ANESTHESIA

> Defined as loss of physiological reflex response to the stimuli provided by anesthesia for surgery with or without loss of consciousness.

**TRIAD OF ANESTHESIA:**

1. **Amnesia**
   - MUSCLE RELAXATION
   - **Analgesia**

2. **Bradycardia**
   - a fact of TRIAD

3. **Respiratory Depression**

Coined by John Lundy & Ralph W. M. Water

**BALANCED ANESTHESIA**

HISTORY

1. 1st IV injections: Given by Christopher Wren & Daniel John Majer

2. Word Anesthesia: Coined by Oliver Wendell Holmes

3. O₂ & N₂O synthesized by Priestly

4. Pain relief by N₂O: Discovered by Humphry Davy

5. 1st inhalational anesthetic used: N₂O in 1844

6. 1st public demonstration of N₂O anesthesia: Given by Horace Wells (for tooth extraction)

7. 1st public demonstration of Ether anesthesia: Given by W. T. G. Morton on 16th Oct 1846

8. 1st person to write book on anesthesia: John Snow

9. Chloroform used for 1st time: 1847

10. 1st local anesthetic used for Spinal anesthesia: Cocaine

11. 1st spinal anesthesia: August Bier

12. 1st person to use curare products for muscle relaxation: Harold G. Quinby

13. 1st Endotracheal intubation was done by: William McEuen

14. ET intubation was made popular by: Evan Magill

15. Father of Anesthesia: John Snow

16. World Anesthesia Day: 16th Oct
PREANESTHETIC CHECKUP (PAC)

Special Attention to Respiratory -
Cardiac -
Airway -

√ ASA Grading: To assess risk & physical status of pt.

Grade 1: Normal Healthy Patient

Grade 2: Mild Systemic ds is well controlled & no functional limitation.

Grade 3: Moderate Systemic ds with functional limitations

Grade 4: Severe Systemic ds is constant threat to life of the patient.
  (Ex: Unstable Angina, Aortic Stenosis, DKA)

Grade 5: Moribund pt who is gonna die or out 3x in short period (24 hrs)

Grade 6: Brain dead pt for organ donation

✓ Surgical condition doesn't affect ASA grading (Doesn't take into account surgical risks). → Main Drawback of ASA

Eq: Pt has Meningioma & headaches ⇒ Grade 1.

✓ Doesn't take into account asymptomatic pt.
EXAMINATION OF AIRWAY

1) MALLAMPATI GRADING (MPG): It is used to assess size of tongue for laryngoscopy.

Grade 0: Tip of epiglottis visualized — 5 grade 0.

Grade 1: Faucial pillar — Uvula & tip

Grade 2: Faucial pillar — Uvula & out tip

Grade 3: Only soft palate

Grade 4: No soft palate — DIFFICULT INTUBATION

2) Thyromental Distance: Distance bw mentum & thyroid
   \( > 6.5 \text{ cm} \)

3) Sternomental Distance: Distance bw sternum & mentum
   \( > 12.5 \text{ cm} \)

4) Adequate Mouth Opening: Distance bw upper & lower incisors
   \( \text{must be } 3 \text{ fingers breadth } \geq 2.5 \text{ cm} \)

5) Movement of Cervical Spine: Decreased movement of cervical spine causes difficult intubation
   \( \text{Impaired with AS (Ankylosing Spondylitis)} \)
MANAGEMENT OF PRE EXISTING DRUG THERAPY

1. Pt on MAO inhibitors: Stopped 3 weeks before Sx
   - Cause severe sympathetic Rx C
     - Pethidine
   - Newer mao inh - Selegilline can be continued up till the day of Sx

2. Anticonvulsants: Should be continued, Morning dose given

3. Levadopa: Should be continued

4. Oral Antihypoglycem: Minor Sx (<30min) Major Sx
   - Morning dose is omitted
   - Shifted from OHA to insulin & morning dose of insulin is omitted.
   - Morning dose is omitted to prevent hypoglycemia as pt is NPO prior to Sx.

5. Oral Anticoagulants: Stopped 3-5 days prior to Sx.
   - (Warfarin)  → Start pt on LMWH & last dose is given up to 14hrs prior to Sx
     - If pt is on regular heparin, last does can be given up to 6hrs prior to Sx

6. Oral Contraceptives: Ideally stopped 4 wks prior to Sx
   - Contain Estrogen & ↑ risk of Thromboembolism
   - Only progesterone pills can be continued

7. Antihypertensives: To be continued except for ACEI & ARB's
   - Cause refractory hypotension during anesthesia
Antianginals: To be continued (except Aspirin) (Nitrates)

Lithium: Stopped 2 days prior to Sx
- Prolongs duration of action of NMDR’s.

Steroids: Duration of therapy > 1 wk in last 1 year.
- Morning dose must be given

Herbal medicine: At least 6-8 wks of Sx

Smoking: Stopped 6-8 wks before Sx (ideally).
- Inhibits ciliary movement

-> Smoking stopped 12-24 hrs prior to Sx =>
- Fall in carboxy Hb levels => Shift of Hb-O2 dissociation to right.
  
-> Smoking also causes sympathetic stim =>
- ↓ Surfactant ↓ req of aminosteroid

ATT Drugs: Must be continued.

Antiplatelet's: iv Aspirin ≤ 75 mg can be continued for
- > 75 mg can be stopped (3d)
- All Sx except closed space surgeries

prior to Sx (Brain, Spinal cord)

Clopidogrel: Potent antiplatelet.
- Stopped 5-7 days before Sx.

MENDELSON SYN: Aspiration in pregnancy
- Criteria
  - pH of aspirate < 2.5
  - Vol of aspirate > 25 mL

-> Adults
- Solids 6 hrs
- Clear liquids 4 hrs

-> Infants
- Solids 4 hrs (milk included in solids)
- Clear liquids (24 hr)

NPO

Duration
PREMEDICATION

Aims: to Reduce anxiety -> DOC Benzodiazepines

First step: Reassurance.

Pharmacological: [Lorazepam] 2mg PO.

✓ 2. Induce Sedation -> DOC Benzodiazepines

✓ 3. ↓ Chances of aspiration
   - PPI's & H2 blockers

✓ 4. Promote hemodynamic stability
   - Cardioprotective β blockers
   - Clonidine

5. Provide analgesia
   - Morphine / Pethidine

6. ↓ Chances of infection
   - Broad spectrum Antibiotics

(Ideal time
for antibiotic)

✓ First dose given 30-60 mins prior to skin incision (@ time of induction).

✓ If Tx prolongs for ≥6 hrs repeat the antibiotic dose.

7. Control of secretions (oral)
   - Atropine / Glycopyrrolate.

8. Amnesia
   - Benzodiazepines.
**Boyle's Apparatus** - Anaesthesia Machine

- Continuous flow type: Fresh gases flow both during inspiration and expiration.
- Low resistance system.

**Anesthesia Machine**

- High Pressure System (350 ppsi)
- Intermediate Pressure System (45 ppsi)
- Low Pressure System

- Cylinders
- Yoke assembly
- Pressure gauge
- Pressure reducing valve
- Emergency O₂ flush

**A. High Pressure System: 350 ppsi**

- Cylinders: Made of 8pt alloy Molybdenum Steel (Mo)
  - Aluminum cylinders - for MRI.

- Size: A to J
  - Smallest

- A & H - not used for medical purposes; H → O₂ Bank

- E - Molybdenum associated with Anesthesia machine
- Contains 660 ft of O₂
- Type D: Contains 470 ft of O₂

- Colour Coding:
  - O₂: Black body & white shoulders
  - N₂O: Blue (MAC-105) & N₂: Black
  - CO₂: Grey
  - Air: Grey body & Black & White shoulders
  - He: Brown
  - Cyclopropane: Orange

- (50% O₂ + 50% N₂) Enetonax: Blue Body & Blue & White shoulders
Storage Form: Liquid

\[ \text{N}_2\text{O} \quad \text{(Not flammable)} \]

Cyclopropane

\[ \text{CO}_2 \]

\( \checkmark \) \( \text{O}_2 \) can also be stored in liquid form, it requires a critical temp of \(-119^\circ\text{C}\)

\( \checkmark \) 1 mol of liquid \( \text{O}_2 \) gives 840 mol of gas

\( \checkmark \) Critical Temp - \( \text{N}_2\text{O} : 36.5^\circ\text{C} \) (@ room temp)

Critical Temp - Air : \(-140.6^\circ\text{C}\)

Dr. Saykey System: PIN-INDEX SAFETY SYSTEM

PIN is present on the anesthetic machine, & hole positions on cylinder valves.

\[ \text{PIN Index} \implies \begin{cases} \text{Air} & 1.5 \checkmark \\ \text{O}_2 & 2.15 \checkmark \\ \text{N}_2\text{O} & 3.5 \\ \text{CO}_2 & 2.6 \checkmark (87.5\%) \end{cases} \]

\( \text{Cyclopropane} : 3.6 \)

\( \text{Entonox} : 7 \)

\[ \text{HELI\textsubscript{O}} \to 71\% \text{ Helium} + 21\% \text{O}_2 \]

(2.4)

Filling Ratio: Ratio of \% of wt of gas to wt of water the cylinder can hold @ 60°F

\[ 0.62 \text{ O}_2 \implies \text{Means 62\% can be filled} \]

Used to prevent over-filling of cylinders.

Tare Weight: Weight of empty cylinder

Yolk Assembly: Yolk assembly holds the cylinder into the anesthesia machine.
3) Pressure Gauze: BOURDAN'S PRESSURE GAUZE: MCly used.

For liquid gases, tot of cylinders must be taken.

4) Pressure Reducing Valve: Decreases high pressure to 45 Psiq

Pressure in Cylinder:
- $O_2: 2000$ psiq (pound square inch)
- $N_2O: 750$ psiq
- Cyclopropane: 60 psiq

It doesn't require pressure reducing valve.

\[
1 \text{ Bar} = 14.6 \text{ Psi}
\]

1 cm Hg = 0.7 mm Hg

5) Emergency $O_2$ Flush: Delivers emergency $O_2 @ 8.5$ bar

6) Intermediate Pressure System:

Flow control valves: Control flow rate of gases.

Colour coded:
- $O_2$: White coloured
- $N_2O$: Blue coloured

Bigger & broader serrations

Smaller & finer serrations

$O_2-N_2O$ proportionating devices: (MASTER & SLAVE MECHANISM)

Provide fixed proportion of $O_2$ when $N_2O$ is released.

Min. 25% always occurs, so max. $N_2O = 75% \times m$

NOTES FROM
JAIN STATIONERY
GAUTAM NAGAR
09654691387
LOW PRESSURE SYSTEM:

* Rotameter: Variable orifice Controlled Pressure FLOWMETER

Thorpe Tubes (Glass tube)

Thorpe tubes are calibrated according to gas they carry

* Variable orifices but constant pressure

the height to which bobbin rises indicates gas flow rate.

* Causes of inaccurate reading of flowmeter

1. Dirt can cause as much as 35%
2. Static electricity inaccuracy
3. Vertical alignment of glass tube is not correct
4. Cracked glass tubes
5. Backflow of gases

* Arrangement of Glass Tubes in Rotameter

O2 is always placed downstream to the other gases.
$\sqrt{O_2}$ must be always downstream to other gases, to prevent hypoxia.

Vapourizers: Made up of Cu as it has good thermal conductivity & specific heat

- Used to deliver inhalational agents
- They are temp & pressure compensated

If temp ↑ = latent heat of vapourization ↓

Temp of liquid ↓

Vapourization ↓

Pressure compensated: Equal delivery @ any altitude (sea level or high altitude)

- They are variable bypass vapourisers
  This is regulated by concentration dail

If the surface area of liquid is less, the no of molecules picked up is less. Wicks of cotton are

- Used to increase surface area of gas

Common GAS OUTLET: Attached to CGO

Wheels of MACHINE made ANTISTATIC by addition of CARBON
* U-tube in the ether vapourizer is made of Cu - which prevents decomposition of Ether.

* Desflurane - contains 2 cores.
  
  Outer core   Inner core
  
  Heated until temp of 89°C

  → Tech 6 Vapourizer is used only with Desflurane.
  
  → Halothane vapourizes @ 50.2°C

* Vapourizers are arranged in order of boiling point of gases else condensed particles will be recovered from 2nd vapourizer.

\[
\begin{align*}
  & A \quad B \\
  \text{Boiling point of } B & \text{ > A.}
\end{align*}
\]

→ All the gases come out thru common gas outlet & the circuit is attached to the common gas outlet.

→ Wheels of anesthesia machine are made anti-static by addition of Carbon. prevent current entry

* O₂ concentrators: Consist of Zeolite which is a Al(OH)₃ lattice which adsorbs N₂ from AIR.

  → Provide 95% O₂ (not 100%).
  
  → Remaining gas is Argon (5%).
  
  → Electronically powered Shakes & silica is used to adsorb the vapour.
CENTRAL SUPPLY LINES:
- Made up of Cu & Colour coded:
  - O₂ - White
  - N₂O - Blue
  - Air - Black
  - Vacuum - Yellow
- Supplies @ pressure of 55-65 psig.
- DIAMETER INDEX SAFETY SYSTEM (DISS) - consists of non-interchangeable different diameter screws for O₂ & N₂O

CIRCUITS
- OPEN CIRCUIT
- CLOSED CIRCUIT
- SEMICLOSED CIRCUIT

OPEN CIRCUIT: Consists of a mask / Schimmelbusch mask.
  - Method is / Open Drop Method.
  - Agents used:
    - Ether
    - Chloroform

Advantage: Easy to use
Disadvantage: Rate of concentration - not controlled
- Vapours can be inhaled by others administering
- Unconscious pt can hypoventilate ⇒ hypoxia & can regain consciousness
- No maintenance.

FGF = 66% N₂O + 33% O₂ + Inhalational agent.
Fresh gas flow
**SEMI CLOSED / SEMIOPEN CIRCUIT:**

NC used is Mapelson System. 6 types - A, B, C, D, E, F

- **MAPELSON A:** aka Magill Circuit
  - ✓ Best for Spontaneous Ventilation
  - ✓ Fresh Gas Flow required to prevent rebreathing is equal to Minute Vol of Pt. (tidalV x RR)
    \[ FGF = MV \] Spontaneous Vent
  - ✓ FGF required to prevent rebreathing is equal to 2-3 times minute vol of Pt in case of controlled ventilation
    \[ FGF = 2-3 MV \] Controlled Vent

- A Modification of Mapelson A is Lack's Circuit

```
Coaxial
\ /
Inner Tube \ Outer Tube
\ /
Expiratory inspiratory
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- **MAPELSON B:** Obsolete

- **MAPELSON C:** Used for Resuscitation & Chest Physiotherapy

- **MAPELSON D:** aka Bain’s Circuit (Coaxial Circuit)
  - ✓ Best for Controlled Ventilation
    \[ FGF - Spontaneous Vent \rightarrow 2-3 MV \]
    \[ FGF - Controlled Vent \rightarrow 1.6 MV \]

- Bain's Circuit is Coaxial
  - Outer Tube - Expiratory
  - Inner Tube - Inspiratory
Mapelson circuit is 1.5 - 1.8m in length. Hence good for head & neck Sx.

**MAPELSON E: aka Ayer's T piece**

O₂ supp. ← connected to ET tube.

✓ Used for spontaneously breathing pts & neonates.

Jackson Rees Modification of Ayer's

Reservoir bag

T-piece

⇒ Spontaneous: 2-5 MV

⇒ Controlled: 1.5 - 2.2 MV

✓ Mapelson E

✓ Mapelson F

VALUELESS CIRCUITS

⇒ no reservoir bag

⇒ (present in all others) incomplete circuit

**List of Coaxial Circuits**

1. Lack's circuit
2. Bain's circuit
3. Penlon circuit
4. Humphry ADE system (combination of Mapelson A, D, E)
5. Mera E (same as Bain)
**CLOSED CIRCUIT:** REBREATHTING SYSTEM

\[ \text{O}_2 + \text{N}_2\text{O} + \text{Inhalational agent} \rightarrow \text{Inspired Gases} \]

\[ \text{O}_2 + \text{N}_2\text{O} + \text{Inhalational agent} \]

\[ \text{CO}_2 \]

**Expired Gases**

\[ 94\% \text{ Ca(OH)}_2 \]

\[ \text{used as catalyst} \]

\[ 5\% \text{ Na(OH)} \]

\[ \text{used as activator} \]

\[ 1\% \text{ KOH} \]

\[ \text{for HARDNESS} \]

\[ \text{SILICA} \]

\[ \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 \]

\[ \text{H}_2\text{CO}_3 + \text{Na(OH)} \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} \]

\[ \text{Na}_2\text{CO}_3 + \text{Ca(OH)}_2 \rightarrow \text{CaCO}_3 + \text{NaOH} \]

**SODALIME**

\[ \text{Absorbs CO}_2 \]

\[ \text{Reusage of Gases} \]

\[ \downarrow \text{requirement of FGF} \]

**SILICA - added to SODALIME for hardness**

**100 gm of SODALIME - Absorbs 23-26 ltrs of CO}_2.**

**Saturation of SODALIME is identified by colour change in SODALIME produced by an indicator.**

\[ \text{INDICATORS}: \]

\[ \text{Ethyl violet} \rightarrow \text{White} - \text{Purple} \]

\[ \text{Mimosa Z} \rightarrow \text{Clayton Yellow} \]

\[ \text{White} \rightarrow \text{Pink} \rightarrow \text{White} \]

\[ \text{Durasorb} \]

**Size of SODALIME granules: 4-8 mesh size (Small Granule size)**

\[ \text{max absorption of CO}_2 \]

\[ \Rightarrow \text{13,700 cal produced for 1 mole of CO}_2 \text{ absorbed}. \]

\[ \text{Air space in canister -52\%} \]

\[ \text{Hardness > 75} \]

\[ \text{Humidity should be >50\%} \]
C/I: Sodalime:

\[ \text{Trielene} \rightarrow \text{dichloroacetylene} \]
Neurotoxic & causes encephalitis
Phosgene causes ARDS.

\[ \text{Sevoflurane (forms Compound A at low flow rates)} \]
Nephrotoxic.

Sevoflurane can be used in Sodalime @ high flow rates.

Baryllime: \[ \sqrt{80\% \text{ Ca(OH)}_2} \]
\[ \sqrt{\text{Ba(OH) } 20\%} \]

\[ \text{Less caustic, hardness occurs d/\text{t water of crystallization}} \]

Interactions of baryllime with anesthetic agents are more so less commonly used.

Closed Circuit - Best for:
- maintaining depth of anesthesia
- removal of expired gases
- maintaining humidification of airway.

Rebreathing Prevention Valve:

1. Located at Expiratory End
2. Prevents rebreathing of expired air
3. Should be as near as possible from pt.

Factors in \( \text{CO}_2 \) absorption in circuit:

1. High Flow
2. Medium Granule
3. Channeling
4. Tidal Volume
5. Dead Space
6. Dry \( \text{CO}_2 \) Adsorbant
7. Loosely packed
- **AMBU BAG**

AMBU stands for **Artificial Manual Breathing Unit**

- Consists of an O₂ inlet & air inlet
  - Sphy inflating rubber bag
  - Unidirectional valve (Mcly k/a RUBEN'S VALVE)
  - Prevents rebreathing

Max O₂ delivered is **100%**.

**Sizes:**
- Neonates: 240 ml
- Children: 500 ml
- Adults: 1000-2000 ml (1-2 ltrs)

- **FACE MASK**

Used to provide seal for positive pressure ventilation

- Made of antistatic rubber

- Sizes are variable

Disadvantages of using wrong sized face mask -

- In proper seal isn't formed & ventilation is not done
- Injury to facial structure, especially eyes
- In small children bigger mask → ↑ dead space

- **GUDELL OROPHARYNGEAL AIRWAY**

Used to prevent back fall of tongue during anesthesia

- Various sizes are available

  - Correct size is determined by distance b/w angle of the mouth & tragus
SAFAR & BROOK'S
AIRWAY

→ Used for Resuscitation by combining 2 Gudell's Airways.

WATER'S AIRWAY

→ Made up of metal while rest are made of plastic.

LARYNGEAL MASK AIRWAY

✓ Supraglottic devices (not definitive airway's)

Advantages:

✓ Prevent is used to suppress airway reflexes

✓ Easy to insert (do not require laryngoscope or MR's)

✓ Can be used for difficult intubation & CPR

✓ Less chances of bronchospasm

✓ Don't cause endobronchial intubation

✓ Less chances of oral trauma.

Disadvantages:

✓ Don't prevent aspiration of gastric contents

✓ Cause Gastric distension

Size of LMA depends on wt of pts

- 1-5 kg : Size 1
- 5-10 kg : Size 1.5
- 10-20 kg : Size 2
- 20-30 kg : Size 2.5
- 30-50 kg : Size 3
- 50-70 kg : Size 4
- 70-100 kg : Size 5
- 100+ : Size 6
Types of LMA's:

1. Classical LMA
2. Flexometallic LMA - Doesn't kink
3. Fast-track LMA - Used for difficult intubation

Max size of Endotracheal Tube that can be passed thru Fast-track LMA:

3 → Size 6 (int. diameter in mm)
4 → 6.5 mm
5 → 7 mm

4. Proseal LMA - Used for controlled ventilation
5. Ideal LMA - Contain made of Gel

LARYNGOSCOPES

Macintosh Blade - Most commonly used (CURVED)
Miller's Blade - in pediatrics (STRAIGHT)
McCoy - Curved & moving tip

Laryngoscope:
- Always held in LEFT HAND
- Inserted in RIGHT SIDE OF MOUTH
- Tongue displaced to LEFT HAND
- Tip of laryngoscope lies @ Vellecula

Laryngoscopy causes Extension @ Atlanto-Occipital Jt Flexion @ Neck

SNIFFING MORNING AIR POSITION.

Oro, Pharyngeal & Laryngeal axis in straight line.
Structures damaged during laryngoscopy: Upper Incisors.

Blood vascular response to laryngoscopy

▲ Hypertension  
▲ Tachycardia  
▲ Arrhythmia

Response can be reduced by giving opioids like:
▲ Fentanyl
▲ β-blockers - Esmolol
▲ Lignocaine

(*) ENDOTRACHEAL TUBES

(*) RED RUBBER TUBE
▲ Reusable & Expensive
▲ Higher tendency to kink
▲ Murphy eye is absent
▲ CuIJ - low volume & high pressure
▲ ↑ chances of tracheal injury d/t high pressure CuIJ
▲ Used for short duration of time
▲ Non-transparent & Radiolucent
▲ Low incidence of sore throat

(*) PVC TUBE
▲ Disposable & Cheap
▲ Low tendency to kink
▲ Murphy eye is present
▲ CuIJ - high volume & low pressure
▲ ↓ chances of tracheal injury
▲ Used for long duration of surgeries
▲ Transparent & Radiopaque
▲ High incidence of sore throat.

Pegging is sign of tracheal intubation.

NOTES FROM JAIN STATIONERY
09654691327
GAUTAM NAGAR
MC size of ET used for adult male - 8 & 8.5 mm
(internal diameter)
✓ adult female - 7.5 & 8 mm
✓ length of tube @ upper incisor - Males 21-22 cm
                           - Female 20-21 cm
✓ cuff of tube should lie in MIDTRACHEA 2-2.5 cm BELOW THE VOCAL CORDS.
✓ cuff should be palpable in SUPRASTERNAL NOTCH
✓ cuff pressure should never exceed 30 cm of H₂O
  (25 cm of H₂O - preferred)
      \[ 1 \text{ cm H}_2\text{O} = 0.7 \text{ mm Hg} \]  

CONFIRMATION OF ENDOTRACHEAL INTUBATION:
✓ Rise & Fall of chest wall
✓ Foaming
✓ CXR
✓ Auscultation Best site: Left Base.
✓ Capnography Fastest & Best test
   \[ \text{Exhaled CO}_2 \ 35-45 \text{ mm Hg} \]

Exp. plateau
         \[ \text{Expiratory upstroke} \]
         \[ \text{Baseline} \]
         \[ \text{Inspiratory downstroke} \]
         \[ \rightarrow \text{NORMAL} \]

FLAT CAPNOGRAM
✓ Cardiac arrest
✓ Esophageal intubation
✓ Disconnection of circuit
✓ Ventilatory Failure
1. **Sudden fall in** \( \text{ET CO}_2 \):
   - Venous air embolism
   - Often seen in posterior fossa
   - \( \text{ET CO}_2 \) in sitting position

2. \( \checkmark \) Most sensitive to detect VAE is Transesophageal Echo.

3. **Sudden rise in** \( \text{ET CO}_2 \):
   - Malignant hyperthermia
   - (Earliest sign is rise in \( \text{ET CO}_2 \))

4. Steep plateau:
   - Bronchospasm

5. \( \rightarrow \) Endobronchial intubation
   - Requirement of muscle relaxation
**Special Endotracheal Tubes:**

- **RAE (Right Angled ET tubes)**
  - Used for cleft lip & cleft palate Sx.

- **Flexometallic / Armoured / Spiral Embedded Tube**
  - Contain metallic spiral rings & donut kink
  - Used for Head & Neck Sx
  - Used for Sx in prone position
  - Used for Spinal Sx.

- **Microlaryngeal Tube** (long & narrow)
  - Used for Sx on larynx.

- **Cole's Tube**
  - Used in children
  - As the subglottis is narrow in them

- **Robert Shaw & Cauley’s Double lumen Tube**
  - Used for cardiothoracic Sx, Lung Surgery, Bronchial Sx, Esophagoscopy
  - Used for single lung ventilation
  - Contains 2 cuffs
  - Tracheal & Endobronchial

  All double lumen tubes are left sided as left bronchus is longer.

- **Final position of double lumen tube is confirmed by FIBEROPTIC BRONCHOSCOPY.**

- **MC cause of hypoxia during one lung ventilation is Increased shunt fraction**
  - Previously malposition of tube was MC
  - And MC of hypoxia.
Endotracheal Tubes in Children:

* Uncuffed tubes are used up to 6 years.

→ In children a minimal permissible leak is allowed.

- Flow rate ∝ 1.4

→ If size of tube is tight (Eq 'r' dec by 1/2 flow rate dec by 1/16th)

→ If leak is very high = replace with bigger size tube.

[*Calculation of Tube size in children*]

1. Preterm baby: Gestational Age
   - \( \frac{10}{10} \)

2. 1-6 months: 3-3.5 mm
3. 6-12 months: 3.5-4 mm
4. 1-6 years: \( \frac{\text{Age} + 3.5}{3} \)
5. 6-12 years: \( \frac{\text{Age} + 4.5}{4} \)

[*Calculation of length*: (Internal diameter \( \times 3 - 1 \))

* NASOTRACHEAL INTUBATION*

*Indications:*

1. Oral Gx
2. # mandible
3. Inadequate mouth opening
4. Awake fiberoptic intubation
5. Tube required for longer duration.

*NOTES FROM*

JAIN STATION
Gautam Nagar
09654691387
1. Base of skull
2. CSF rhinorrhea (can result in meningitis)
3. Nasal mass/Adenoids
4. Coagulopathy

Other features:
1. Injection rate of 15-20%.
2. Nasal Mucosal damage
3. Good oral hygiene.
4. Decreased movement of ET tube.

Narrowest Part of Airway
- Adults
- Children

In adults, orotracheal intubation ↑ the dead space.
In children, orotracheal intubation ↓ the dead space.

Physiological dead space: Decreased in:
- Supine posture
- Neck flexion
- Use of Bronchoconstrictors
- Orotracheal intubation
- Tracheostomy

Increased in:
- Standing
- Hyperextension of neck
- Anticholinergics

Anatomical dead space: Decreased in Massive Pleural Effusion
- Endotracheal intubation (150 ml)
- Atropine
- Halothane
- Inspiration

(continued)
DEFINITIVE AIRWAYS:

- Nasotracheal intubation
- Orotracheal intubation
- Tracheostomy Tubes
- Cricothyrotomy (Percutaneous airway)

Respiratory Rate DOESNT CHANGE in respect to Pt's position

Trendelenburg, Horizontal, Lithotomy, Prone, Lat. decubito

ET Tube → Nas. 18 days
**IV Anesthetics**

- **B: Barbiturates**
  - 1. Thiopentone
  - 2. Methohexital

- **Non-Barbiturates**
  - 1. Ethomidate
  - 2. BzB
  - 3. Ketamine
  - 4. Propofol

- **Steroidal Anesthetics**
  - Valid:
    - Althesin
    - Eltaganone
    - Propanidid
  - **High incidence of allergic reactions**
  - Withdrawn (not used)

- **GABA Receptors**
  - 1. Ethomidate
  - 4. Ketamine

- **NMDA Receptors**
  - 2. Propofol
  - 3. Thiopentone
  - 5. Methohexital

**Higher the lipid solubility => Stronger is the anesthetic agent**

**I- THIOPENTONE** - Highly protein bound

1. Used for first time in 1934. **"TRUTH SERUM"** (70-80%)
2. Yellow Amorphous powder & 6% Anhydrous Sodium Carbonate (6% Na₂CO₃)
3. Prepared & Stored in Nitrogen atmosphere
4. pH = 10.5 - 11 (therefore shouldn't be mixed with RL as it precipitates)
5. Dose: [3-5 mg/kg BW] Adequate dose → loss of oculomotor reflex

Once constituted it is stable @ Room temp for 2 days & In Refrigerator → 5 days
64 Used in a concentration of 2.5% 

- Dose >2.5% ⇒ Pain on injection & Venous Thrombosis
- Dose <2.5% ⇒ Awareness during anesthesia.

Can be detected by BIS (Bispectral Index)

**BIS** ⇒ Type of EEG used to detect awareness/depth of anesthesia.

100% ⇒ Fully Conscious

⇒ BIS 60-85: Adequate Sedation
- 40-60: Adequate Anesthesia
- <40: Cortical Depression
- >overdosage of anesthetics.

Q. Pt presents with previous 1/10 of awareness of surgery,
BIS can be done to prevent this.
Alternate to BIS ⇒ ENTROPY

74 Onset of Action: within 30 sec & lasts up to 15-20 min.
37 The O₂ atom is replaced by Sulfur which markedly increases
the lipid solubility ⇒ More potent.

7 Short Duration of Action ⇒ d/Methyl (CH₃) group attached to it.
7 @ approximately 30 min only 10% of Thiopentone remains in
the brain.

6 Depresses the reticular activating system present in the brainstem
7 Pt regains consciousness from thiopentone anesthesia by the
process called Redistribution (not metabolism/elimination)

**SYSTEMIC EFFECTS:**

**CVS:** Peripheral Vasodilatation ⇒ Hypotension & Tachycardia.
Tachycardia: also occurs d/t central vagolytic effect.

Respiratory Sys: ↓ Causes Apnea

Tx: (IPPV) (intermittent positive pressure ventilation)

⇒ Reflex Bronchospasm & Laryngospasm when given in inadequate dose & airway manipulation is done.

CNS: All IN anesthetics are cerebral vasodilators

Except Ketamine

⇒ Decrease ICP.

⇒ Decreases Cerebral Metabolic rate markedly & hence is cerebroprotective ⇒ Doc for head injury pts.

⇒ Powerful anticonvulsant → Doc for epilepsy pts

⇒ Anti-analgesic → hence threshold for pain

⇒ Doesn't provide any muscle relaxation

⇒ Decrease intraocular pressure.

→ Crosses placenta & causes fetal depression

→ May show some anti-thyroid action

Absolute Cl↓:

⇒ Acute intermittent porphyria & Varigale porphyria.

⇒ Safely given in Porphyria Cutanea Tarda.

⇒ Ethomidale Cl↓ also Cl↓ in Pentazocin porphyria.

⇒ Ketamine is porphyrogenic in Rats.
INTRA ARTERIAL INJECTION OF THIOPENTONE

In case of inadvertent intraarterial injection of Thiopentone → When injected in ante-cubital fossa can go intraarterial leads to precipitation (dlt high pH) & Vasospasm of artery.

C/F: 1) Pt complains of sharp severe pain
2) Loss of distal pulse
3) Whitening & Blanching of Hand.

Mx: 1) Do not remove the needle.
2) Flush the needle with Saline
3) Give Vasodilators like Phentolamine.
4) Stellate Ganglion/Brachial Plexus Block
   (Causes vasodilation of UL vessels which results in restoration of blood flow)

Prevention: Always given on OUTER ASPECT OF FOREARM.

II. METHOHEXITOL

1) Short acting, cardiostable barbiturate.
2) Small doses → causes convulsions.
   (Proconvulsant in nature)
3) Indicated for ECT (Electroconvulsive Therapy)
ETHOMIDATE

1. Milky while liquid
2. Causes pain on injection
3. Rapid onset of action
4. Most Cardiovascular stable agent
5. Highest incidence of Nausea & Vomiting
6. 30-60% incidence of Myoclonus activity
7. Causes Adreno-cortical Suppression & inhibit Steroid synthesis (leading to ↑ mortality & was withdrawn, nowadays its used only for emergencies)

KETAMINE

1. Causes Dissociative Anesthesia (dissociation of Thalamic from limbic system where pt remains conscious apparently but unresponsive)
2. A phenacyclidine derivative & all the hallucinations & delirium
   Ketamine is dlt phenacyclidine.
3. Metabolism: Ketamine
   ↓
   Nor-Ketamine (also has 30% anesthetic potency of Ketamine)

4. Strongly analgesic in nature

Systemic Effects:

CNS: ↑ Causes sympathetic stimulation → Hypertension & Doc for Hypovolemic Shock pts Tachycardia
 Increases myocardial O\textsubscript{2} demand. Hence (C/I)

- HD p\textsubscript{15}
- HTN p\textsubscript{15}
- Aortic Aneurysm

Respiratory Sys: it Causes minimal respiratory depression

- Rapid injection may cause Apnea.
- Potent Bronchodilator
  - Doc for Asthmatic p\textsubscript{15}
- Maintains upper airway reflexes &
  - Doc for Full Stomach p\textsubscript{15}
- Marked increase in saliva & oral sec &
  - therefore always combined with anticholinergics

CNS

- Increases cerebral blood flow & ICP
- (C/I) in Head injury p\textsubscript{15}
- SOL of Brain
- Epilepsy p\textsubscript{15}

- Causes Hallucinations & occur more commonly in Young p\textsubscript{15}
  - Children & Older ppl: less incidence of Hallucinations.
- Hallucinations can be reduced by BZD's.
- Auditory Hallucinations >> Visual Hallucination

EYE: Increases intraocular pressure & therefore
- (C/I) in Glaucoma p\textsubscript{15}. 
Uses:
1. For short surgical procedure
2. For diagnostic purpose
3. For Burned dressings
4. For Field Anesthesia

Dose: 1-2 mg/kg body weight.

**PROPOFOL**
(aka 2, 6 Disopropyl phenol)

*Milky white liquid available as 1-2% emulsion.*

Contains Soyabean Oil
Glycerol
Egg Lecitin

Since composed of organic compounds a good culture medium for microbial growth.

Hence an open vial of propofol is discarded after 6 hrs.

3. Safely used in Egg allergy pts.
4. Anesthesia & propofol is associated with quick recovery & hence DOC for Day Care Surgery.

5. Metabolism:
   - 70% in liver (also undergoes Extrahepatic metabolism)
   - 30% in lungs

6. Causes pain on injection & pain can be reduced by mixing it with LIGNOCaine

**Systemic Effects:**

- CVS: Ir Hypotension - may cause Brady cardia (as propofol blunts the carotid body receptor response)
Respiratory Sys: It Causes appea longer than thiopentone Max depression of Upper airway reflexes \bowtie for LMA insertion.

CNS: \( \uparrow \) Decreases ICP & Cerebral Metabolic Rate \( \uparrow \) Anticonvulsant but may cause involuntary mov\( \) \( \uparrow \) Antiemetic \( \downarrow \) Antipuritic \( \downarrow \) Antioxidant

\( \rightarrow \) Doesnt provide any Muscle Relaxation
\( \rightarrow \) Decrease intraocular pressure

\( \checkmark \) Propofol \( \checkmark \) Nitrous Oxide

\( \checkmark \) Propofol Infusion Syndrome

\( \triangle \) Metabolic Acidosis

\( \triangle \) Skeletal Myopathy

\( \triangle \) Acute Cardiomyopathy

\( \checkmark \) Occurs in children on prolonged infusions dlt failure of metabolism of FFA's.
DROPERIDOL

1. Acts upon Dopamine 🧘
2. Sedative & powerful antiemetic
3. Causes α adrenergic blockade ⇒ Fall in BP.

   ↓
   causes ↑ secretion of Adrenaline from adrenal medulla.
   ⇒ ↑ in BP.

5. Combined with Fentanyl ⇒ NEUROLEPTANALGESIA.

   ✓ 2.5 mg Droperidol + 50 μg Fentanyl in Ratio of 50:1
   ✓ Characterized by immobility
     Variable amnesia
     Analgesia.

   ✓ When N2O is given along with this combination
     it is k/a NEUROLEPTANESTHESIA.

BENZODIAZEPINES

1. Not used as induction agents but as co-induction agents to reduce the dose of main induction agents

2. Acts upon cerebral cortex & ↑ Cl- ion conductance

3. Decrease MAC by 30%.

4. Mildly MR's @ Spinal cord level.

   ✓ DIAZEPAM

   1. Oil based & causes pain on injection
   2. Given IM & IV
   3. Long acting & causes Retrograde Amnesia

   ✓ MIDAZOLAM

   1. Water based injection
   2. Short acting & causes Anterograde Amnesia.
TOTAL INTRAVENOUS ANESTHESIA
(TIVA)

✓ Combination of Propofol & Remifentanil
✓ Associated with Quick recovery hence useful in day care Sx & Neuro Sx.

*Drugs producing inactive metabolites: <
  Propofol
  Ethomidate
  Thiopentone
  Midazolam
  Methobexitol
  Ketamine

*Drugs producing active metabolites:

NOTES FROM
JAIN STATIONERY
GAUTAM NAGAR
09654691327
**Gudell's Stages of Anesthesia**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Respiration</th>
<th>Tidal Vol</th>
<th>Pupils</th>
<th>Eye Pos.</th>
<th>Reflex</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Irregular</td>
<td>Small</td>
<td>Constrict</td>
<td>Divergent</td>
<td>Nil</td>
</tr>
<tr>
<td>2</td>
<td>Irregular</td>
<td>Large</td>
<td>Dilated</td>
<td>Divergent</td>
<td>Eyelash</td>
</tr>
<tr>
<td>3</td>
<td>Regular</td>
<td>Large</td>
<td>Constrict</td>
<td>Divergent</td>
<td>Pharyngeal, Skin &amp; Conjunctiv</td>
</tr>
<tr>
<td>Plane 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plane 2</td>
<td>Regular</td>
<td>Medium</td>
<td>½ dilated</td>
<td>Fixed</td>
<td>Corneal</td>
</tr>
<tr>
<td>Plane 3</td>
<td>Regular</td>
<td>Small</td>
<td>¾ dilated</td>
<td>Central</td>
<td>Laryngeal</td>
</tr>
<tr>
<td>Plane 4</td>
<td>Jerky</td>
<td>Small</td>
<td>Fully dilated</td>
<td>Central</td>
<td>Carinal Anal</td>
</tr>
<tr>
<td>4</td>
<td>——</td>
<td>——</td>
<td>Apnea</td>
<td>——</td>
<td></td>
</tr>
</tbody>
</table>

- Jerky respiration is d/t intercostal muscle paralysis.
- Eyelash reflex abolished with thiopentone.
- Stage 3 Plane 3
- Apnea in Stage 4 is d/t Brainstem depression
- Carinal reflex (cough on stimulation & suction catheter at carina) is lost in plane 4.
- Various steps of anesthesia is d/t slow induction with Ether.

**Notes from Jain Stationery**

Gautam Nagar
09654691327
INHALATIONAL ANESTHETICS

ETHER

1. Pungent smelling
2. Decomposes on exposure to light. Stored in Amber coloured bottles.
3. Causes marked increase in secretions
4. High chances of laryngospasm @ induction
5. Highly inflammable & explosive. Not used with cautery.
   (also cyclopropane)
6. Only agent which preserves the ciliary activity
7. Potent Bronchodilator
8. Crosses the placenta —
9. Causes hyperglycemia should not be used in Diabetics.

METHOXYFLURANE

1. Absorbed in rubber tubing (also halothane)
2. Most potent inhalational agent.
3. Highest boiling point
4. Hepatotoxic
5. Causes vasopressin resistant high output Renal Failure.

TRILENE

1. Most potent analgesic agent.
2. Reacts with Sodalime
3. Used for Labour analgesia.
CYCLOPROPANE

1. Stored in orange coloured cylinders
2. Causes sympathetic stimulation useful in shock pls.

CHLOROFORM

1. Hepatotoxic
2. Causes Ventricular Fibrillation ⇒ Sudden death.
3. Causes Hyperglycemia Avoided in diabetics.
4. Sweet & pungent

NITROUS OXIDE

1. Aka Laughing Gas.
2. Prepared by heating Ammonium nitrate @ 235-240°C
3. 1.5 times heavier than air & 35 times more soluble in blood than N₂.
4. Colourless & Odourless gas but like O₂ supports combustion.

Systemic Effects

CVS: i. Causes direct myocardial depression along with sympathetic stimulation
   ii. Also increases pulmonary vascular resistance avoided in pulm. HTN pls.

Resp. Sys.: i. ↑ Tidal Vol & ↑ RR ⇒ Minutec Ventilation is stable
   ii. Inhibits the carotid body hypoxic drive.

CNS: i. ↑ ICP & ↑ cerebral metabolic rate
    ii. Provides analgesia.
    iii. No effect on CSF secretion & absorption.
Biotransformation & Toxicity: If given for more than 6 hrs it irreversibly oxidises cobalt atom of Vit B$_{12}$ & causes inhibition of Vit B$_{12}$ dependent enzymes
- Methionine Synthetase
- Thymidylate Synthetase

Inhibition of these enzymes leads to:
- BM depression / Megaloblastic Anemia
- Peripheral Neuropathy
- Perineal Anemia

C/I: Has tendency to expand any air containing cavity.
Hence C/I in Venous air Embolism
⇒ Occurs MCly in sitting position in posterior fossa Sx.
⇒ Most sensitive to detect VAE: TEE

- Pneumothorax
- Lung cyst / Bullae ⇒ Bullae rupture
- Intracranial Sx (esp. post. fossa Sx)
- Vitreoretinal Sx (esp. when Sulphurhexafluoride SHF6)

- Tympanoplasty
- Pulmonary HTN pts
- Acute intestinal obstruction (Eq: Volvulus)

⇒ N$_2$O may be Teratogenic

may be Emetogenic (High incidence of Nausea & Vomiting)
Concentration Effect:

⇒ Rapid uptake of N\textsubscript{2}O into blood allows more N\textsubscript{2}O to come thus shortening the induction time.

Second Gas Effect: N\textsubscript{2}O not only increases its own concentration but also other inhalational agents' k/a.

Diffusion Hypoxia / Fink's Phenomenon:

In old debilitated pts breathing room air

\[ O\textsubscript{2} + N\textsubscript{2}O \xrightarrow{\text{H}_{2}O} O\textsubscript{2} + N\textsubscript{2} \]

Alveoli

Blood

The partial pressure of gas depends on the no of molecules of gas.
Nitrogen Narcosis: Seen in deep sea divers breathing compressed air

⇒ At high pressures solubility of gases increases
  ⇒ (N₂) Gases become soluble in the axons of neurons
  ⇒ Disruption of nerve transmission in the neuron.

⇒ This can be avoided by using Helium instead of Air along with O₂ (Heliox)

ENTONOX

- Mixture of 50% O₂ & 50% N₂O

⇒ Used for Dental anesthesia & Labour analgesia.

POYNTING EFFECT: At -6°C the O₂ & N₂O separate in 2 layers
  So pls 1st breath only O₂ - No analgesia, then
  breaths only N₂O - Hypoxia.
FLOURINATED INHALATIONAL AGENTS

IV HALOTHANE:

a) Sweet smelling
b) Undergoes spontaneous oxidative decomposition which is retarded by Thimol preservative & Amber coloured bottles.

c) Absorbed in Rubber tubings
d) Reacts w/ metals in vapourizers in the presence of water vapour

SYSTEMIC EFFECTS

CVS: iv) Causes direct myocardial depression → Fall in BP
   
   ii) Slow down SA → AV node conduction → Bradycardia.

   iii) Sensitizes heart to dysrhythmogenic effects of Adrenaline. Adrenaline shouldn’t be given w/ Halothane.

   iv) Agent of Choice for Mitral Stenosis HOCM.

RS: iv) Causes respiratory depression

   ii) Causes severe depression of hypoxic pulmonary drive

   iii) Potent Bronchodilator Choice for Asthmatic pts

   iv) Decreases ciliary activity

CNS: iv) Potent cerebral vasodilator → ↑ ICP

   Hyperventilation → CO₂ washout → cerebral vasodilatation

   This response is blunted by Halothane → cerebral hypoperfusion

   Hence prior to hyperventilation is required w/ Halothane.

   i) Minimum ↓ of Cerebral Metabolic rate
Doesn't produce any analgesia

Causes Shivering - Halothane Shakes

Antidote: Pethidine.


Maximum ↓ in total hepatic blood flow & portal vein flow.

Maximally metabolized in the body - more than 20%.

Halothane Hepatitis:

Pathology: Centrilobular Necrosis
Mortality: 70-80%.

C/I: 1) Raised ICP
2) Pheochromocytoma
3) Severe Hypovolemia
4) With Aminophylline known to cause arrhythmias.

Enflurane

Also like Halothane sensetizes the heart to dysrhythmogenic effects of Adrenaline.

Mildly reduces renal concentrating
Can cause Tonic & Clonic seizures C/I in epileptic pts.
37 ISOFLURANE: Most commonly used

- Punget Smelling

**SYSTEMIC**

CVS: iv Peripheral vasodilatation \( \Rightarrow \) Hypotension & Bradycardia.

Doc for deliberate hypotensive anaesthesia.

ii) Powerful coronary artery vasodilator

Agent of choice for cardiac Sx in pt \( \text{\textit{v}} \) good LVF.

Agent of choice in poor LVF: Opioids.

iii) Sometimes ass \( \text{\textit{v}} \) CORONARY STEAL SYNDROME.

CNS: iv Cerebral vasodilator but simultaneous hyperventilation can be done to \( \downarrow \) rise in ICT

\( \text{\textit{v}} \) Causes isoelectric EEG @ 2 MAC (Flattline)

\( \Rightarrow \) Maintains total hepatic blood flow & portal vein flow & also maintains hepatic venous saturation.

Doc for Liver Transplant Sx.

C/I: iv Severe Hypovolemia

\( \text{\textit{v}} \) Malignant Hyperthermia.

47 DESFLURANE:

- Very punget smelling

Lowest Blood Gas Coefficient \( \Rightarrow \) Highly insoluble in blood.

\( \Rightarrow \) High alveolar Tension \( \Rightarrow \) High cerebral tension

Fastest induction & Fastest Recovery.
by Has very high vapour pressure & boils @ Room temp @ high altitudes.

cr Requires special vapourizer & the outer core of Desflurane vapourizer is heated up to 89°C.

Tech 6 Vapourizer is used.

dr Sudden ↑ in desflurane con ⇒ Sympathetic Stimulation

(Always be gradually increased) ⇒ HTN & Tachycardia.

ei Minimally metabolized in the body (Halothane - Max met)

Ĵró Pungent Smelling ⇒ Not suitable for inhalational
Irritating to airway ⇒ induction in children

Ĵr Degraded by Bauxylene absorbant to harmful levels of CO which can shift Oxygen Hemoglobin dissociation curve to left.
Prevented with Sodalime.

5) SEVOFLURANE

aj Mildly sweet smelling ⇒ Agent of choice for induction in children & Day Care Sx
by Low blood gas coefficient

cr Cardiac output is not well maintained as with iso/desflurane

dr Prolongs QT interval on ECG.

CNS : Least cerebral vasodilation.

Associated with Quick recovery ⇒ Choice for Neurosurgical plcs.

⇒ Reacts with Sodalime to form compound A ⇒ Nephrotoxic
⇒ Minimum FGF rate of 2 lt/min should be used with Sevoflurane.

⇒ Degraded by metal & environmental impurities to harmful levels of Hydrogen fluoride ⇒ Causes acid burn of Respiratory
This can be prevented by addition of H\textsubscript{2}O during manufacturing & storing in sp1 plastic containers.
**Features of Depolarizing Block:**

1. Only succinylcholine is available (Depolarizing MR).
2. Causes Muscular Fasciculations.
4. Does not show FADE/POST-TETANIC STIMULATION.
5. Succinylcholine dose of >5 mg/kg BW ⇒ causes conformational changes in R & the block starts behaving like non-depolarizing block ⇒ PHASE II BLOCK.

5. Onset of action of Sch: 30 secs & lasts for 15-20 mins.
6. Doc for full stomach patients.
7. Sch causes: Fasciculations
   Bradycardia (esp. in children after 2nd dose).
8. Metabolized by Pseudocholinesterase & its deficiency leads to increased duration of Action—SCHOLINE APNEA.
Scholine Appearance: Tx - IPPV & FFP (Fresh Frozen Plasma)

- Increases K+ level by 0.5 mmol/lts

BURNS
Spinal cord injury
Stroke
Cerebral Palsy

- Sch chloride from 48 hrs to 9 months after these injuries

- Causes Masseter Ms spasm & these children are more prone to malignant hyperthermia.

- MC triggering factor for Hyperthermia: Succinylcholine.

- Sch - chloride in Muscular Dystrophies

  - Causes severe Ms rigidity preventing respiration & intubation in Dystrophica Myotonica.

- Sch → Causes Histamine realese & Ganglion

  - Causes Post OP myalgias d/t fasciculations

FEATURES OF NON-DEPOLARIZING BLOCK:

1. Doesn't cause Fasciculations
2. Shows FADE / POST TETANIC STIMULATION
3. Reversed by Neostigmine

Drugs can be used in Renal Dysfunction:

- Atracurium
- Cisatracurium
- Mivacurium
- Succinylcholine.
**ORDER OF BLOCKADE:**

- Ptosis — Diplopia — Ms of Face, Jaw, Neck & limbs
  - Diaphragm
  - last Ms to get paralyzed & 1st Ms to recover.

Ms which recover before Adductor Pollicis are:

- Diaphragm
- Rectus Abd
- Laryngeal Adductors
- Orbicularis Oculi

Histamine is released by:

- Atracurium
- Mivacurium
- Succinylcholine
- D-Tubocurarine
  - Maximum Histamine release
  - Ganglion blockade.

Vagolytic Activity Occurs with:

- Gallamine
- Pancuronium
  - ± Rocuronium.

Sympathetic Activity Occurs with:

- Gallamine
- Pancuronium.
NEUROMUSCULAR MONITORING

→ Me muscle used: Adductor Pollicis

→ Me nerve used: Ulnar Nerve.

→ Ms corresponding to laryngeal paralysis: Orbicularis Oculi.

→ Me mode of NM monitoring: Train of Four (TOF)

\[ \text{\begin{array}{c}
\text{1} \\
\text{2} \\
\text{3} \\
\text{4} \\
\end{array}} \text{ sec} \]

\[ \text{Normal Ms} \]

\[ \text{Effect of Sch (DMR)} \]

\[ \text{Effect of NDMR} \]

⇒ When height of T4 is atleast 70% of height of T1 pt can be safely extubated.

→ Gold std for Neuromuscular Monitoring: Electromyography
ATRACURIUM BESYLATE

a) Intermediate acting
b) Metabolized 70% by Hoffmann degradation
   30% by Alkaline Ester Hydrolysis.
c) Dose: Acc to total body weight.
d) Produces a metabolite K/a LAUDONOSINE can cause convulsion.

Doc for Renal & Hepatic failure pls
Pls & Atypical pseudocholinesterase
Myasthenia Gravis pls (1/10th of Normal dose is used)

CISATRACURIUM

a) Isomer of Atracurium
b) 3 times more potent
c) Donot release Histamine *
d) Only Hoffmann degradation
e) Laudonosine levels are lower.

MIVACURIUM

a) Slow onset & Ultrashort duration of action
b) Metabolized by Pseudocholinesterase
c) Causes Histamine release
d) Always given by continuous infusion.

DOXACURIUM

a) Most potent & Long acting
**D-TUBOCURARE**

- Long acting
- Undergoes mainly renal metabolism
- Causes ganglionic blockade leading to fall in BP
  - Good for arterial surgeries
- Causes maximum histamine release.

**VECURONIUM**

- Intermediate acting
- Mainly undergoes hepatic metabolism
- Most cardio stable

**PANCURONIUM**

- Long acting
- Causes sympathetic stimulation useful in shock patients

**ROCURONIUM**

- Intermediate acting
- Pain on injection
- NDMR – of choice in full stomach patient
- Sugammadex: Specific antagonist for Rocuronium

**RAPACURONIUM**

- Rapid onset of action
- Causes high incidence of bronchospasm in children & therefore withdrawn
GALLAMINE
at Max propensity for Vagal Blockade.
b) Only MR - 10 cross placenta: c/i in pregnancy
c) Metabolized 100% by kidneys c/i in Renal Ds.

METOCURINE
a) Also metabolized 100% by kidneys
b) Contains iodine c/i in iodine sensitive pts.

ALCURONIUM
a) Decomposes in presence of light
b) Causes high incidence of anaphylactic Rx.

Factors prolonging Neuromuscular Blockade:
-Aminoglycosides
-Polymyxins
They themselves cause Neuromuscular blockade.

Reversal of Neuromuscular Blockade:
Neostigmine Quartenary ammonium compound.
Does not cross BBB - No central effects

Disadvantages: i) Bradycardia, most dangerous. Hence
ii) Bronchospasm, always combined with Atropine/Glycopyrrolate.
iii) ↑ intestinal Miosis
iv) Urinary Bladder contraction
v) ↑ Salivary Secretions
Sign of Best Reversal: Sustained Head lift for > 5 sec.
**Administration of Anesthesia**

**1. Fasting for Elective Sx**

- Pre-oxygenation with 100% O₂ for 3-4 min
  - ↓
  - IV induction
  - ↓
  - MR relaxant
  - ↓
  - IPPV & Bag & Mask
  - ↓
  - Intubation

**2. Full Stomach**

- Pre-oxygenation with 100% O₂ for 3-4 min
  - ↓
  - IV induction
  - ↓
  - MR relaxant
    - Rocuronium
    - Rapid Onset
    - Succinylcholine
  - ↓
  - Sellick's Maneuver
    - (Pressure upon cricoid cartilage)
    - Closes esophagus against cervical vertebrae & prevents regurgitation & aspiration
  - ↓
  - Intubation
    - Cuffed Endotracheal Tube
LOCAL ANESTHETICS

- Local anesthetics are weak bases.
- 3 Types of Fibers:
  - A fibers: Myelinated, largest fibers
  - B fibers: Unmyelinated, smallest fibers

  A fibers: Motor & Muscle Tone.
  B fibers: Autonomic preganglionic
  C fibers: Autonomic postganglionic
    - Temp
    - Pain
    - Touch
    - Pressure

Sensitivity to local anesthetics: $B > C > A$

$A_y > A_S > B > C$

Sensitivity to hypoxia: $B > A > C$

Pressure: $A > B > C$

Sequence of Blockade: Autonomic > Sensory > Motor

Recovery: Motor > Sensory > Autonomic

Sequence of Sensory: Temp > Pain > Touch > Pressure > Propriocept (cold > hot)
Local Anesthetics

- Amino ester (1° in spelling)
- Metabolized in plasma by pseudocholinesterase except cocaine (metabolized in liver)
- Unstable compounds
- Metabolized to a compound 4°

\[
\text{PABA}^{\text{4}} \text{ responsible for high incidence of allergic Rx.}
\]

Local Anesthetics

- Amino amide (2° in spelling)
- Metabolized in the liver
- Stable compounds
- Less incidence of allergic reactions

Local Anesthetics

- Short acting
  - CHLORPROCAINE

Local Anesthetics

- Intermediate acting
  - COCAINE
  - LIDOCAINE

Local Anesthetics

- Long acting
  - BUPIVACAINE
  - ROPIVACAINE
  - DUBICAINE

Mechanism of Action:

undissociated

\[
\text{Na}^+ \text{ channels} \quad \text{Ionic} \quad \text{Non-ionic} \quad \text{Nodes of Ranvier}
\]
PHARMACOKINETICS

(a) IV Absorption: Depends on site of injection

Vascular site — More absorption & less duration of action.

⇒ Peak plasma concentration after single shot of local anesthetic:

IV > Tracheal > Intrapleural > Intercostal > lumbar epidural > Brachial plexus

(b) Depends on dose

- High dose
- Small dose

(c) Addition of vasoconstrictor: Decrease the local blood flow ⇒ increased duration of action

(d) Pharmacological profile of drug.

⇒ pK_a: The pH @ which drug is 50% ionic & 50% non-ionic

pK_a value more closer to physiological pH

⇒ more faster acting.

⇒ Differential Sensory Blockade: Shown by \{Bupivacaine & Ropivacaine\}

- High Conc: Sensory & Motor Blockade
- Low Conc: Only Sensory Blockade

* Used for labour analgesia.
Addition of Adrenaline:

Conc of 1:2,00,000 is used
1:4,00,000 conc is also available.

✓ Addition of Adrenaline to lignocaine increases both sensory & motor blockade.

✓ Addition of Adrenaline to Bupivacaine increases only sensory blockade.

Alternate to Adrenaline is Phenylephrine

✓ Conc used 1:20,000
✓ doesn't cause Tachycardia.

Addition of Sodium bicarbonate:
leads to Rapid onset & ↑ duration of action
less subcutaneous pain
Quality of block is improved.

Toxicity of Local Anesthetics:

Manifests in CNS or CVS.
17 Headache
27 Dizziness
37 Auditory
47 Visual
57 Musc Twitching
67 Tremors
77 Convulsions

Lignocaine: Bupivacaine
Toxicity Ratio = 1:3
Drugs used in case of Bupivacaine Toxicity are:

a) Intralipid formulations (makes Bupivacaine soluble)
b) Bretyllium
c) Amiodarone \(\rightarrow\) Anti-arrhythmic
d) Lignocaine

Local anesthetic \(\neq\) Adrenaline is C/I for RING BLOCKADE:

- Finger
- Toes \(\nRightarrow\) Contain End arteries
- Penis

**CHLOR PROCAINE**

a) Shortest acting
b) Most acidic of all local anesthetics
c) C/I for spinal anesthesia
d) Causes Neurotoxicity

**LIGNOCAINE**

a) Most commonly used LA
b) Cones used: 4% Topical
   1%. Nerve Blocks
   0.5%. Regional IV
   2%. Epidural
   5%. Heavy spinal anesthesia.
   2%. Jelly Urethral procedures.

\(\text{ct Max Safe Dose} - \exists \) Adrenaline 7 mg / kg

\(\exists\) out Adrenaline 3 mg / kg
BUPIVACAINE

> Long acting
> Concentration used: 0.5%. Heavy spinal anesthesia.
> 0.5%. Nerve Blocks
> 0.125% - 0.225%. Painless labour

C/I for Bier's Block or IVRA.

PROCAINE

> LA of choice in pts with Hx of malignant hyperthermia.

BIER'S BLOCK

(aka Intravenous Regional Anesthesia)

> Can be used both for UL & LL
> By 2 cannula's are used & 2 tourniquets < proximal
> Drugs used: Lignocaine 0.5% without
> Prilocaine 0.5%. Adrenaline

C/I: Scleroderma
> Sickle cell Ds
> Raynaud's Ds.

Does not provide any post operative analgesia.

CELIAC PLEXUS BLOCK

> Used for pain relief of Gastric & Pancreatic Ca.
> Causes blockade of lumbar sympathetic chain.
> Most adverse E: Hypotension
EMLA
(Eutactic Mixture Of Local Anesthetic)

A combination of 2% lignocaine & 2.5% prilocaine
Used to decrease needle phobia.
Should not be used on cut surfaces & mucous membranes.
**Spinal Anesthesia**

Aka Subarachnoid Block / Central Neuraxial Blockade.

Structures pierced during Spinal Anesthesia

- Skin
- Subcut
- Supraspinous
- Intraspinous ligament
- Ligamentum Flavum
- Dura matter
- Arachnoid matter

- In adults spinal cord ends @ Lower border of L1
  
  (or)

  @ Upper border of L2.

  Spinal Anesthesia can be given L2,3 10 15 S1

- Highest point of Iliac crest corresponds to L4-5 interspace.
- Spinal can be given in lateral & sitting position
- Can be given either midline (blw 2 spinous process) or Paramedian

\[ \begin{align*}
\text{Bypasses supra &} \\
\text{intraspinous ligament}
\end{align*} \]

Drugs used for Spinal Anesthesia:

- Lignocaine 5% Heavy (SG of Drug > SG of CSF)
- Bupivacaine 0.5% Heavy
Pencil Tip ← Needles → Non Pencil Tip

Includes:
  a) Syringe
  b) Whitcare

Factors affecting height of blockade:
  a) Dose: Higher the dose higher the block
  b) Baricity: Means SG of Drug
      Hyperbaric drugs are used
      Isobaric drugs move along the CSF.
  c) Volume of Drug: Increases the
  d) Position of Patient:
  e) Patient Factors:
     i) Age: Old age - calcified liq → ↑ space → ↑ pressure
     Drug dose is reduced
     ii) Height: Tall pt - ↑ invertebral body size
         ⇒ ↑ dosage.
     iii) Pregnancy: Pressure on IVC ⇒ Engorged
         Epidural plexus of veins ⇒ ↓ space
         and cord ⇒ ↑ pressure
         ✓ Drug dose is reduced.
         - Also in pregnancy nerve endings become
           more sensitive to LA agents.
     iv) Abdominal Tumors: Same effect as pregnancy.
         Sensitivity of Nerve endings not ↑
Factors not affecting height of Blockade:
✓ Weight of Pt
✓ Sex of Pt
✓ Direction of Needle
✓ Speed of Injection
✓ Barbotage (Obsolete)
  ↓
mixing & remixing of CSF & LA.
✓ Addition of Adrenaline

**Systemic Effects of Spinal Anesthesia:**
Sympathetic is blocked & Parasympathetic becomes dominant.

**CNS:**
- Hypotension & Tachycardia
- Hypotension & Bradycardia - Seen in high Spinal (d/t block of cardiac symp. supply)

**Reasons of Hypotension during Spinal:**
1. ↓ Venous Return
2. Bradycardia leading to ↓ CO
3. Blockage of Adrenal Gland
4. LA toxicity

**RS:** All parameters remain unaffected except:
- ↓ maximum breathing capacity
- ↓ active exhalation
- ↓ d/t paralysis of intercostal Ms.

**Causes of Apnea during Spinal**
1. ↓ Blood Supply to Brain coz of Hypo
2. High Spinal (Phrenic N Block)
3. Total Spinal (up to Brainstem - Pt unconscious)
CNS: Sensory level + 2 \(\Rightarrow\) Autonomic Block
Sensory level - 2 \(\Rightarrow\) Motor Block

\(\text{GIT:}\) Increased peristalsis \& Relaxation of Sphincters
Small contracted Gut.

\(\text{Temp:}\) Heat loss \& Shivering.

\(\text{Genitourinary System:}\) Urinary Retention (loss of motor effort)
24 Placid \& Engorged penis. One of successful signs of Blockade.

Complications of Spinal Anesthesia:
1\text{st} Hypotension: can be prevented by pre-loading pt with fast fluids + Raised leg end + Vasopressors like Mephentramine.

2\text{nd} Atropine for Tx of Bradycardia.

3\text{rd} Apnea: Tx is IPPV + correction of Hypotension

4\text{th} Epidural Hematoma \(\Rightarrow\) Paraplegia

5\text{th} Post dural puncture headache.
- Low pressure headache
- Occurs 24-48 hrs after Spinal anesthesia
- Usually occipital but may be frontal
- Resolves within 7-10 days.

Prevention:
1\text{st} Use pencil tip needle
2\text{nd} Higher gauge needle (small diameter)
3\text{rd} Adequate Hydration
4\text{th} Less Ambulation in 1st 24 hrs post op (lying flat)
Tx: i\textsuperscript{r} Adequate analgesia
    ii\textsuperscript{r} Correct dehydration
    iii\textsuperscript{r} Inj of 50ml of NS in epidural space
    iv\textsuperscript{r} Epidural Blood patch $\rightarrow$ Definitive Tx.

6\textsuperscript{r} Paralysis of Cranial Nerves:
    6\textsuperscript{th} N - Mclvly involved

7\textsuperscript{r} Meningitis
8\textsuperscript{r} Anterior spinal A- Syndrome
9\textsuperscript{r} Backache
10\textsuperscript{r} Urinary Retention.

C/T (ABSOLUTE) OF SPINAL ANESTHESIA:
    a) Raised ICP
    b) Refusal of Pt
    c) Severe MS & AS
    d) Infection @ local site
    e) Severe Hypovolemia
    f) Severe Coagulopathy

**SADDLE BLOCK**

Spinal anesthesia is given in sitting position & pt is allowed to sit for 8-10 min. The effect is in the form of Saddle
K/a Saddle Block.
EPIDURAL ANESTHESIA
(B/t dura & ligamentum flavum)

- Continuous with thoracic cavity & hence negative pressure space.
- Lies 4-5 cm from skin
- Needle used: Touhy's Needle
  - 16/18 Guage needle
- Drugs used: Lignocaine 2%
  - Bupivacaine 2.5
- Volume requirement: 15-20 ml
- Epidural space: 0.5 cm breath in lumbar region
  - Sudden loss of resistance
  - Hanging drop technique
  - DURAN SIGN (Rapid injection into epidural space ↑ rate & depth of breathing)
  - WESTPAL SIGN (Absence of knee jerk after anesthesia)

* For C-section: Level of T4 - S5 is required.
* Remifentanil: Shouldnt be used for Spinal
* For all HB's in pregnancy ⇒ Epidural is the choice.

✓ Sedation
✓ Delayed Resp. Depression
✓ Nausea & Vomiting
✓ Urinary Retention
✓ Pruritis - not related to histamine release
CPR

Order: Compression — For Adult, Child & Infant: Rate of Compression - 100/min
Airway
Breathing

Compression: Ventilation = Adult 30:2

children  Single Res: 30:2
Infant    Double Res: 15:2

⇒ Adrenaline: Doc for CPR
0.1 mg (1:1000) - IV administration.
⇒ According to AHA guidelines Atropine shouldn't be given.

Site of CPR: Center of Chest.
Compression: Atleast 2 inches.
Fluids: Dextrose containing fluids never given

Ribs MCly #: Ribs 5, 6, 7