ANAESTHESIA

Terms you will become familiar with in this section of the module

anaesthesia	thorpe tube
general anaesthesia	volatile
local anaesthesia	bi-metal strip
regional anaesthesia	baffle
epidural	patient circuit
ANZCA	circle circuit
inhalation	reservoir bag
vapouriser	granule
back bar	pressure release valve
flow meter	Occupational Health and Safety
rotameter	scavenging system
	hypoxia

General anaesthesia: a state of reversible loss of sensation and consciousness. [Chung & Lam, 1997].

INTRODUCTION

In established Medical Centres, general anaesthesia is usually delivered with an **anaesthetic machine** [pronounced ann-uss-thetik]. The function of the anaesthetic machine is to deliver a safe and accurate mixture of anaesthetic gases and oxygen to the patient. Delivery of accurate doses of anaesthetic gases is essential to keep the patient 'deep enough' (asleep), without overdosing the anaesthetic gases. Because of this, the anaesthetic machine has become an essential piece of equipment. As a result, it is essential that this piece of equipment is fully operational at all times.

The **anaesthetist** [pronounced ann-ees-thut-ist] has the task of calculating appropriate levels of anaesthetic gases based on such variables as body weight and the type of disease or health condition of the patient. Ensuring that the anaesthetic machine delivers a correct mix of oxygen and anaesthetic gases during the operation and weaning the patient back to normal breathing afterwards is an important aspect of the role of this specialist.

ANATOMY & PHYSIOLOGY

Under a **general anaesthetic**, patients are unconscious (asleep) and unable to feel pain or sense other stimuli. As a result, they are unable to protect themselves or to respond to self-protective physiological warning signs which they would normally try to act upon [eg the blink reflex when something threatens our eyes or even pupil contraction to protect against strong lights]. In extreme cases, brain function is slowed down [**depressed**] to a point where the ability to perform normal functions such as breathing are affected. It is also possible that usually unconscious body functions such as the beating of the heart may be adversely affected.

It is the total responsibility of the anaesthetist to make sure that these life-threatening events do not occur. As a result, all technology associated with anaesthesia is carefully checked before every operation according to strict checklists and protocols or policies published by the **Australian and New Zealand College of Anaesthetists**. The check of the machine is designed to pick up any problems that may affect its function. If a fault or problem is picked up and unable to be remedied, your technical expertise may be required. The role of the biomedical engineer or technician in supporting the anaesthetists in maintaining their equipment is extremely important.

Under a **local anaesthetic**, a limited part of the body is made insensitive to pain and the patient remains awake [eg a person who needs stitches in a finger may require a local anaesthetic injected around the finger to make it numb].
Regional anaesthesia [pronounced ann-us-thee-zee-ah] numbs an area of the body such as the pelvic area for a woman giving birth to a baby [epidural].

Equipment which is ***emphasised,*** **referred to or used** in this section includes:

- ***Anaesthetic machine***
- **End Tidal CO_2 monitor**
- **Pulse oximeter**
- **flow meter/rotameter/thorpe tube**
- ***back bar***
- ***vapouriser***
- **reservoir bag**
- **pressure release valve**
- ***nerve stimulator***
- ***ventilator***
- ***capnograph***

• *Anaesthetic gas analyser*

Anaesthetic machine

Patients who require surgery usually require an anaesthetic. Mr Jones, who needed an arthroscopy to repair his knee after trying to keep up with his sons playing football, [see section 2] is given a general anaesthetic so that he will be asleep and insensitive to pain during the operation. In the unconscious state, he will not respond to what he might feel, hear or see. As a result, the surgeon will not have to worry about Mr Jones moving his knee or adjusting his position at critical moments.

The anaesthetist is a specialist doctor who has studied and gained extra qualifications through the Australian and New Zealand College of Anaesthetists.

To complete this section you will need access to resource books and manuals that describe the components and action of the anaesthetic machine in detail.

Gases supplied by cylinders or through bulk supply pipelines

[Inhalational anaesthetic gases supplied from vapourisers will be discussed later in this section]

fig 1. Gas cylinders for anaesthesia

Activities

Identify the gases supplied from cylinders or through bulk supply pipelines to the anaesthetic machine.
Note the standard colour coding for each gas.
Identify the difference in screw threads, pipeline diameters and screw direction used to prevent the hoses and cylinders being connected to the incorrect source of gas or being placed on the incorrect inlet on the machine. Note how these differences increase safety and reduce the possibility of mistakes in set-up.
Compare the differences in cylinder storage of gases compared to pipeline supply. Note the pressure differences and the use and location of pressure regulators for each these sources.

Questions

Consider the importance of standards for the colour coding of gas cylinders used in medical and scientific applications. How do the colour codings, screw threads, tube diameters and thread direction work together to increase safety in anaesthesia?

Identify the pressure gauges on the anaesthetic machines used in your hospital. What information do these gauges provide?
When should an oxygen cylinder be changed?
When should a nitrous oxide cylinder be changed?
What is the difference between the way oxygen and nitrous oxide are stored in cylinders?
Considering the difference in storage, how would you explain to a non-technical person why the cylinders are changed at different pressures and before they are empty?
Investigate what safety measures should be observed when handling and moving cylinders.
From your knowledge of the way cylinders are stored, what effect would leaving cylinders in the sun have on the pressure in each? What are the storage implications of this difference? Do the storage and handling procedures need to be changed for cylinders which are ‘empty’?

This next section tracks the flow of gas once it enters the anaesthetic machine. The section identifies a number of components connected to what is commonly known as the **back bar** [see fig 2].

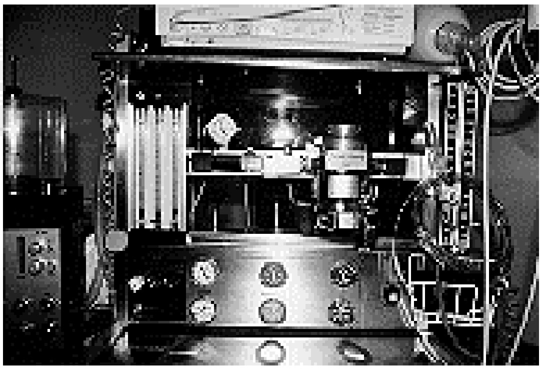

fig 2. The back bar

The **flowmeters** [or **rotameters]** on anaesthetic machines, otherwise known as **Thorpe tubes**, are quite different from conventional types of flowmeters [see three thorpe tubes on left in fig 2].

Image to follow

fig 3. Thorpe tube flowmeter
[Source: Morgan & Mickhail, 1992: 4-4]

Activities

Using your resource books and manuals, note the special features of Thorpe tubes which make them different from conventional flowmeters. Identify and note the safety features that are specifically designed to prevent mishaps from occurring and dangerous mixes of gases being delivered to the patient.

After the gases leave the flowmeters, they are mixed together to flow along the back bar to the **vapourisers** where they are mixed with a **volatile anaesthetic agent** [a volatile liquid has a very low boiling point so it vapourises easily to the gaseous phase at room temperatures- like perfume or aftershave spray] **.**

The vapouriser [see fig 4 below] depends on the flow of the oxygen/nitrous oxide mixture to create a constant rate of evaporation of the anaesthetic agent to help keep the patient asleep. Temperature changes affect evaporation rates so the casing of the vapouriser is constructed to resist minor atmospheric temperature variation. A change in the rate of flow of gas across the volatile agent increases the percentage of anaesthetic agent in the resulting mixture. Flow rates are set manually from the control cone [see diagram below] and variation is minimised by use of a temperature sensitive element [**bimetal strip**] to change flow rates automatically in response to temperature variation during operation.

Image to follow

fig 4. Variable bypass vapouriser
[Source: Morgan & Mickhail, 1992: 4-8]

The number of different volatile anaesthetic agents in use vary in cost, immediate effects, recovery rates and after-effects. Common volatile agents include: ethrane, isoflurane, sevoflurane

Activities

The hot air hand dryer blows air across the wet skin surface to evaporate water and carry it from the site by convection. The vapourisers on the back bar work by the same principle but rely on the boiling point of the volatile anaesthetic agent being much lower than for water. In the same way, blowing on a hot drink carries evaporated water [as steam] from the surface of the drink and lowers its temperature. Pouring the hot drink into your saucer increases the surface area for evaporation and cools the drink more quickly.

Use the manual and reference books to establish the detail of vapouriser operation on your anaesthetic machines.
How does the liquid agent convert to a gaseous form?
How does the oxygen and nitrous oxide mix with the volatile agent?
Does the vapouriser you are investigating have **internal baffles**?
What effect do these have on surface area of the volatile agent?
What effect do baffles have on the flow of gases through the vapouriser?

How do vapourisers attach to the machine?
Consider safety issues with vapourisers. What information are you able to find, either on reading or on discussion with people in the clinical area, about safety associated with vapourisers and volatile agents?
What other important components of the machine are you able to discover within the back bar?

From the back bar, a carefully balanced mixture of gases flows into the section called the **patient circuit** [see fig 5]. There are many types of patient circuits but their common feature is that anaesthetic gases from the machine are delivered to the patient and returned or exhausted so that a balance of gases is achieved, monitored and maintained throughout the period of the general anaesthesia.

Image to follow

fig 5. Anaesthesia circuit system
[Source: Morgan & Mickhail, 1992: 4-4]

The circuit most commonly in use in adult hospitals is known as a **circle circuit**. The circuit includes a **reservoir bag** or balloon, the closely fitting face mask covering both nose and mouth, and a carbon dioxide absorbent [**soda lime**] filled with soda lime granules [see fig 6].

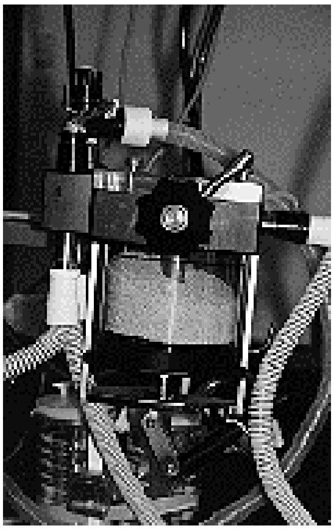

fig 6 moisture absorbtion

Activity

Use your reference books to read up on the circle circuit. Note the direction of gas flow through the circuit, use of one way valves, the soda lime absorber, how the circuit connects to the machine.
Notice in diagrams that the mask that is fitted to the patient's face appears to be at the end of the circuit. For the gases to be delivered effectively to the patient, it is important that the anaesthetist hold this mask firmly over the patient's nose and mouth to create a good seal.

Questions

What is the purpose of the APL valve or **pressure release valve**? How does the pressure release valve help to ensure patient safety?

What is the chemistry of the soda lime absorbers? Is this reaction reversible?
How can the state of the soda lime absorbers be guaranteed before and during an operation?

Some soda lime contains a coloured chemical [**ethylene violet**] which acts as an indicator of the level of carbon dioxide absorbed by the soda lime. Is the colour loss reversible? **Ethylene violet** is reactive with fluorescent light? How can this interfere with normal soda lime checking procedures? What other difficulties are associated with the use of coloured soda lime?
What effect would the use of carbon dioxide exhausted soda lime have on the mixture of gases being inhaled by the patient? How would this affect the ability of the patient to maintain normal oxygen intake levels?

Small surplus amounts of the anaesthetic gases and nitrous oxide will be exhaled by the patient into the atmosphere of the operating room. This gas has substantial implications for the **Occupational Health and Safety** of staff who work in operating rooms.

Although there is no long-term effect of anaesthesia on the client, the effect of constant exposure to anaesthetic gases by medical teams has been reported as responsible for an increased incidence of miscarriages for women, birth defects in the children of both males and females, kidney damage [nephrotoxicity], and neurological problems. While research has not established proven links, the establishment of routine safety procedures is strongly suggested.

Scavenging systems are used to exhaust surplus gases from the anaesthetic circuit and exhaust them from the operating room to the air outside. Because of the possible danger of cumulative exposure to anaesthetic gases and nitrous oxide in operating room staff, the inclusion of a scavenging system should be an essential feature in all anaesthetic circuits.

Activities

Use your resource materials to explore the range of occupational health and safety risks produced by uncontrolled short and long-term breathing of anaesthetic gases. Make notes on the safety aspects of routine gas scavenging which should be used in the operating room?
Are scavenging systems established in the operating rooms of your Medical Centre?
Who is responsible for the checking and maintenance of the scavenging systems?
Are these routines necessary in wards where oxygen and other gases are available through bulk pipelines?

Who is responsible for monitoring the atmosphere levels of potentially toxic gases in your medical centre? Are the results of an established monitoring routine published for your medical centre staff?

It is important for you to know what types of anaesthetic machines you have in your hospital. Make sure that you have considered the following information as well:

- anti-hypoxic device in use on the machines in your hospital
- oxygen failure device/alarm
- emergency oxygen flush button
- non-return valve
- pressure relief valve.

Now that you are more familiar with the components of the anaesthetic machine, you should arrange with the anaesthetic department of your hospital to observe a member of the staff going through the check of the machine that was mentioned above. Ask this person to explain as they go what it is they are doing and checking. You may also wish to ask for a copy of the checking policy if your biomedical engineering department doesn't already have one. At this time you may wish to ask the staff member what the most common problems are that arise during the check of the machine, eg. leaks.

Nerve stimulators

Terms you will become familiar with in this section of the module

neuro-muscular blocking	endo-tracheal tube
transmitter substance	ventilator
muscle cell membrane	neuro-muscular blockade

The need to keep anaesthetic levels balanced so that the client remains unconscious without the risk of overdose is a basic principle of modern anaesthesia.

The use of local and regional anaesthetics and low dose general anaesthesia, however, creates a need to include muscle relaxation as part of anaesthetic technology. Muscle relaxation makes surgical intervention easier, reduces the extent of the surgery and makes necessary stretching and manipulation at the operating site easier.

Anatomy and Physiology

Nerves send impulses to muscles to signal them to move, contract and relax, for breathing, talking and, particularly, for self protection.

Neuro-muscular blocking agents are drugs that prevent nerve impulses from reaching the muscles. **Neuro** [pronounced new-roh]- refers to nerves and **muscular** refers to muscles, hence **neuromuscular**. The point where nerve impulses stimulate muscles is called the **neuro-muscular junction** and it is at this point that muscle relaxing drugs have their effect.

Neuro-muscular blocking agents either prevent the uptake of **transmitter substance** from the nerve ending across a tiny gap [**synapse**] to the **muscle cell membrane** or they create a massive depolarisation which prevents the muscle cell membrane from responding to further stimulus. Without incoming signals from the nerves, the muscle is paralyzed. Many of the neuro-muscular blocking agents used in modern anaesthesia work in a similar way to the poison Curare, used on the tips of arrows by South American Indians to paralyse animals [and enemies]. Local anaesthetics act to prevent depolarisation by blocking the passage of sodium ions so that nerve impulses cannot be transmitted.

Neuro-muscular blocking agents prevent movement so the client is actually paralyzed. Under general anaesthesia, the nerves controlling breathing are also blocked. To overcome this, a special breathing tube [**endo-tracheal tube**]is placed into the patient's lungs so that a **ventilator** can take over the patient's breathing.

It is important that clients who are given muscle relaxing drugs are monitored closely during surgery to ensure that the muscle relaxant doesn't start to wear off. The anaesthetist monitors neuromuscular function to ensure that an adequate **neuromuscular blockade** is maintained.

A **peripheral nerve stimulator** is used to assess the extent of neuromuscular blockade. Some anaesthetists use the nerve stimulator routinely when muscle relaxing drugs are given, others prefer to use nerve stimulators for particular types of surgery.

The nerve stimulator is designed to deliver an electrical stimulus, which will cause a muscle to twitch when it is applied to a **peripheral nerve**. This twitch is seen as movement. Usually the ulnar nerve is chosen for stimulation and a **twitch** of the thumb is observed. The peripheral nerve stimulator is used to monitor the degree of neuromuscular blockade. Two electrodes [similar to those used to monitor with the ECG] are placed over the ulnar nerve and leads are attached to deliver an **electrical stimulus** [a controlled electric shock] from the nerve stimulator.

Image to follow

fig 7. Stimulation of the ulnar nerve [adductor pollicis muscle]
[Source: Morgan & Mickhail, 1992: 6-32]

The stimulator is used in three different modes: single twitch, train of four and tetany. Use of the monitor assists the anaesthetist to maintain appropriate levels of muscle relaxation. It may also be used to ensure that neuromuscular blocking drugs have worn off sufficiently for the client to breathe on their own post-operatively.

Activities

Using your resource materials, establish the basic difference between single twitch, train of four and tetany modes.
How is each of the modes used?
In discussion with the anaesthetist, identify the different stages of anaesthesia at which each mode is more likely to be used?

Visit an operating room at your medical centre to see these monitors in use.

Arrange with the anaesthetist to experience neuromuscular stimulus at low levels in each of the three modes.
Warning: to avoid painful shocks, **do not try to use the peripheral nerve stimulator on yourself.**

Using your resource materials, establish the similarities and differences between a peripheral nerve stimulator and a defibrillator.

Peripheral nerve stimulators may also used to locate nerves when the anaesthetist needs to inject local anaesthetic around them.

Activity

In discussion with the anaesthetist, discuss situations in which it would be important to locate the position of the nerve before injecting local anaesthetic.

Ventilators

Terms you will become familiar with in this section of the module

mechanical ventilation	volume limiting
stretch receptors	time cycling
reflex action	ICU ventilator

Anatomy and Physiology

As previously discussed, the use of neuromuscular blockade with clients under general anaesthetic nearly always involves **mechanical ventilation**. As the lungs are filled during normal breathing, they respond to excessive intake of gases through **stretch receptors**. Inspiration ceases as the **reflex action** established by the stretch receptors signals to the chest muscles that gas intake should stop. Under anaesthesia, the ability of the stretch receptors to signal to muscles is suppressed or even stopped. The possibility of the lungs being over-inflated is a risk the anaesthetist has to monitor carefully.

Although they function in similar ways, the mechanical ventilators used in anaesthesia are slightly different to those used in a critical care unit. As a result, their external appearance is quite different [see fig 8].

Image to follow

fig 8. Ventilator

Questions

Most anaesthesia ventilators are **volume limited** but **time cycled**. The anaesthetist is able to set the volume breathed by the client for each minute of time.
Using your resource materials, revise what 'volume limiting' and 'time cycling' mean.
Suggest why it is important to include a minute volume limiting facility on an anaesthesia ventilator when a tidal volume limiter is more common on an ICU ventilator.
How is time cycling useful for the anaesthetist?

Compare and contrast an **ICU ventilator** with an **anaesthesia ventilator**. What are the main differences?
What are the important alarms for an anaesthesia ventilator?

Airway gas analysis: **Capnography**

Terms you will become familiar with in this section of the module

capnograph	in-line sampling
end tidal carbon dioxide	sidestream sampling
respiration	

As we breathe out [**expire**], we exhale large amounts of carbon dioxide. The **capnograph** measures how much carbon dioxide is being exhaled in each breath. A capnograph is used routinely in anaesthetic practice to monitor **end tidal carbon dioxide**. This monitor is very reliable and accurate.

Anatomy & Physiology

During general anaesthesia, the ability of the respiratory centre in the brain to signal changes in breathing [**respiration]** rate to maintain oxygen levels in the blood is inhibited. When this occurs, the anaesthetist must control blood gas levels by **mechanical ventilation**. The end of breath [**end-tidal**] measurement of carbon dioxide - which is closely related to the level of carbon dioxide in arterial blood, becomes an important measurement for the anaesthetist because it establishes the efficiency of gas exchange occurring within the lungs. A graphical waveform is displayed on the monitor with a digital readout of the carbon dioxide level. This monitor functions in a similar manner to pulse oximetry, relying on beams of infra-red light.

Questions

The capnograph may be used as an **in-line** or **sidestream sampler**. What is the difference?
What differences in reading would you expect using the capnograph as an in-line sampler and a sidestream sampler?
Suggest why one use might be preferred over the other.

Activities

Visit an operating room at your medical centre and view the capnographs that are used. Are they being used in-line or sidestream? Obtain a manual of the capnographs and familiarise yourself with how these particular monitors measure Carbon dioxide.

Speak with the nursing staff about their most common problems with capnographs.
Develop a simple approach to reducing these problems indicating the most likely reasons for the problems and the physiological effect each

problem would have on the client if it occurred un-observed during an operation.

A common complaint is that moisture accumulates within the gas analysis system. This build-up prevents accurate measurement from occurring.

Questions

Where does the moisture come from?
What can nursing staff do to reduce the problem of moisture build-up in the capnograph?
What effect does the moisture build-up have on the displayed level of end tidal carbon dioxide?
How could a misinterpretation of this level affect the response of the anaesthetist if the problem remained unidentified?

Anaesthetic gas analysers

Some capnograph monitors can identify and measure the levels of **inhalational anaesthetic agents** used [these are the gases that are vapourized - the volatile agents such as halothane, enflurane, isoflurane or sevoflurane]. Older capnographs are usually not able to analyse anaesthetic agents.

The way the capnography machine analyses anaesthetic agents is dependent on the type of machine. Most newer machines utilise the same infra-red technology that the capnograph is using to determine carbon dioxide levels. This technology is also used in **pulse oximetry**. You should access the manual to determine exactly how the monitors on your machines analyse these gases.

Questions

Why is it important to measure how much anaesthetic gas the patient is inhaling?
What risks might be involved in allowing the client to inhale excessive amounts of: volatile anaesthetic agent, nitrous oxide, oxygen?
How important is it to continuously monitor the level of unconsciousness of the client under general anaesthesia?
The use of neuro muscular blocking agents creates paralysis.
What implications does this have for monitoring the levels of inhaled anaesthetic agents?

End file