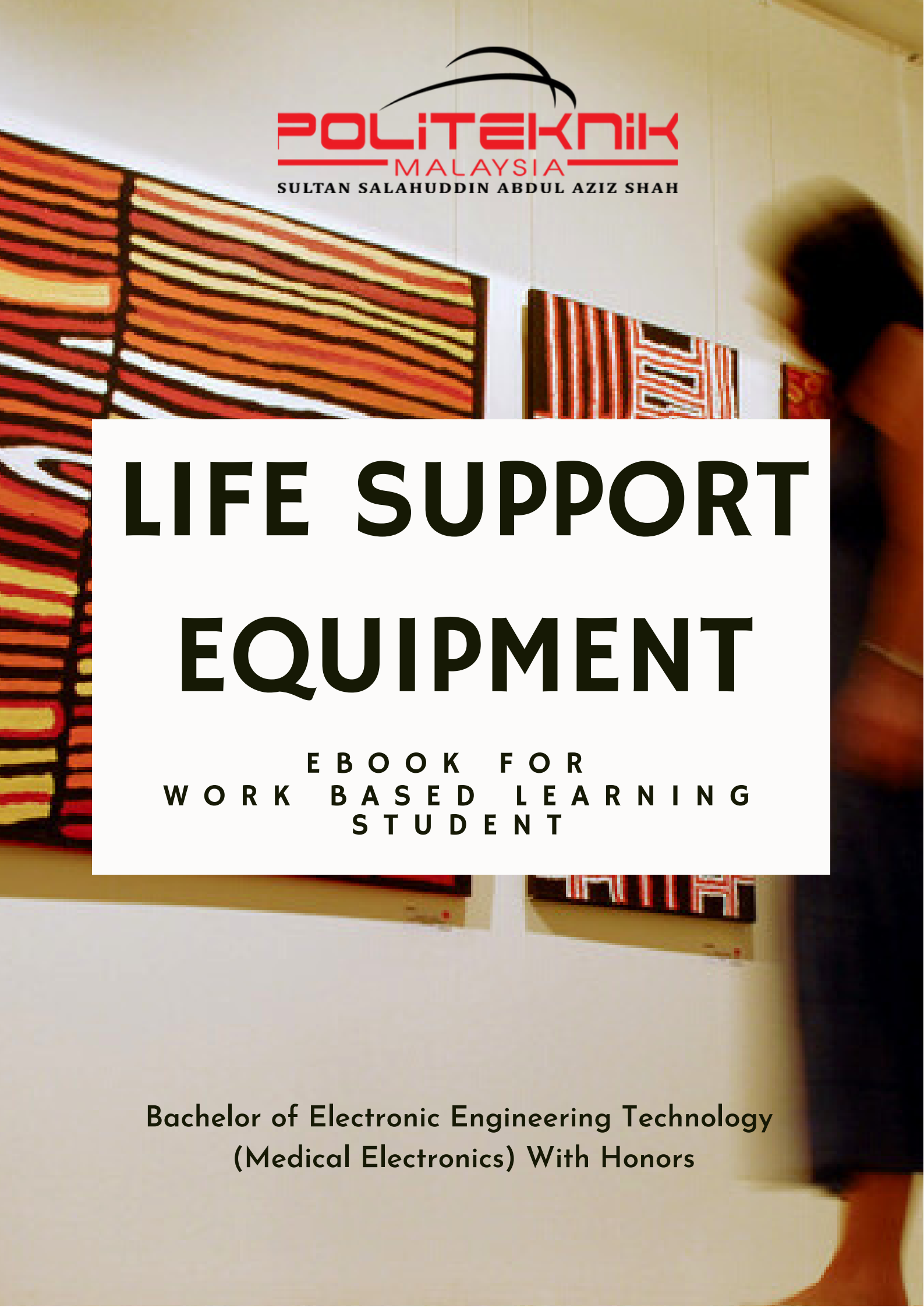

POLITEKNIK MALAYSIA
SULTAN SALAHUDDIN ABDUL AZIZ SHAH

LIFE SUPPORT EQUIPMENT

EBOOK FOR
WORK BASED LEARNING
STUDENT

Bachelor of Electronic Engineering Technology
(Medical Electronics) With Honors

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EDITORS: :

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Mariana Binti Rosdi
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Special project by :
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INTRODUCTION

LIFE SUPPORT EQUIPMENT

This e-book provides a foundation for life support equipment with the knowledge and skills related to biomedical equipment such as ventilators, anaesthesia machines, and dialysis units. We will be exposing possible barriers for a wider application of this equipment.

The initial part of the e-book is dedicated to basic principles of life support equipment in hospitals, assuming that understanding how a device works is one of the pre-requisites to improving the quality of its application and, ultimately, the outcomes. In-depth reviews help the technical solutions designed to solve the problems of the different potential complications.

We welcome your comments, suggestions, and criticism. We hope to make continuous improvements in a second edition and would greatly appreciate any input with regard to format, organization, content, presentation, or about specific questions. We look forward to hearing from you.

Study hard and good luck!

love and joy

Table of Contents

1.0 VENTILATOR

- A mechanical ventilator is an automatic machine designed to provide all or part of the work the body must do to move gas into and out of the lungs.
- The act of moving air into and out of the lungs is called breathing, or, more formally, ventilation.
- The simplest mechanical device we could devise to assist a person's breathing would be a hand-driven, syringe-type pump that is fitted to the person's mouth and nose using a mask.

Why are ventilators used?

1. To deliver high concentrations of oxygen into the lungs.

2. To help get rid of carbon dioxide

3. To decrease the amount of energy a patient uses on breathing so their body can concentrate on fighting infection or recovering

4. To breathe for a person who is not breathing because of injury to the nervous system, like the brain or spinal cord, or who has very weak muscles.

5. To breathe for a patient who is unconscious because of a severe infection, build-up of toxins, or drug overdose

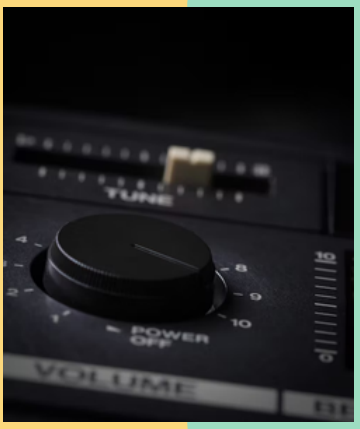
TYPES OF VENTILATORS

Pressure cycled

Flow is shut off when a preset amount of pressure in the lungs is reached

Time cycled

Flow is shut off when a preset time limit is reached

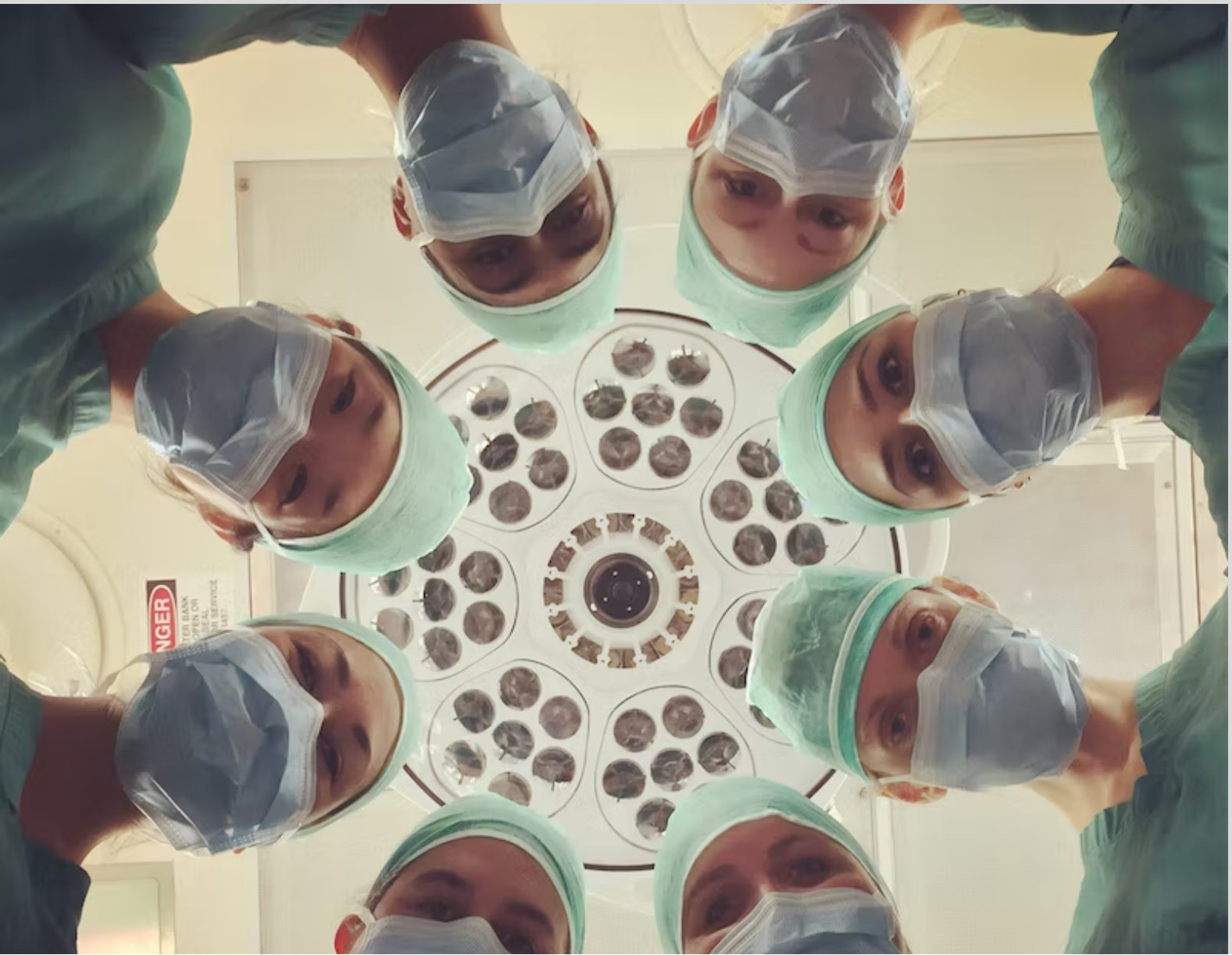


Volume cycled

Flow is shut off when a preset amount of volume is reached

DID YOU KNOW ?

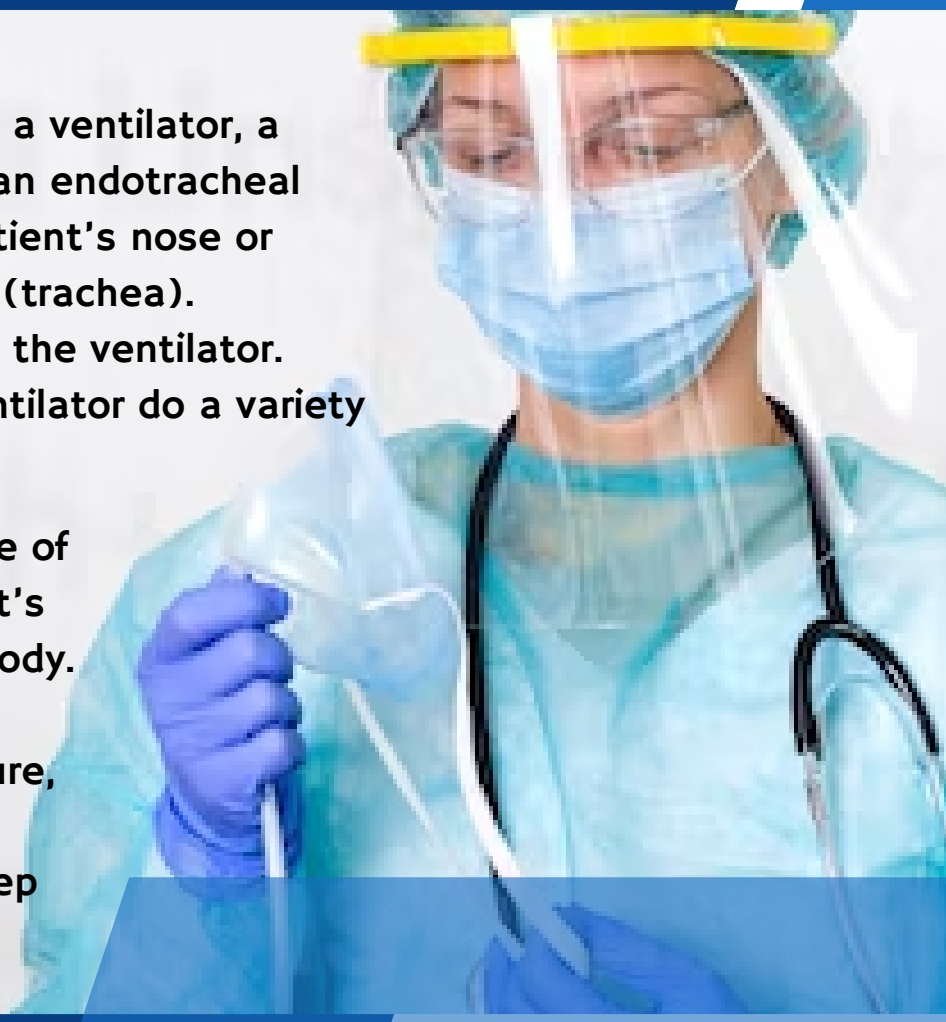
For people over 65 who require emergency ventilator use, about **2 out of 3** survive to leave the hospital. Older people with chronic conditions tend to have more disabilities after ventilator use and lower survival rates.



5 CATEGORIES OF PULMONARY PROBLEMS WHICH NEED FOR MECHANICAL VENTILATORY SUPPORT

1. Central nervous system problems which depress the drive to breathe (e.g., cerebrovascular accident).
2. Neuromuscular problems which lead to the failure of the peripheral nerves and muscles that aid respirations (e.g., multiple sclerosis).
3. Musculoskeletal and pleural dysfunctions (e.g., flail chest)
4. Problems with the airways themselves (e.g., asthma)
5. Reduction in the ability to exchange gases (e.g., pneumonia)

How does a ventilator work?



When a person needs to be on a ventilator, a healthcare provider will insert an endotracheal tube (ET tube) through the patient's nose or mouth and into their windpipe (trachea).
This tube is then connected to the ventilator.
The endotracheal tube and ventilator do a variety of jobs.

The ventilator pushes a mixture of air and oxygen into the patient's lungs to get oxygen into the body.
The ventilator can also hold a constant amount of low pressure, called positive end-expiratory pressure (PEEP), in order to keep the air sacs in the lung from collapsing.

The endotracheal tube allows doctors and nurses to remove mucous from the windpipe by suction.
If a person has a blockage in the trachea, such as from a tumour, or needs the ventilator for a long period of time, then they may need a tracheostomy procedure.

During a tracheostomy, a surgeon makes a hole in the patient's neck and trachea, then inserts a breathing tube called a tracheostomy tube into the hole.

The tracheostomy tube is then connected to the ventilator.
A tracheostomy tube can stay in as long as needed, but does not have to be permanent and can be removed if a patient no longer needs it.
It is possible for a person to talk and eat with a tracheostomy tube.

Ventilator **TESTING**

What is ventilator testing?

Ventilators apply volume and pressure to a patient's lung, to deliver assisted breathing. They are a vital part of critical care, which means the accuracy of ventilation variables is fundamental to patient safety. It is important that set values and actual values are equal

Why test ventilators?

Ventilators are sophisticated medical devices essential in supplying respiratory support to critical ill patients in clinical facilities and homes. They are also regularly used during surgery whilst patients are under anaesthesia. Long term ventilation at home is progressively becoming more common, initiated by an increase in severe respiratory diseases.

How to test ventilators?

Medical ventilator types differ by application with diverse ranges. Therefore, a ventilator tester must be capable of measuring flow, volume, pressure and oxygen over a wide range of values.

It is important that a gas flow analyzer is triggered correctly to measure the breath-based parameters. Detection of inspiration duration occurs during a ventilator's breath cycle. Exhalation time occurs via the test lung to the expiratory valve on a ventilator.

VISUAL INSPECTION

Visual inspection is a relatively easy procedure to make sure that the medical equipment in use still conforms to the specifications as released by the manufacturer and has not suffered from any external damage and/or contamination. These can include the following inspections:

1. Housing Enclosure – Look for damage, cracks etc
2. Contamination – Look for obstruction of moving parts, connector pins etc
3. Fuse rating – check correct values after replacement
4. Cabling (supply, Applied Parts etc) – Look for cuts, wrong connections etc
5. Markings and Labelling – check the integrity of safety markings
6. Integrity of mechanical parts – check for any obstructions

QUANTITATIVE TASKS

1. Tidal Volume Accuracy Test
2. Peak Pressure Inspiratory positive airway pressure(IPAP)
3. Positive End Expiratory Pressure (PEEP) System Test/expiratory positive airway pressure (EPAP)
4. Breath Rate
5. O2 % Accuracy Test

CRITICAL THINKING

skills

WHO	Who created the first mechanical ventilator?
WHAT	What are the 2 types of ventilators? What is ventilator used for?
WHERE	Where is ventilator inserted? Where is ventilation greatest in the lungs
WHY	Why do we need to perform maintenance on the ventilator? Why ventilators are situated close to the ceiling
WHEN	When should mechanical ventilation be removed?
HOW	How many types of ventilators are there? How long can a person survive after removing ventilator?

2.0 ANESTHESIA MACHINE

THE ANESTHESIA MACHINE

ANESTHESIA SYSTEMS ARE COMPRISED OF
5 KEY COMPONENTS:

1.Gas Regulation and Flow Control
2.Vaporization
3.Gas Management and Scavenging
4.Ventilation
5.Monitoring

Principal of anesthesia operation

Anesthesia is a state of controlled, temporary loss of sensation or awareness that is induced for medical and veterinary purposes.

It may include some or all of analgesia (relief from or prevention of pain), paralysis (muscle relaxation), amnesia (loss of memory), and unconsciousness.

Types of Anesthesia

1.Local Anesthesia
Local anesthesia is an anesthetic agent given to temporarily stop the sense of pain in a particular area of the body

2.Regional Anesthesia
Regional anesthesia is used to numb only the portion of the body that will undergo the surgery

3.General Anesthesia
General anesthesia is an anesthetic used to induce unconsciousness during surgery. The medicine is either inhaled through a breathing mask or tube, or given through an intravenous (IV) line.

DID YOU KNOW ?

- People Who Smoke May Need More Anesthesia Than Nonsmokers
- Anesthesia May Affect Your Memory
- Anesthesia Doesn't Always Put You to Sleep

THE COMPONENTS OF AN ANESTHESIA MACHINE

OXYGEN SOURCE

Patients will need help breathing while under, and oxygen is important.

OXYGEN FLOWMETER

Most machines have electronic proportional control valves that keep everything consistent.

HEADS-UP DISPLAY

A monitor on the machine allows doctors and technicians to track the flow of the gases and make sure the flow is consistent.

PATIENT BREATHING CIRCUIT

This is how the anesthetic is delivered to the patient, usually a hose and face mask that fits over the patient's nose and mouth.

SCAVENGING SYSTEM

This removes any excess gases from the machine and prevents it from contaminating the immediate atmosphere.

CHECKING ANESTHESIA MACHINES

8 Categories of check:

01 **Emergency ventilation equipment**

02 **High-Pressure system**

03 **Low-Pressure system**

04 **Scavenging system**

05 **Breathing system**

06 **Manual and automatic ventilation system**

07 **Monitors**

08 **Final Position**

https://anaesthetists.org/Home/Resources-publications/Guidelines/Checking-Anaesthetic-Equipment

CHECKLIST FOR ANAESTHETIC APPARATUS

1. Check that the anesthetic machine is connected to the electricity supply (if appropriate) and switched on.

2. Check that an oxygen analyzer is present on the anesthetic machine

3. Identify and take note of the gases that are being supplied by the pipeline, confirming with a `tugtest' that each pipeline is correctly inserted into the appropriate gas supply terminal

4. Check the operation of flowmeters

5. Check the vaporizer(s)

6. Check the breathing system to be employed

7. Check that the ventilator is configured appropriately for its intended use

8. Check that the anesthetic gas scavenging system is switched on and is functioning correctly

9. Check that all ancillary equipment that may be needed is present and working.

10. Ensure that the appropriate monitoring equipment is present, switched on and calibrated ready for use

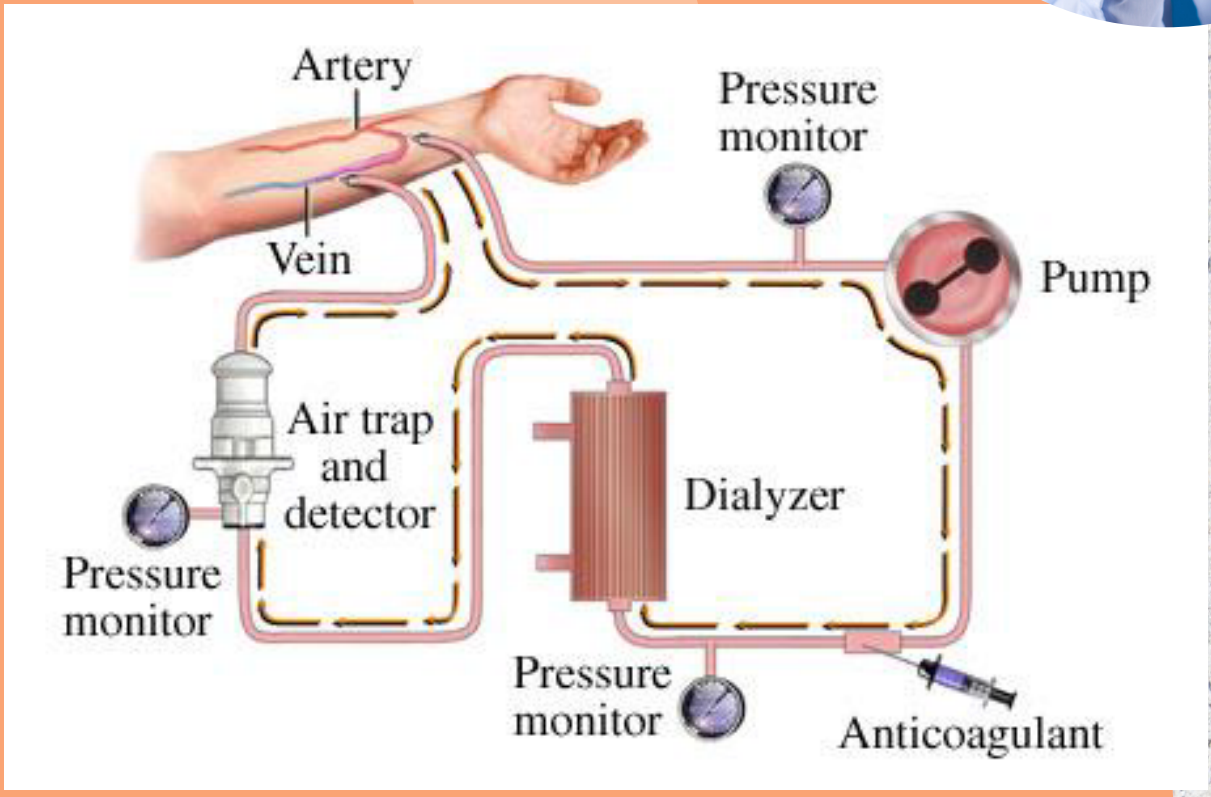
PROBLEM SOLVING

Write briefly about how you understand the following questions:

How does Anesthesia Work?	
What are the 3 main types of anesthesia?	
What is the most common type of anesthesia?	
What drugs are in general anesthesia?	
What are the most important parts of the anesthesia machine?	
How do I know if my anesthesia machine is leaking?	

3.0 DIALYSIS EQUIPMENT

PRINCIPLE OF
DIALYSIS



How the waste substances in the blood such as urea is removed from the blood?

- They are removed from the blood in the dialyzer.
- In the dialyzer, the blood with waste products will flow past one side of a semi-permeable membrane.
- On the other side of this membrane, there is a special substance called dialysate, which pulls waste from blood. The waste such as urea will pass through the membrane.

FUNCTIONS OF HEMODIALYSIS

- Cleanses the blood of accumulated waste products
- Removes the by-products of protein metabolism such as urea, creatinine, and uric acid.
- Removes excessive fluids
- Maintains or restores the buffer system of the body
- Maintains or restores electrolyte levels

Types Of Dialysis

- **Haemodialysis (HD)**
- **Peritoneal Dialysis (PD)**

Hemodialysis is the diffusion of dissolved particles from one fluid compartment into another across a semipermeable membrane. The client's blood flows through one and the dialysates in another fluid compartment.

Table of Comparison Between

Haemodialysis & Peritoneal Dialysis

Difference between haemodialysis and peritoneal dialysis

Aspect	Haemodialysis	Peritoneal Dialysis
Area dialyzed	Blood directly through arterial and venous access	Abdominal wall through a dialysing fluid
Frequency of dialysis	3-5 times a week	Every day
Potential side effects	Fatigue Low blood pressure	Risk of infection Limited membrane function
Major risks of treatment	Gastrointestinal effects Skin effects Fluid imbalance Inflammation Mental health impacts	Hernia Weight fluctuations Infection

DO YOU KNOW THE HISTORY DIALYSIS ?

DIALYSIS (FROM GREEK DIALUSIS, MEANING DISSOLUTION, **DIA**, MEANING THROUGH, AND **LYSIS**, MEANING LOOSENING OR SPLITTING) IS A PROCESS OF REMOVING WASTE AND EXCESS WATER FROM THE BLOOD AND IS USED PRIMARILY AS AN ARTIFICIAL REPLACEMENT FOR LOST KIDNEY FUNCTION IN PEOPLE WITH RENAL FAILURE

HTTPS://WWW.NCBI.NLM.NIH.GOV/BOOKS/NBK563296S.

The mechanism used for purification

Dialysis machines filter unwanted minerals from blood by 2 means:

Diffusion
Movement of solute across a semipermeable membrane from a region of high concentration to one of low concentration

Ultrafiltration
Ultrafiltration is made possible by the osmosis movement of water across a semipermeable membrane from low osmolality to high osmolality.

Osmolality –number of osmotically active particles in a unit (liter) of solvent

PRINCIPLES OF HEMODIALYSIS

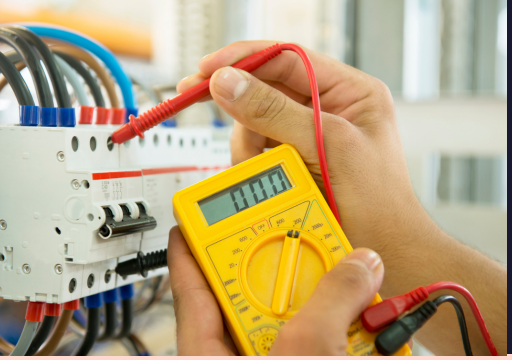
- Diffusion is the movement of particles from an area of greater concentration to one of lesser concentration

- Osmosis is the movement of fluids across a semipermeable membrane from an area of lesser concentration of particles to an area of greater concentration of particles

- Ultrafiltration is the movement of fluid across a semipermeable membrane as a result of an artificially created pressure gradient

HAEMODIALYSIS (HD) -It involves the diffusion of solutes across a semipermeable membrane. Hemodialysis utilizes counter-current flow, where the dialysate is flowing in the opposite direction to blood flow in the extracorporeal circuit.

PERITONEAL DIALYSIS -In peritoneal dialysis, a sterile solution containing glucose (called dialysate) is run through a tube into the peritoneal cavity, the abdominal body cavity around the intestine, where the peritoneal membrane acts as a partially permeable membrane.



PROBLEMS WITH HEAMODIALYSIS

1

Rapid changes in BP

Fainting, vomiting, cramps, chest pain, irritability, fatigue, temporary loss of vision

2

Fluid overload and restrictions,Hyperkalaemia

-esp. in between sessions
-more stringent with HD than PD

3

Loss of independence Pain with needles & Problems with access

poor quality, blockage etc. Infection

4

Bleeding & Infections

from the fistula during or after dialysis
during sessions; exit site infections; blood-borne viruses. g. Hepatitis, HIV

PROBLEMS WITH PERITONEAL DIALYSIS

01 Responsibility

Some kidney patients get tired of the responsibility of doing their peritoneal dialysis every day.

02 Body image

Some peritoneal dialysis patients find it challenging to accept a permanent PD catheter. They worry that the catheter may affect their sexual activity and relationship with their partner.

03 Fluid overload

Fluid overload occurs when there is too much fluid in the body

04 Dehydration

Dehydration occurs when there is too little fluid in the body. It can be caused by excess fluid loss due to diarrhea or sweating

05 Discomfort

Dehydration occurs when there is too little fluid in the body. It can be caused by excess fluid loss due to diarrhea or sweating

PLANNED PREVENTIVE MAINTENANCE (PPM)

QUANTITATIVE TASKS

1. Hydraulic Check
2. Ultrafiltration System and Membrane Pump

DIALYSIS MODE

1. Extracorporeal Component
2. **Conductivity**
3. Blood Pump

TEST YOUR UNDERSTANDING

1. What are the 3 principles of dialysis?

2. What are the 5 factors affecting dialysis?

3. How much fluid is removed during dialysis?

4. How many times a dialyzer can be used?

5. Osmosis is the movement of particles from an area of greater concentration to one of lesser concentration

TRUE/FALSE

6. Dialysis machine filter unwanted minerals from blood

TRUE/FALSE

7. **D_____T__N**

Occurs when there is too little fluid in the body. It can be caused by excess fluid loss due to diarrhea or sweating

8. **D_ _F_ _ _ _N**

Waste products and excess fluid through the peritoneum into the dialysate

ELECTRICAL SAFETY STANDARDS

IEC 60601.

- Class I—Live part covered by basic insulation and protective earth
- Class II—Live part covered by double or reinforced insulation
- Class IP—Internal power supply

ELECTRICAL SAFETY TEST

The electrical safety test verifies ground continuity and verifies that forward leakage current are within safe limits.

LEAKAGE MEASUREMENT LIMITS

- NC—normal conditions
- SFC—single fault conditions

TYPE PATIENT-APPLIED PART :

- ☑ Type B—Patient applied part earthed
- ☑ Type BF—Patient applied part floating (surface conductor)
- ☑ Type CF—Patient applied part floating for use in direct contact with the heart

IEC 62353

IEC 62353, is used for medical device testing in hospitals. IEC 62353 was developed because IEC 60601.1 is a type-testing standard with no risk management criteria and is impractical for testing in the hospital environment.

The IEC 62353 standard will provide;

- Global test reference to allow uniform testing
- Development tools for saving and suitable test sequences
- A method of record keeping and maintenance procedures

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