By Adam Hollingworth

Breathing Circuits

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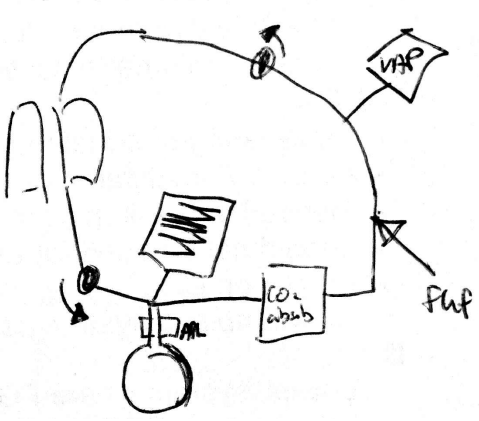
Breathing Circuits

- gas exits the anaesthesia machine (via common gas outlet) ⟹ breathing circuit
- function of circuit:
  - delivery O2 & volatiles to pt
  - eliminate CO2 ⟹ via gas inflow or soda lime absorption

Classification Overview

- simple:
  - open - old fashioned dropping ether onto gauze
  - semi-open -
    - Mapleson systems
    - typically used for induction of patient
    - usually a single limb system that uses an APL valve to
      - control pressure of gas
      - allow waste gas to leave
    - need high FGFs to prevent rebreathing
  - semi-closed - as next
  - closed - use a Co2 absorbent so gases are re-circulated

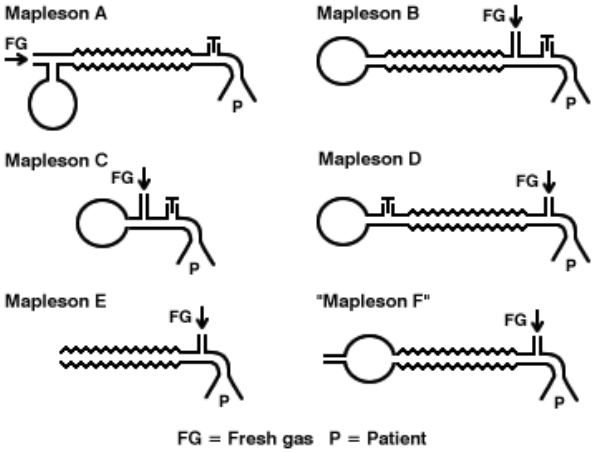
    ↳ semi-closed to closed depends on amount of FGF
- clinical:
  - non rebreathing:
    - eg Mapleson classification
    - adv:
      - provide good control of inspired gas conc
      - less dead space & less resistance ∴ good for babies
      - no sodalime required
    - disadv:
      - less economical as expired breath is wasted to atmosphere
      - atmospheric pollution
  - rebreathing systems
    - without modifications ⟹ expired alveolar gas with 5% CO2 is inspired as part of next Vt
    - amount of CO2 rebreathed depends on 4 factors:
      - design of breathing circuit - ie soda lime in circuit
      - mode of vent - spont or controlled
      - fresh gas flow rate - high enough ⟹ washout of CO2
      - pts resp pattern
- example of modern semi closed:



- features:
  - APL valve before sodalime - ↓CO2 to absorb
  - FGF after sodalime - ↓airflow through absorber
  - vap after FGF ∴ predictable vap conc on outflow limb
  - unidirectional valves on insp & exp limb

Mapleson Classification

- systems A-E (F added later)
- does not include systems with CO_2 absorption ∴ are non-rebreathing circuits
  ↳ prevention of re-inspiration of CO_2 depends on fresh gas flow rate



best for:
- Spont: A > DEF > BC
- IPPV: DEF> BC> A

Mapleson	Systems	Uses	FGF SV	FGF IPPV
A	Magill Lack	Spontaneous Gen Anaesthesia	70-100 ml/kg/ min	Min 3 x MV
B		Very uncommon, not in use today		
C		Resuscitation Bagging		Min 15 lpm
D	Bain	Spontaneous IPPV, Gen. Anaes	150-200 ml/kg/ min	70-100 ml/kg/ min
E	Ayres T Piece	Very uncommon, not in use today		
F	Jackson Rees	Paediatric <25 Kg	2.5 – 3 x MV Min 4 lpm	

- A =
  - good for spont breathing & FGF can be lower
  - but APL valve close to pt ∴ difficult to use
  - is a modification Lack system:
    - APL valve moved to machine end using a coaxial cable
    - adds volume to system and makes pt end heavy
- B & C =
  - rebreathing of exhaled gases occur even when v high fresh gas flow rates are used
  - note FGF is distal to outlet valve
  - inspiration is taken from same space into which prev breath was expired
  - should not be used for anaesthesia
  - mapleson C:
    - = ambibag system used for emerg resus
- D -
  - coaxial system where FGF delivered directly to pt
  - needs v high FGF to prevent rebreathing of CO_2

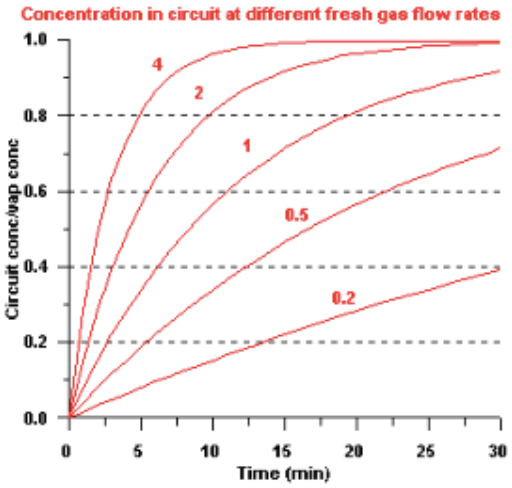
  - convenient to use & common for induction
- F:
  - most commonly used
  - used for paeds surg

Semiclosed/Closed Systems

- used for maintenance of GA
- can also be used for induction but slower process
- needs a
  - CO_2 absorber - exothermic reaction ⟹ adds warmth & humidity to circuit
  - resp gases monitoring system to measure CO_2 & volatile agent
- speed of FGF dictates closed vs semi closed
  - if FGF equally exact metabolic uptake of gases ⟹ closed
- closed system:
  - adv: minimised volatile agent use, O_2 use, atmospheric pollution
  - disadv: system inherently unstable ⟹ mismatching of flow to pt ⟹ over fill or under fill
- semi closed:
  - adv: higher flows allow use of precision out of circuit vaporiser
  - disadv: use more O_2, volatile, more pollution
- features of semiclosed system:
  - undirectional valves on insp & exp limb- ensure correct flow of gases around circuit system
    ↳ if fail ⟹ rebreathing
  - pressure relief valve
  - need smaller tubing in paeds - too much dead space to generate pressure to open valves

Vaporisers in Circuit

- vaporiser in circuit (VIC):
  - placed in insp limb of circuit
  - theory:
    - if plane of anaesthesia becomes light ⟹ ↑MV ⟹ ↑agent vaporised ⟹ deepen anaesthesia
    - but not that reliable
  - must be low resistance vaps
  - need to empty of condensed water vapour regularly
  - are cheap & simple
  - difficult to adjust required dose of volatile esp in circle system
- vaporiser out of circuit (VOC):
  - accurate - introduce precise conc of volatile into circuit
  - rate of change of anaesthetic conc in circuit depends on FGF ie ↑ed FGF ⟹ equilibration faster



Types of Semi Closed Circuit

- standard parallel Y system
- extendible parallel Y system
- complete semi closed circuit system
- co-axial semi closed circuit system

CO2 Absorbers

- machines use double canisters in series:
  - top canister:
    - is exposed expired gas first
    - most of CO2 removed
  - bottom canister - removes any remaining CO2
- when top canister exhausted ⟹ discarded & bottom canister moved to top
  ↳ = most efficient way of using

Contents

- soda lime activator =
  - NaOH
  - KOH
- silica added as hardener
- indicators - sodasorb (ethyl violet) - colourless when fresh, purple when exhausted due to pH change

Problems

- soda lime incompatible with trichloroethylene - but never used
- sevoflurane unstable in soda lime ⟹ compound A (but now thought not a problem)
- may see exhaustion of soda lime without colour change
- carbon monoxide: produced by all volatiles to varying degrees:
  - des > enflurane> iso >> sevo
  - worse in dry absorbent such as baralyme
  - minimise by:
    - turn O2 off at end of case
    - change absorbent regularly
    - use low flows
    ↳ or use different absorbant eg lithium hydroxide lime or house brand absorbents specific to volatile ↳ with less NaOH or KOH

Reactions

- 2 systems:
  - sodium hydroxide = sodalime
  - potassium hydroxide = baralyme (now withdrawn)
- 3 steps in chemical reaction

$H2O + CO_2 \Rightarrow H_2CO_3$

$H_2CO_3 \Rightarrow 2NaOH \Rightarrow Na_2CO_3 + 2H_2O$

$Na_2CO_3 + Ca(OH)_2 \Rightarrow CaCO_3 + 2NaOH$

- CaCO3 = insoluble precipitate

Clinical Signs of Exhaustion of SodaLime

- modern system should alarm if CO2 rebreathe >2-3cmH2O
- other signs:
  - rise (later a fall) in HR & bp
  - tachypnoea
  - resp acidosis
  - dysrhythmias
  - signs of SNS activation:
    - flushed
    - cardiac irrgularities
    - sweating
  - ↑bleeding at surg sites
  - ↑ed ETCO2

(**not** dark or cherry red blood!)

Fresh Gas Flow Requirements

- approximated resting O2 consumption can be calculated:

O2 consumption (mlmin) = 10 x (weight $^{0.75}$) weight in kg

Body weight (kg)	O_2 consumption (ml / min)
5	33
10	56
20	95
40	160

Anaesthetic Machine Checks

- 3 levels:
  - level 1
  - level 2
  - level 3

Level 1

- = detailed check performed by trained service personnel of all systems before being put into use
- Must be done on new systems and systems after service or repair

Level 2

- performed at the beginning of each anaesthetic list
- responsibility of anaesthetist but may be delegate to qualified person

Level 3

- before starting anaesthesia for each pt:
  - check vaporiser if it has been changed
  - check breathing system
  - check IV or LA devices
  - check other apparatus eg suction