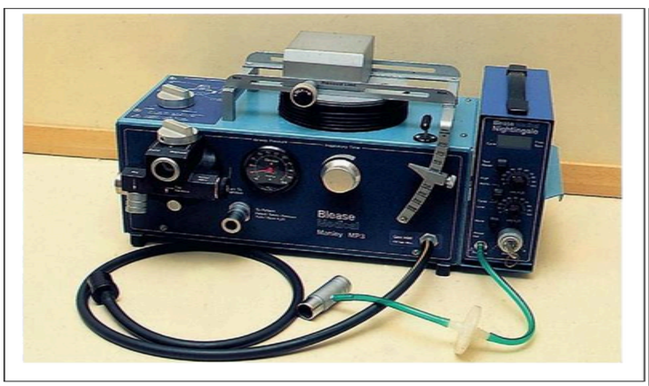
Mechanism of action of the bag in bottle ventilator.

Problems in practice and safety features.

1. Positive pressure in the standing bellows causes a PEEP of 2–4 cm H_2O.
2. The ascending bellows collapses to an empty position and remains stationary in cases of disconnection or leak.
3. The descending bellows hangs down to a fully expanded position in a case of disconnection and may continue to move almost normally in a case of leakage.

Manley MP3 ventilator:

This is a minute volume divider (time cycled, pressure generator). All the FGF (the minute volume) is delivered to the patient divided into readily set tidal volume




Advantages

- No electrical power required.
- Simple to use and reliable.
- Does not waste pressurized gas, because all of the FGF is divided and supplied to the patient; no additional gas flow is required to drive the ventilator.
- The ventilator may be used in conjunction with a circle system.

Disadvantages

- Only a single mode of mechanical ventilation is possible.
- Generates back pressure within the breathing circuit, which can affect the accuracy of vaporizers within the circuit

Penlon Nuffield 200 ventilator:

The Penlon Nuffield 200 is an intermittent blower ventilator. It is small, compact, versatile, and easy to use with patients of different sizes, ages, and lung compliances. It can be used with different breathing systems. It is a volume-preset, time-cycled flow generator in adult use. In pediatric use, it is a pressure-preset, time-cycled, flow generator

Components

1. The control module, consisting of an airway pressure gauge (cmH2O), inspiratory and expiratory time dials (seconds), inspiratory flow rate dial (L/s), and an on/off switch. Underneath the control module, there are connections for the driving gas supply and the valve block. Tubing connects the valve block to the airway pressure gauge.
2. The valve block has three ports:

a) A port for tubing to connect to the breathing system reservoir bag mount.

b) An exhaust port which can be connected to the scavenging system

c) A pressure relief valve that opens at 60 cmH2O.

4. The valve block can be changed to a pediatric (Newton) valve

Problems in practice and safety features

1. The ventilator continues to cycle despite breathing system disconnection.
2. Requires high flows of driving gas.

Uses

It is used for short periods of ventilation, most commonly in the anesthetic room, but also sometimes in remote locations such as the radiology department. An MRI- compatible unit is available.

High-frequency jet ventilator

This ventilator reduces the extent of the side effects of conventional intermittent positive pressure ventilation (IPPV). It generates low tidal volumes at a high frequency, leading to lower peak airway pressures. High-frequency jet ventilation is better tolerated by alert patients than conventional IPPV. It is frequently used in anesthesia for ear, nose, and throat (ENT) surgery

Problems in practice and safety features

1. Barotrauma can still occur as expiration is dependent on passive lung and chest wall recoil driving the gas out through the tracheal tube.
2. High-pressure (35–40 cmH_2O) and system malfunction alarms are featured

Spinal, Epidural, and Combined Spinal–Epidural Anesthesia

Regional anesthesia with central neuraxial blockade has gained widespread popularity and is commonly used nowadays. Hence, a knowledge of the various techniques to achieve these blocks and the needles and catheters used for administering spinal, epidural, or combined spinal-epidural anesthesia is required for a safe and effective central neuraxial blockade.

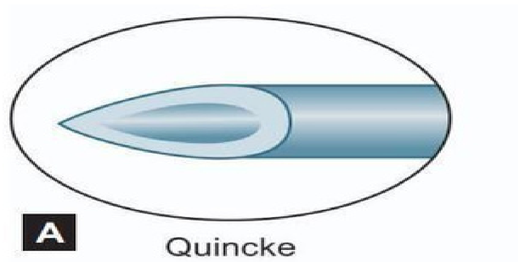
Spinal needles:

Quincke: a cutting needle used for the drainage of cerebrospinal fluid (CSF) in patients with intracranial hypertension. Also the technique of LP.

Easy to use

Cutting = more CSF leak = more PDPH

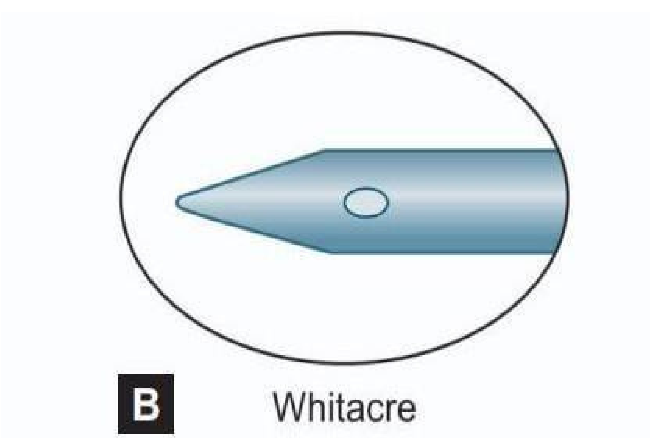
Splitting insertion is used to reduce PDPH



Whitacre: developed conical pointed needles described as ―resembling a sharpened pencil‖ and a distal side orifice next to it. They were popularly called ―pencil point needles.‖

Difficult to use

pencil point = less CSF leak = less PDPH



Components

The needle's length varies from 5 to 15 cm; the 10-cm version is most commonly used. They have a transparent hub to identify the flow of CSF.

A stylet is used to prevent a core of tissue from occluding the lumen of the needle during insertion.

Spinal needles are made in different sizes, from 18 G to 29 G in diameter The 25-G and smaller needles are used with an introducer, which is usually an 18-G or 19-G needle.

Mechanism of action

1. The large 22-G needle is more rigid and easier to direct. It gives a better feedback feel as it passes through the different tissue layers.
2. The CSF is slower to emerge from the smaller-sized needles. Aspirating gently with a syringe can speed up the tracking back of CSF.
3. Continuous spinal anesthesia can be achieved by inserting 3–4 cm of the 28-G spinal microcatheter into the subarachnoid space.

Problems in practice and safety features

1. Wrong route errors: To avoid administering drugs that were intended for intravenous administration, all spinal (intrathecal) bolus doses and lumbar puncture samples are performed using syringes, needles, and other devices with safer connectors that cannot connect with intravenous Luer connectors

Epidural needles

The epidural needles are designed to allow the passage of epidural catheters through them. Tip with a blunt bevel having a curve at 15–30° through which passes the epidural catheter at an angle and not straight, hitting the dura or spinal canal.

EPIDURAL CATHETER:

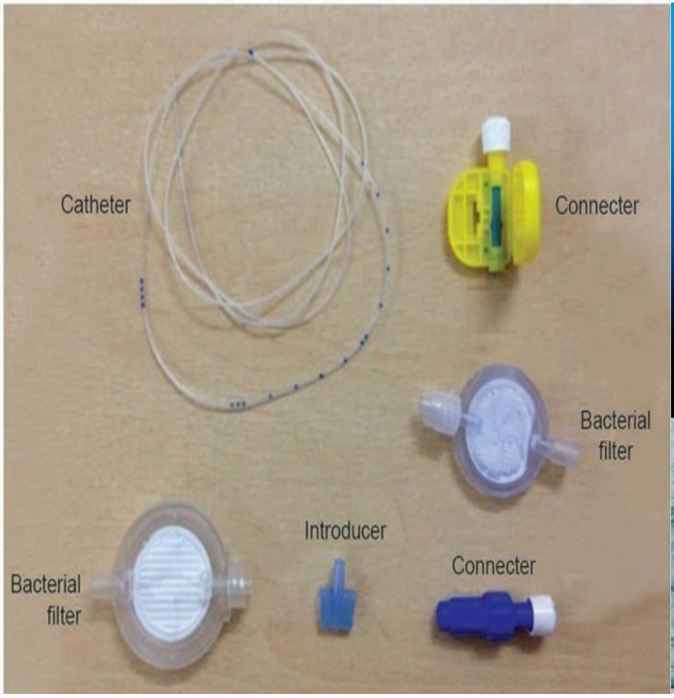
Made up of nylon or polyvinyl chloride.

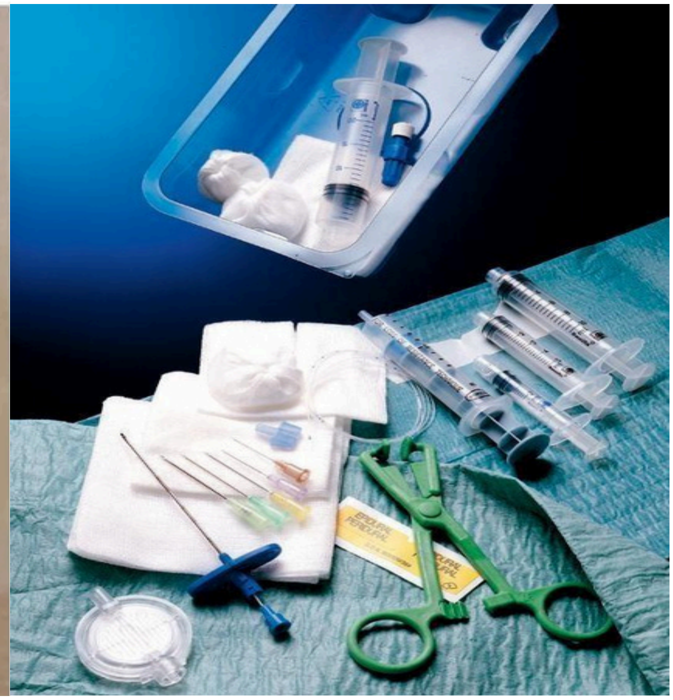
Radiopaque.

The tip is atraumatic and rounded, having lateral holes and a closed end.

Connector with Luer-lock cap

Catheter length: 90–100 cm with markings at 5 cm, 6 cm, 7 cm, 8 cm, 9 cm, 10 cm, and 15 f cm, 20 cm from the tip.

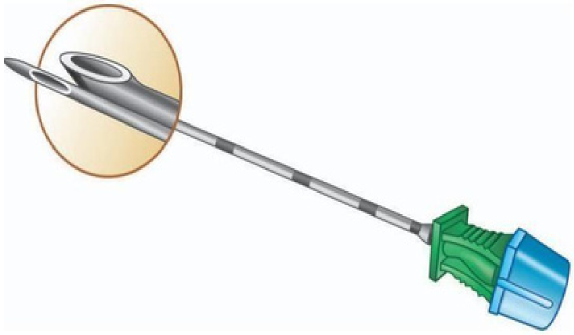


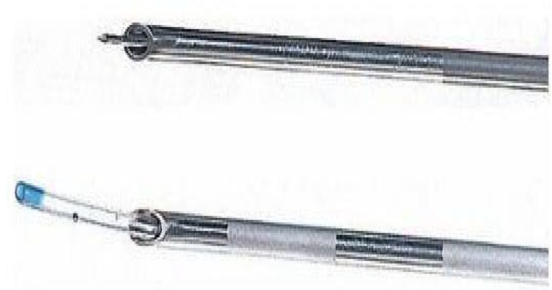


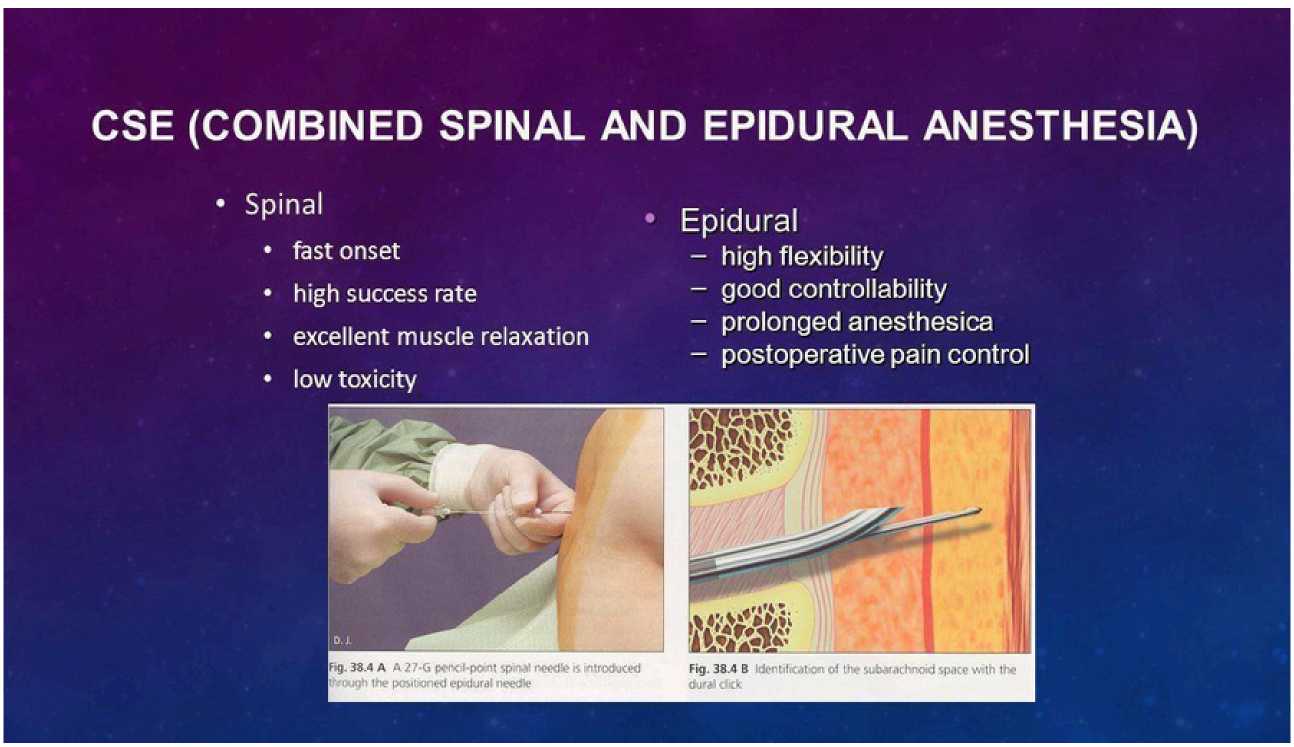
Color-coded: dark blue (18G), light blue (16 G).

The catheter distance from tip to the epidural space is 3–4 cm. The catheter should be advanced only 3–5 cm into the epidural space.
The catheter should appear 15–18 cm at the hub of the needle.

COMBINED SPINAL–EPIDURAL NEEDLES







DISADVANTAGES OF COMBINED SPINAL– EPIDURAL ANESTHESIA

Difficulty in passing the epidural catheter after spinal LA is given in the needle-through-needle single space technique.

Displacement of the epidural catheter in the subarachnoid space.

Time-consuming if technical difficulties, such as in obese patients.

INDICATIONS

Orthopedics—especially hip and knee replacements and lower limb surgeries.

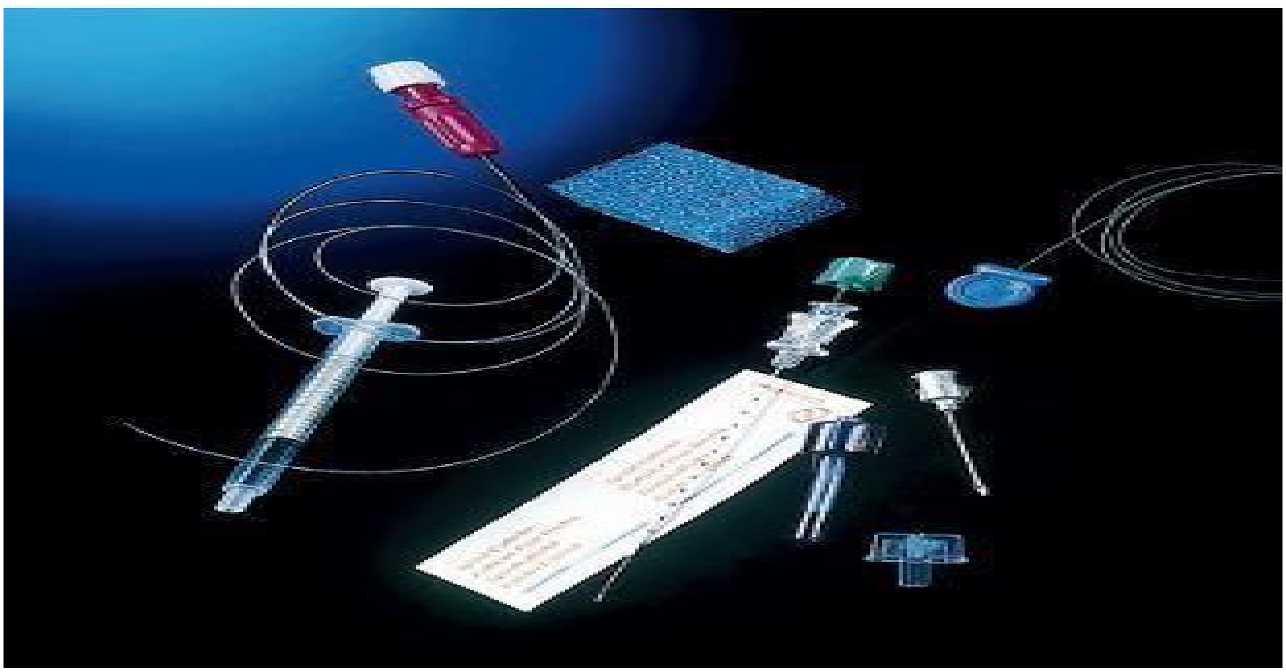
Gynecological, urogenital, rectal, perianal, pelvic, upper, and lower abdominal surgeries.

Microvascular surgeries of the lower limbs.

In labor analgesia (walking epidural) with intrathecal opioids and later continued with epidural doses of bupivacaine if cesarean section is required.

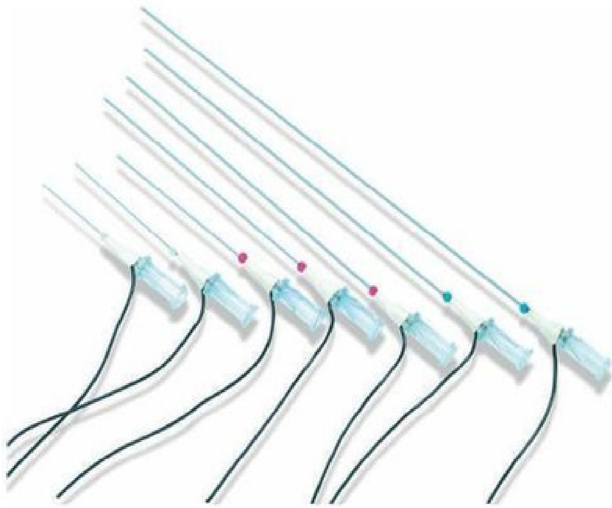
Spinal microcatheters

1. They are difficult to advance.
2. There is a risk of trauma to nerves.
3. Cauda equina syndrome is thought to be due to the potential neurotoxicity from the anesthetic solutions rather than the microcatheter.



Nerve block needles

These needles are used in regional anesthesia to identify a nerve plexus or a peripheral nerve. The needles are connected to a nerve stimulator to aid in localizing the nerve using an insulated cable to prevent leakage of current



22G-sized needles are optimal for the vast majority of blocks.

A. interscalene block: 25–50 mm
B. axillary block: 35–50 mm
C. psoas compartment block: 80–120 mm
D. femoral nerve block: 50 mm
E. sciatic nerve block (depending on the approach): 80–150 mm.

Peripheral Nerve Stimulator

Peripheral nerve stimulators (PNS) and nerve block stimulators are electronic devices used to locate nerves or manage pain by delivering electrical impulses

Components

1. Two surface electrodes (small ECG electrodes) are positioned over the nerve and connected via the leads to the nerve stimulator.
2. Alternatively, skin contact can be made via ball electrodes, which are mounted on the nerve stimulator casing.
3. The case consists of an on/off switch and the facility to deliver a twitch, train-of- four (at 2 Hz), and tetanus (50 Hz). The stimulator is battery operated.

Sites for monitoring neuromuscular blockade

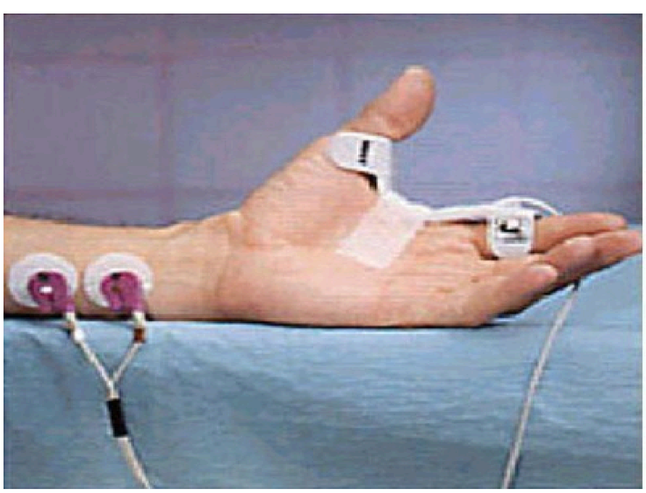
The electrodes should not be applied in areas with inflammation, edema, or injury.
Selection of Site Depends on Following Factors

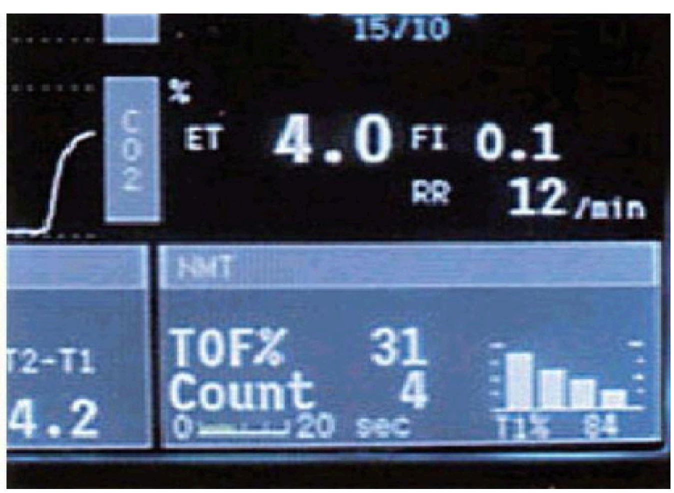
- Should be away from surgical site
- Easily accessible to anesthesiologist for intraoperative monitoring
- Preferably, the pulse oximeter probe and blood pressure cuff should not be applied on the same extremity as the PNS
- Peripheral nerve stimulators should not be applied on the paretic extremity, as it may misinterpret resistance to NDMRs.

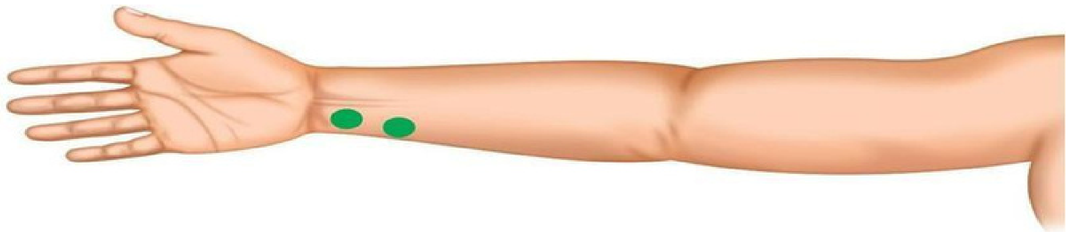
Various Sites

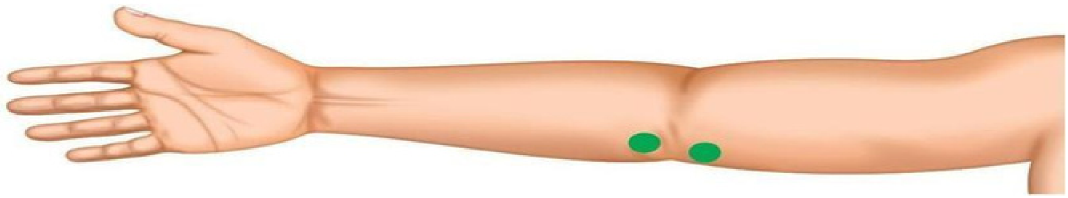
Ulnar Nerve

Stimulation of the ulnar nerve leading to contraction of the adductor pollicis muscle (thumb) is the most commonly monitored site.. The ulnar nerve can be stimulated at the wrist, elbow, or hand.









Median Nerve
Posterior Tibial Nerve

Response is seen in the form of plantar flexion of the foot and big toe.

Peroneal Nerve (Lateral Popliteal)

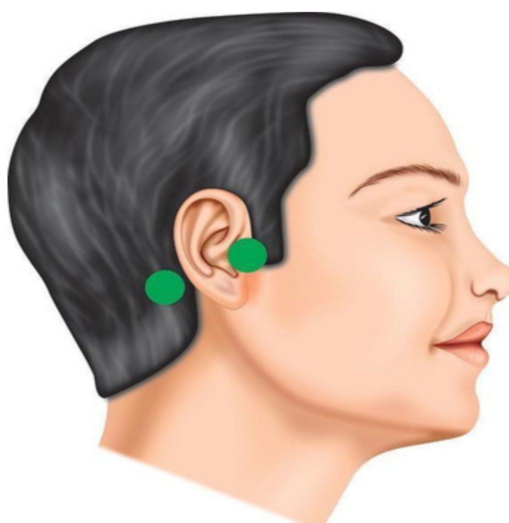
The electrodes are placed on the lateral aspect of the knee. A response is elicited in the form of dorsiflexion of the foot.

Muscular Branch of the Femoral Nerve

It can be stimulated in the vastus medialis muscle. It is useful in monitoring NM function, especially in the prone patient

Facial Nerve

It is the best at detecting the onset of relaxation in the muscles of the jaw, larynx, and diaphragm. The negative electrode is placed anterior to the inferior part of the earlobe, and the other electrode is placed just posterior or inferior to the lobe.



The facial muscles are relatively resistant to NMB drugs. Thus, the facial nerve should not be used to assess the recovery from NMB drugs.

Mandibular Nerve

Spinal Accessory Nerve

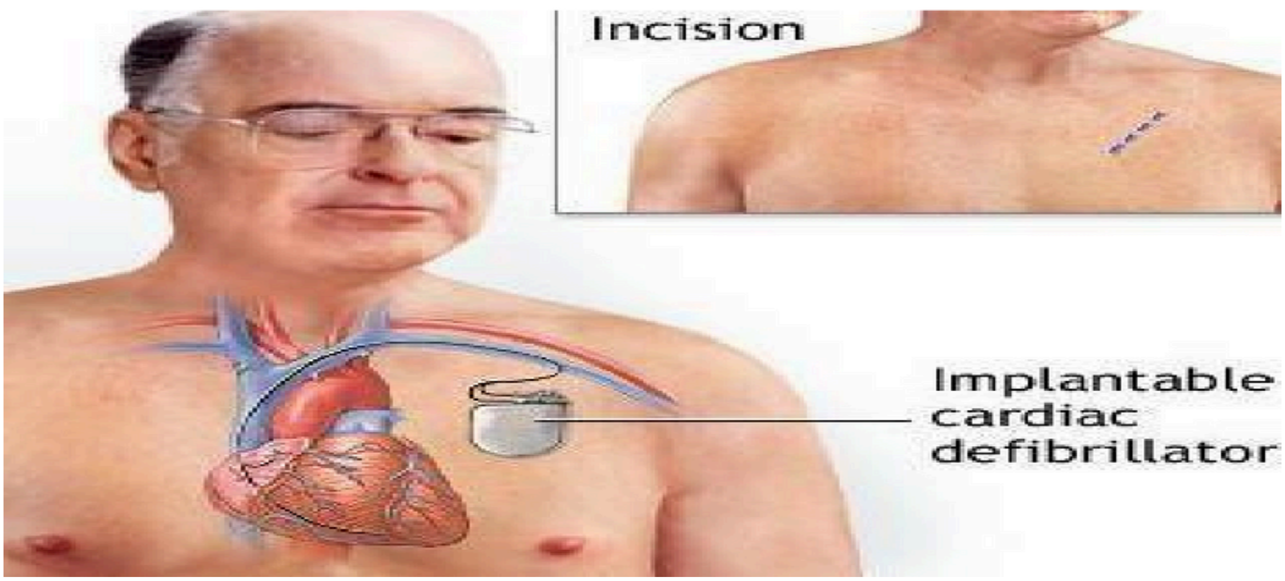
Recurrent Laryngeal Nerve

Percutaneous stimulation can be done by placing the two electrodes between the notch, between the thyroid and cricoid cartilages. Response can be measured by placing the tracheal tube cuff between the vocal cords and measuring pressure changes within the cuff or by phonomyography.

Defibrillator and Pacemaker

This is a device that delivers electrical energy to the heart, causing simultaneous depolarization of an adequate number of myocardial cells to allow a stable rhythm to be established.

Defibrillators can be divided into



In patients with permanent pacemaker and intra cardiac defibrillator implants, care should be taken such that the external defibrillator paddles should be at least 10 cm away from the implanted devices and the current vector of the external. Defibrillator should be perpendicular to the implanted device. The implanted device should be assessed ER for any mal function after cardioversion.

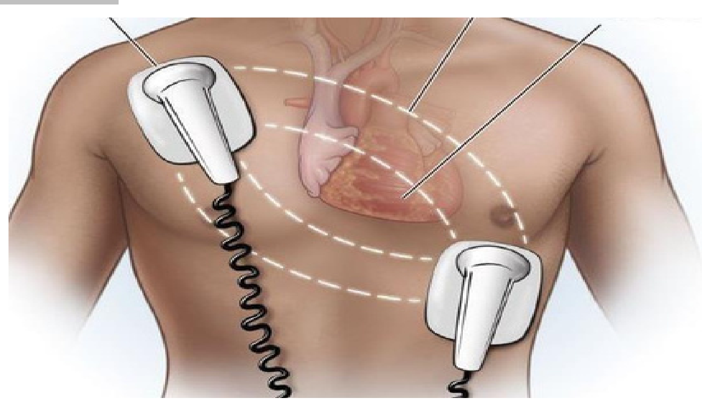
Components

1. The device has an on/off switch, Joules setting control, charge and discharge buttons.
2. Paddles can be either external (applied to the chest wall) or internal (applied directly to the heart). The external paddles/pads are usually 8–8.5 cm in size.

Working principle

1. DC energy rather than AC energy is used. DC energy is more effective causing less myocardial damage and being less arrhythmogenic than AC energy.
2. Transformers are used to step up mains voltage from 240 V AC to 5000–9000 V AC. A rectifier converts it to 5000 V DC.
3. The DC shock is of brief duration and produced by discharge from a capacitor
4. The defibrillator paddle placement on the chest wall has two conventional positions:

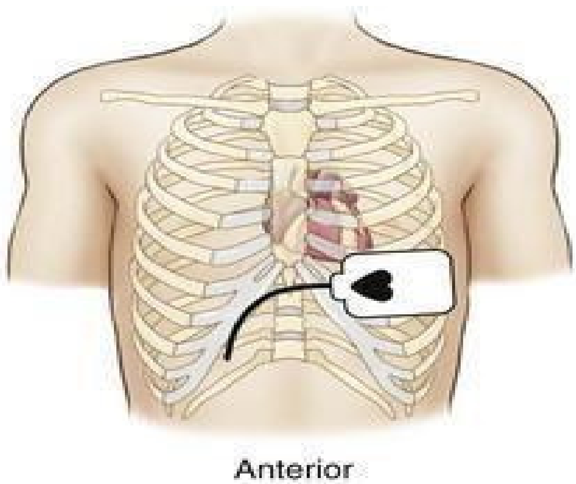
   a) Anterolateral position



a single paddle is placed on the left fourth or fifth intercostal space on the midaxillary line. The second paddle is placed just to the right of the sternal edge on the second or third intercostal space.

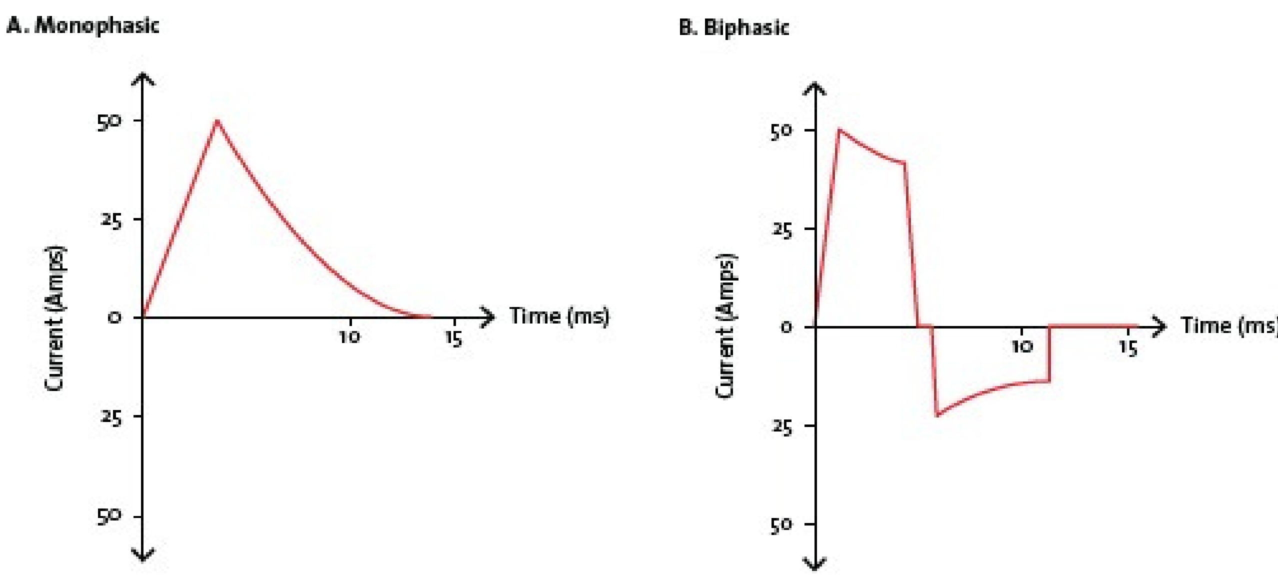
b) Anteroposterior position

A single paddle is placed to the right of the sternum, as above, and the other paddle is placed between the tip of the left scapula and the spine.



NOTE

1. Because the skin can conduct away a significant portion of the current, it is common practice to employ conductive gel or pregelled pads so as to ensure good contact. Even in ideal circumstances, only 10–30% of the total current reaches the heart.
3. Defibrillator Waveforms

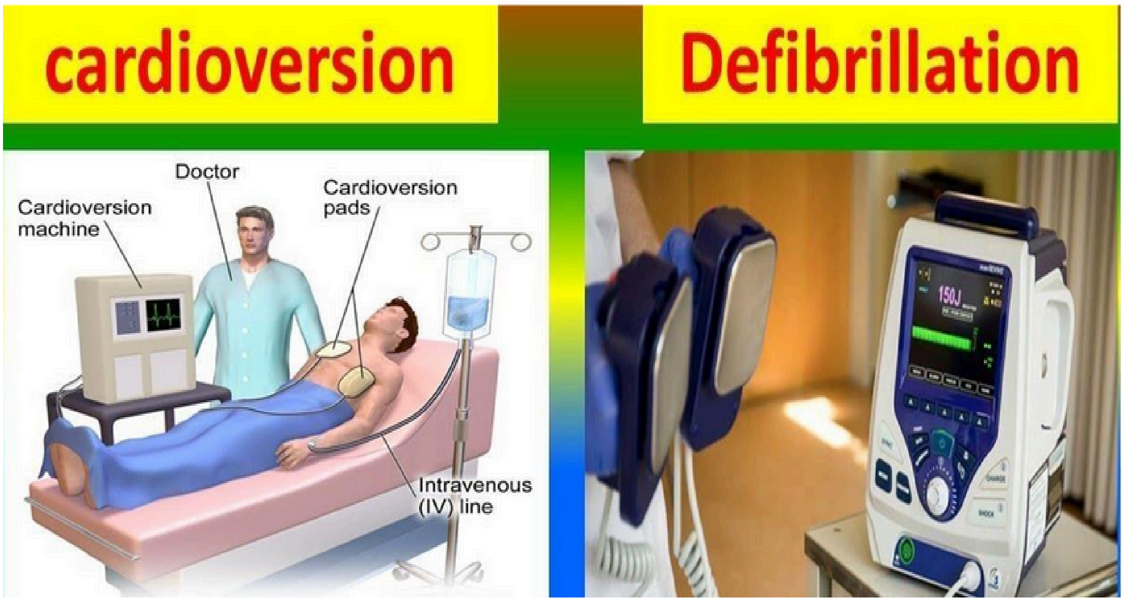


Energy Selection

There is an important distinction between defibrillation and cardioversion:

Defibrillation vs. Cardioversion

	Defibrillation	Cardioversion
Type Arrhythmia	Ventricular Fibrillation (VF)	Ventricular Tachycardia (VTach)
Level of Consciousness	Unconscious	Conscious
Synchronicity	Asynchronous	Synchronized with R wave
Energy Level	Starts at 200 joules	Starts at 25 – 50 joules



Defibrillators

- AED and manual versions are available.
- A step-up transformer increases mains voltage then a rectifier converts it to direct current. DC energy is discharged from a capacitor.
- Modern defibrillators use a biphasic current flow.
- Implanted automatic internal defibrillators are becoming more popular with pacemaker capabilities.

Blood warmer

A blood warmer device is a critical medical tool designed to heat blood, blood products, and intravenous (IV) fluids to normal body temperature (37) before transfusion, preventing hypothermia in patients during surgery, trauma care, or massive transfusions

Dry heat warmer

an electrically powered device that uses hot air or heated plates (no water) to warm:

- IV fluids
- Irrigation fluids
- Blankets
- Occasionally blood products (approved models only)

Used to prevent perioperative hypothermia.

Coaxial Blood Warmers

A coaxial blood warmer is an inline fluid/blood warming device in which blood flows through an inner tube, while heated fluid or electrically heated coils flow in an outer concentric (coaxial) chamber, allowing heat exchange without mixing.

Water heater warmer

A water heater warmer is a device that uses warm water as the heating medium to warm IV fluids or blood products, either by immersing coils/tubing or through a water-jacket system, allowing heat transfer without direct contact with the fluid.

Components

1. The on /off switch.
2. The thermometer gag for the degree of the water.
3. Thermostat control.
4. Light for the work of the devise and the other for over heat.
5. Heater inside the container and protected by steel net cover.

A ***B***

A. Inline fluid warmer. The intravenous fluid infusion or blood transfusion sets passes through the warmer and is effective for slow infusion rates. The device should be placed as near to patient as possible and is particularly useful for slow blood transfusions in theaters, recovery rooms and wards; B. Inline fluid warmer in use along with forced air warming intraoperatively.