By Adam Hollingworth

Environmental Safety

Macroshock & Microshock

- ANZ electrical sockets =
  - 50Hz - excellent frequency to induce VF
  - 230V
  - A/C

Macroshock

- definition unclear:
  - any term of an electrical current >10mA (but usually >100-300mA) passing though skin/body or
  - that current passes through trunk/heart
- aka electrocution ie immediate obvious injury
- usually occurs via skin to skin pathway
- note a high voltage/low current shock is not dangerous
- sources:
  - poorly designed equipment
  - lightning
  - melted power cords

Microshock

- defined = otherwise imperceptible electrical current applied to heart muscle of sufficient strength/ frequency/duration to cause disruption of normal cardiac function ie arrhythmia
- theoretically a risk in pts with protruding intracardiac electrical conductors eg
  - pacemaker electrodes
  - saline filled catheters
  - cardiac catherterisation
- in anaesthetised pt no pain or reflex to prevent ongoing electrical exposure:
  - during invasive cardiac procedure pt contacts both:
    - source of current - AC/DC
    - common return pathway
  - low current, long time of exposure could ⟹ death
- source of current:
  - wall socket
  - faulty equipment
  - poorly designed equipment
- current flows down entry point eg limb ⟹ focuses & converges onto catheter in heart
  ↳ focusing = major danger of microshock
- catheter is conductive ∴ takes current back out of body to equipment connected to
  ↳ & destination of current also need to earth to complete circuit
- never been proven to have occurred ever!

Preventative strategies

- Studies on dogs suggest threshold of 10uA (microampere) for danger of inducing VF
- modern medical devices contain protective strategies to limit danger.
  ↳ these categorised:
    - unprotected
    - body floating
    - cardiac protective
- simple circuit breaker not practical as need theatre equipment to work continuously to sustain life

Unprotected

- class 1 = earth & fuse
- class 2 = double insulation ∴ doesnt need earth
- class 3 = low voltage, low current <10uA

Body Floating

- has a floating circuit ∴ no earth possible
- need line isolation monitor ie looks for flow of current out of circuit to external earth. if occurs then shuts circuit down

Cardiac Protective

- eg pacemaker, also not earthed

Explosions & Fire

- historically very large risk of fire & explosion with explosive anaesthetic agents
- now non existent due to non-explosive agents
-

Anaesthetic Waste Gases

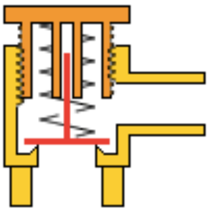
- 1970s-1980s studies raised concerns about:
    - hepatic disease
    - ↓ed mental performance
    - ↓manual dexterity
    - ↑rate of miscarriage
    - ↑incidence of congenital abnormalities in children from male & female anaesthetists
- but questions over there methodology
- control methods include:
    - good anaesthetic practise
    - frequent changes of theatre air
    - gas scavenging
- despite this exposure will still occur:
    - inhalation induction
    - mask ventilation
    - leaks around uncuffed paeds ETTs

Scavenging

- need to maintain a vapour free operating theatre environment
- exist maximum accepted concentrations of volatile agent over 8hr time weighted average:
    - N_2O = 25ppm
    - any halogenated agent = 2ppm

Breathing System Outlet

- excess gas is usually vented from breathing circuit via adjustable pressure limiting vale (pop off)
  ↳ except in Mapleson E & F systems

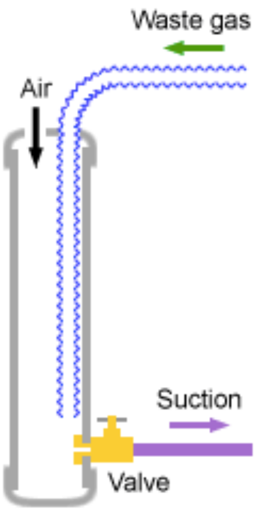


- valve held in place by weak spring
- tension adjusted by screw mechanism
- outlet of breathing system connected to scavenging system

Types of Scavenging

- charcoal canisters:
  - removes halogenated anaesthetics by filtration
  - advs:
    - no set up cost
    - mobile
  - disadv:
    - must be replaced every 12hours
    - does not remove N_2O
    - heating canister ⟹ release of inhalational agents
- passive systems (dump it outside):
  - collecting & transfer system connected to outlet ⟹ receiving system
  - can use a reservoir bad with pressure valves to guard against over +ve or -ve pressure
  - waste gas then ducted out of building via:
    - open window
    - pipe through wall
    - extractor fan
  - adv: cheap & simple
  - disadv: impractical in some buildings
- active systems:
  - flows:
    - need 80L/min to maintain removal of expired gases from theatres **or**
    - 15 air change/hr/operating room to avoid accumulation
  - connect outlet to hosp vacuum system via interface controlled by needle valve
    - reservoir made of plastic pipe capped at both ends with a needle valve at the bottom
    - 2 holes in top of plastic pipe:
      - air inlet
      - waste gas inlet
    - valve is adjusted so air is slowly sucked into pipe when machine is in use

  - adv:
    - convenient in large hospitals where many machines in multiple rooms
  - disadv:
    - vacuum system & pipe work is expensive
    - needle valve needs continual adjustment



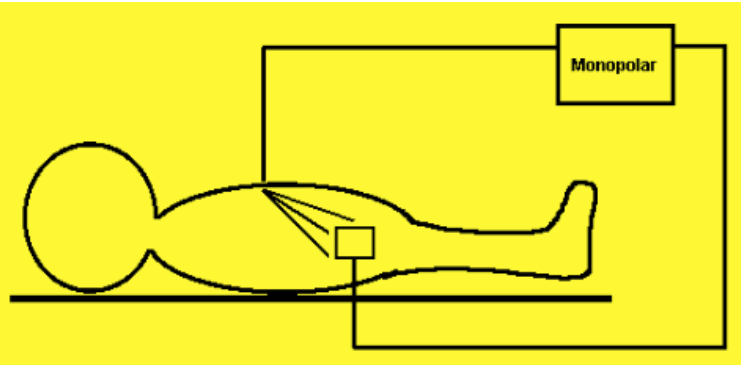
Medical Gases

- see respiratory.pages

Surgical Diathermy

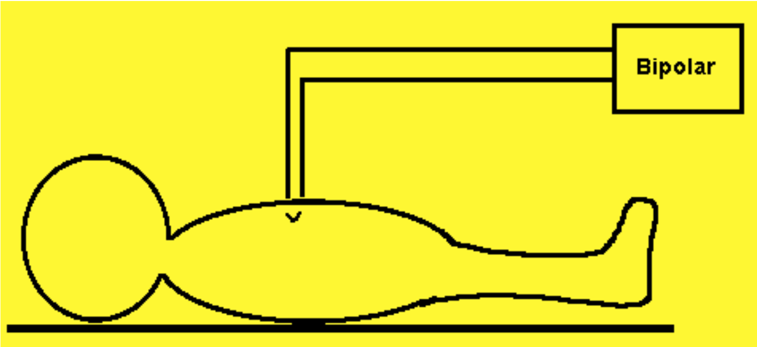
- = use of high frequency electric current to produce heat
- used to either
    - cut or destroy tissue
    - produce coagulation
- frequency:
    - mains electrics = 50Hz
    - diathermy = 10kHz to 1MHz
- patients body forms part of the electrical circuit
- current has no effect on muscles

Monopolar diathermy



- electrical plate is placed on pt & acts as indifferent electrode
- current passes instrument ⟹ indifferent electrode
- surface area of instrument compared to indifferent electrode is markedly smaller ∴
    - heat produced at instrument
    - no heat at indifferent electrode

Bipolar Diathermy



- = 2 electrodes are combined in the instrument eg forceps or pen device
- current passes between tips of instrument rather than through pt

Effects of Diathermy

- depend on current intensity & wave form:
  - coagulation :
    - high frequency A/C
    - interrupted pulses of current 50-100/sec
    - square wave form
  - cutting:
    - A/C
    - continuous current
    - sinus wave form

Risks

- could interfere with pacemaker function
- arcing can occur with metal instruments & implants
- superficial burns if use spirit based skin prep
- diathermy burns under indifferent electrode is incorrectly applies
- channeling effects if used on viscus with narrow pedical eg penis/testis

Lasers

- laser = light amplification by stimulated emission of radiation
- creation of laser requires:
  - energy source
  - lasing medium
  - optical resonater/outlet coupler
- process of laser creation:
  - light hits molecules and excites them
  - proton is released and then reflected back into medium
  - protons hit molecules of medium ⟹ release of further protons in a chain reaction
  - these photons make up light emissions which is then managed into:
    - collimated = parallel output beam results in little energy loss
    - coherent = waves are all in phase resulting in little energy loss
    - monochromatic = all of same wave length
- effects of laser depends on the following effects:
  - photothermal - predominant clinical effect

- photochemical
- photomechanical
- pulsing of output can reduce thermal damage

Uses of Lasers

Laser	Wavelength (nm)	Pulse length	Uses
Carbon dioxide	10,600	continuous	tissue cutting
Neodymium-YAG	1064	continuous	coagulation
Neodymium-YAG	1064	10 ns	posterior capsulotomy
Ruby	694	100 mss	tattoo removal
Argon	488-514	continuous	coagulation
Excimer	308	10 ns	photorefractive keratotomy

Laser safety

- lasers are classified according to amount of damage they can cause:
    - class 1 = generally safe
    - class 2= safe within the time of the blink reflex
    - class 3 = cause blindness after short exposure from mirrored surfaces
    - class 4 = unsafe even with reflection from non-mirrored surfaces
- all medical lasers = class 4
- ∴ pt & operator should wear goggles

Risks

- to pt:
    - excessive burning
    - scar formation
    - visceral perforation
- to operator:
    - accident skin exposure
    - corneal or retinal burns
- anaesthetic risk:
    - burns/eye inj
    - upper airway laser ⟹ ETT ignite ⟹ airway fire
- to ↓risk:
    - damp swabs next to adjacent tissues
    - non combustable gases
    - goggles

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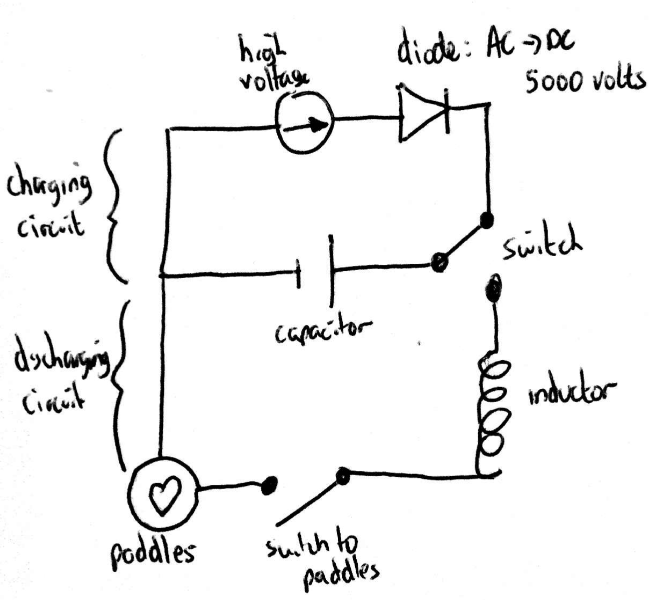
Defibrillators

Defib Circuit



- capacitance (farads) = $\frac{\text{charge (columbs)}}{\text{potential diff (volt)}}$