Manual of Anaesthesia

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JAYPEE

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CHAPTER

4 Inhalational Anaesthetic Agents

CRITERIA FOR AN IDEAL INHALED ANAESTHETIC DRUGS

1. Causes rapid, smooth pleasant induction, amnesia and anaesthesia readily
2. Adequate muscular relaxation
3. Safe, potent, easily reversible. Absence of flammability, nonexplosive
4. Readily acceptable by the patient
5. Cheap, readily available
6. Easy to administer
7. Nontoxic, no side effects/complications
8. Safe for the vital organs like brain, heart, lungs, liver and kidneys.

Desirable Features

1. Low blood-gas solubility. Insolubility causes quicker induction of and recovery from anaesthesia
2. High potency and volatility
3. Resistance to biotransformation
4. Ether structure conveys cardiac stability
5. Halogenation reduces flammability
6. Compatible with adrenaline.

True Anaesthetic Gases

Nitrous oxide, Cyclopropane.

Their saturated vapour pressure are above ambient pressure and exist as liquid under pressure. Other agents are volatile liquids with SVP below ambient pressure and these need special calibrated vaporisers for their use.

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Following Factors Increase the Rate of Anaesthetic Induction

1. Increased anaesthetic concentration
2. Increased fresh gas flow
3. Increased alveolar ventilation
4. Reduced cardiac output
5. Second gas effect: When nitrous oxide is administered with a volatile anaesthetic agent, the rapid uptake of nitrous oxide increases the effective minute ventilation during anaesthetic induction. Moreover the uptake of N_2O from the alveoli decreases the volume of gas remaining in the alveoli and increases the concentration of remaining gases within the alveoli and thus anaesthetic induction is enhanced. At the end of N_2O anaesthesia, the reverse effect occurs and *diffusion hypoxia* may develop. This can be prevented by supplemental oxygen therapy
6. Use of nonrebreathing anaesthetic circuit
7. Low blood gas solubility coefficient.

Following factors increase the rate of recovery from anaesthesia

1. Increased fresh gas flow
2. Increased alveolar ventilation
3. Use of nonrebreathing circuit
4. Low blood gas solubility
5. Low tissue gas solubility
6. Decreased anaesthetic duration.

Minimum alveolar concentration (MAC)

1. A standard measure of the potency of inhaled anaesthetics
2. It is the partial pressure of an inhaled anaesthetic at 1 atmosphere that prevents skeletal muscle movement in response to noxious stimuli in 50% cases
3. Factors increase MAC:
   (i) Young age (ii) hyperpyrexia (iii) alcoholics (iv) infants (v) hypernatraemia (vi) CNS stimulants like MAO inhibitors, tricyclic antidepressants, cocaine, amphetamine
4. Factors decrease MAC:
   (i) Hypothermia (ii) IV anaesthetics (iii) premedicants (iv) neonates (v) elderly (vi) pregnancy (vii) lithium (viii) CNS depressants like benzodiazepines, barbiturates, propofol, etc. (ix) Alpha 2 adrenergic agonists like clonidine.
5. MAC is not affected:
   (i) Sex (ii) duration of anaesthesia (iii) metabolism of anaesthetics (iv) hyper/hypokalaemia (v) thyroid dysfunction, etc.
6. MAC values for combinations of inhaled anaesthetics are additive.
7. Administration of nearly 1.3 MAC prevents skeletal muscle movement in almost all patients during surgery.
8. MAC of common inhaled anaesthetics :
   (i) Nitrous oxide 110 (ii) halothane 0.75 (iii) isoflurane 1.15 (iv) enflurane 1.68 (v) desflurane 7.25 (vi) sevoflurane 2.05 (vii) ether 1.92 (viii) trichlorethylene 0.2 (ix) methoxyflurane 0.16 Cyclopropane 9.2.
9. Agent with minimum MAC will be the most potent.

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Nitrous Oxide

1. Nonirritant sweet smelling gas supplied in blue colour coded cylinders. It is stored as a liquid at room temperature
2. First anaesthetic use in 1844
3. Low blood gas solubility
4. Smooth and rapid induction of anaesthesia
5. Weak anaesthetic agent, cannot produce surgical anaesthesia when used alone
6. Excellent analgesia
7. Nitrous oxide 50% in oxygen is used for painless labour
8. Causes mild depression of cardiovascular system
9. May cause megaloblastic changes in bone Marrow in prolonged use
10. Prolonged N_2O anaesthesia may cause diffusion of the gas into the body cavities
11. At the end of anaesthesia high percentage of expired volume may consist of N_2O, so that onward diffusion of gas lowers alveolar partial pressure of oxygen (Diffusion hypoxia).

Entonox

1. A mixture of 50% nitrous oxide in oxygen.
2. Stored as a gas in cylinders whose body is blue and shoulder in white / blue quarters under a pressure of 1987 lb per sq. inch
3. Under pressure some parts of mixture may remain in gaseous phase at temperature and pressure at which N_2O is normally in liquid phase (Poynting effect)
4. It is stored horizontally at least above 10°C
5. It liquefies at–7°C
6. In cold climate there may be liquefaction and separation of the components. This may lead to uneven delivery of gases. To prevent this, the cylinder should be inverted several times to ensure adequate mixing. Rewarming in a water bath may also be helpful
7. Uses :
   a. For relief of pain in labour
   b. Burn dressing
   c. Management of chronic pain, cancer pain, etc.

Cyclopropane

1. Supplied in an orange cylinder as liquid at a pressure of 75 lb per sq. inch
2. Pleasant smell, nonirritant, potent. Not metabolised
3. Rapid induction of anaesthesia, potent anaesthetic gas
4. Sympathomimetic action. Arterial pressure is maintained and may increase
5. Can cause salivation, increased bronchial secretion and occassional bradycardia
6. Flammable, highly explosive
7. Expensive
8. Respiratoy depression, bronchospasm
9. Post-cyclopropane hypotension can occur (Cyclopropane shock)

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10. Emergence delirium can occur
11. Contraindications
    i. Use of diathermy
    ii. Use of adrenaline
    iii. Asthmatic patients
    iv. Pheochromocytoma.

Diethyl ether

1. Colourless, pungent volatile liquid
2. Relatively nontoxic, safe, potent anaesthetic agent
3. Produces good muscular relaxation
4. Causes an increase in sympathoadrenal activity. Heart rate and blood pressure may increase a little
5. Excessive salivation, cough, laryngospasm due to irritant vapour
6. Bronchodilation
7. Raises blood sugar level
8. Raises CSF pressure
9. Reduces body temperature
10. Postoperative nausea/vomiting is common
11. Induction is slow, unpleasant stage of excitement
12. Explosion risk
13. Ether convulsion can occur
14. Passes through placental barrier
15. Cheap and can be used without sophisticated apparatus and compressed gas cylinders.

Trichloroethylene

1. Colourless liquid but coloured with waxoline blue dye for identification
2. Highly lipoid soluble, nonexplosive
3. Potent agent with considerable analgesic effects
4. Blood pressure is well-maintained but cardiac arrhythmias are common
5. Nonirritant to tracheobronchial tree
6. Prolonged induction and recovery rate
7. Muscular relaxation is not good
8. Reacts with soda lime, cannot be used in closed circuit
9. Cheap and mostly safe in adequately ventilated patient.

Halothane

1. A halogenated hydrocarbon (not an ether as it lacks etheric bond)
2. Heavy, colourless volatile liquid with sweet smell. Needs thymol for stability
3. Potent and nonflammable, nonexplosive
4. Well-tolerated, provides rapid and smooth induction of anaesthesia

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5. Causes dose related fall in blood pressure, myocardial depression, sensitizes the heart to circulating catecholamines causing arrhythmias
6. Potentiates competitive muscle relaxants
7. Post-operative shivering can occur
8. May be associated with nonspecific hepatotoxic damage. It may be due to its breakdown products either causing damage directly or by immunological toxic response
9. Causes bronchodilation
10. May cause hypotension
11. Salivation and other secretions are not increased
12. May cause marked uterine relaxation leading to postpartum haemorrhage
13. May trigger malignant hyperpyrexia
14. Early postoperative restlessness is common
15. Special calibrated vaporiser is needed.

Methoxyflurane

1. Clear colourless, volatile anaesthetic with characteristic fruity smell
2. Potent anaesthetic and good analgesic
3. Slow induction due to its low volatility. Slow recovery
4. Excellent muscular relaxation
5. Diminishes cardiac output and causes hypotension
6. May cause cardiac arrhythmia
7. No sensitisation of myocardium to catecholamines
8. Uterine muscles inhibited
9. Causes high output renal failure due to fluoride ion containing metabolites. Extensive metabolism (more than 30%)
10. May cause postoperative headache, emergence delirium
11. May trigger malignant hyperpyrexia.

Enflurane

1. Potent volatile anaesthetic liquid
2. Clear, colourless, pleasant ethereal smell
3. Noninflammable, nonexplosive, noncorrosive
4. Produces rapid smooth induction of anaesthesia
5. Depresses cardiovascular and respiratory systems. Myocardial depression is dose dependent
6. Nonirritant to respiratory tract, does not increase tracheobronchial secretions
7. Good muscular relaxation, potentiates nondepolarising muscle relaxants
8. Relaxes uterine muscles
9. Depresses central nervous system, but in high concentration may cause epileptiform fits
10. Increases intracranial pressure and cerebral blood flow
11. Only about 2% undergoes biotransformation in liver and metabolites are excreted in urine as organic or inorganic fluorides. But nephrotoxicity is extremely rare

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12. No major liver and kidney dysfunction
13. Little risk of teratogenesis.

Isoflurane

1. An isomer of enflurane, clear colourless volatile liquid. Noninflammable
2. Somewhat pungent and irritant, causes coughing
3. Induction and recovery are mostly rapid. Low blood gas coefficient
4. Causes profound respiratory depression
5. Produces hypotension, myocardial depression, reduction in cardiac output, fall in peripheral vascular resistance
6. Potentiates muscle relaxants
7. Uterine relaxation can occur
8. Decreases cerebral metabolism, and increases cerebral blood flow. Intracranial pressure may rise. Does not cause seizure activity
9. Only 0.2% is metabolised in liver, no significant toxic metabolites are formed.

Desflurane

1. Fluorinated ether, potent volatile anaesthetic liquid
2. Induction is rapid, recovery is prompt
3. Pungent, irritant to airway; breath holding and laryngospasm can occur
4. Dose dependent fall of blood pressure, fall in peripheral vascular resistance
5. Respiratory depression can occur
6. Metabolism of desflurane to trifluorocretic acid and inorganic fluoride is about 10 times less than that of isoflurane.

Sevoflurane

1. Fluorinated methyl ethyl ether
2. Potent anaesthetic
3. Nonirritant to airway
4. Respiratory and cardiovascular effects are mostly similar to those of halothane
5. Induction is rapid and recovery is prompt
6. Does not sensitise the myocardium to catecholamines
7. Instability in soda lime.

Fluroxene

1. Fluorine containing ether, potent volatile anaesthetic liquid
2. Good analgesic
3. Induction and recovery mostly smooth and rapid
4. May cause profound respiratory depression
5. May cause uterine relaxation

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6. Cardiac output and blood pressure are well-maintained
7. Passes through placental barrier readily
8. Increases intracranial pressure.

Note:

Volatile anaesthetic agents are mostly divided in two groups:

1. Halogenated hydrocarbons: Halothane, trichlorethylene, chloroform
2. Ethers: Enflurane, isoflurane, methoxyflurane, diethyl ether, etc.

Some physical properties of inhalational anaesthetic agents are shown in Table 4.1.

Table 4.1. Showing some physical properties of inhalational anaesthetic agents

	Mol. Wt.	*Boiling Point*	*Vapour pressure at 20°C mm/Hg*	*Oil/Water solubility*	*Blood/gas solubility*	*MAC*
Diethyl ether	74	35°C	460	3.2	12	1.92
Trichlorethylene	131	87°C	60	400	9	0.17
Halothane	197	50°C	243	220	2.5	0.75
Methoxyflurane	165	105°C	23	400	13	0.16
Enflurane	184	56°C	180	120	1.9	1.68
Isoflurane	184	49°C	250	174	1.4	1.15
Cyclopropane	42	– 33°C	78	34.4	0.45	9.2
Nitrous oxide	44	– 88°C	680	3.2	0.47	105

- Hepatotoxic volatile anaesthetics : Halothane, chloroform
  Nephrotoxic volatile anaesthetics : Methoxyflurane, sevoflurane
  Epileptogenic: Enflurane
- Inflammable and can cause explosion : Diethyl ether, cyclopropane.

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Manual of Anaesthesia

Salient Features

- A concise but informative text
- Presents the text in lucid and simple language
- Covers all the fundamentals of clinical anaesthesia in an update manner
- Point wise format to make the text reading interesting and easily graspable
- Serves as a primer to the students, teachers and practitioners of anaesthesia.

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