HISTORY OF ANESTHESIA

- **Dioscorides** – used the term anesthesia
- **Oliver Wendell Holmes** – 1846 – termed anaesthesiology
- **William T. G. Morton (The father of modern anaesthesia)** – October 16, 1846 **(World Ether day)** demonstrated general anesthetic effects of ether.
- **Carl Koller**-1884- introduced cocaine as an ophthalmic anesthetic
- **Niemann**-1860- introduced cocaine as a local anesthetic
- **Joseph Priestley** – produced Nitrous oxide- 1772
- **Horace Walls:** demonstrated use of Nitrous oxide for tooth extraction-1844
- On December 21, 1846, **Robert Liston** performed first surgical operation under ether anesthesia
- **W. E. Clarke** in 1841 administered anesthesia for a dental extraction [not made widely noted]
- **August Bier**- 1898-first **spinal anesthesia/ father of spinal anesthesia**
- **Simpson:** first to use chloroform
- **John Lundy** first used IV anesthetic thiopentone -1934
- **Ferdinand Cathelin** – 1901 – caudal epidural anesthesia
- **Fidel Pages** – 1921 – Lumbar epidural anesthesia
- **Alexander Wood-1855** – invented needle & syringe
- **Harold Griffith- 1942** – used curare
- **Lofgren**-1943- introduced Lidocaine
- **John Lundy & Ralph waters:** coined 'balanced anesthesia'
- **Ketamine**: first used by Domino & Corsen
- **Succinyl choline:** synthesized by Bovet
- **First Boyle's machine:** Edmund Gaske Boyle in 1917
- **First endotracheal intubation:** Ivan Magill
- **First nasal intubation:** Stanlers Rowbothon

Preoperative Physical Status Classification of Patients According to the American Society of Anesthesiologists

Class	Definition
P1	A normal healthy patient
P2	A patient with mild systemic disease (no functional limitations)
P3	A patient with severe systemic disease (some functional limitations)
P4	A patient with severe systemic disease that is a constant threat to life (functionality incapacitated)
P5	A moribund patient who is not expected to survive without the operation
P6	A brain-dead patient whose organs are being removed for donor purposes
E	If the procedure is an emergency, the physical status is followed by "E" (for example "2E")

American Society of Anesthesiologists Physical Status Classification

ASA 1	Healthy patient without organic, biochemical, or psychiatric disease
ASA 2	A patient with mild systemic disease, e.g., mild asthma or well-controlled hypertension. No significant impact on daily activity. Unlikely to have an impact on anesthesia and surgery
ASA 3	Significant or severe systemic disease that limits normal activity, e.g., renal failure on dialysis or class 2 congestive heart failure. Significant impact on daily activity. Probable impact on anesthesia and surgery
ASA 4	Severe disease that is a constant threat to life or requires intensive therapy, e.g., acute myocardial infarction, respiratory failure requiring mechanical ventilation. Serious limitation of daily activity. Major impact on anesthesia and surgery
ASA 5	Moribund patient who is equally likely to die in the next 24 hours with or without surgery
ASA 6	Brain-dead organ donor

PNEUMATIC SYSTEM

High pressure system	Intermediate pressure system	Low pressure system
• Receives gases from the cylinder at high, variable pressures and reduces to lower, constant pressures • Includes **hanger yokes, pressure indicators and pressure regulators**	• Receives gases from the pressure regulator or the pipeline inlet to the anesthesia machine. • Includes master switch, pipeline inlet connections, pipeline pressure indicators, piping, gas power outlet, O_2 pressure failure devices, O_2 flush, additional pressure regulator & flow control valves	Consists of flow meters

- The high pressure system is a cylinder, pressure regulator and yoke assembly.
- The intermediate pressure system is from yoke of assembly to flow control valve
- Low pressure system is downward from the flow control valve to common gas outlet

GAS SUPPLY

Pipeline inlets

- Oxygen, nitrous oxide, and often air are delivered to the operating room through a piping network
- The tubing is color coded and has **diameter index safety system** fitting that prevents incorrect hose attachment.

Cylinder inlets

- Cylinders are attached to the machine via **hanger-yoke** with a **pin index safety system** to prevent errors.
- **Cylinder pressure** is usually measured by a **Bourdon pressure gauge**.
- A flexible tube within this gauge straightens when exposed to gas pressure, causing a gear mechanism to move a needle pointer.

Flow Control Circuits

Pressure Regulators

- To reduce the cylinder gas pressure to **45-47 psig** before it enters the flow valve.
- Oxygen is reduced to **20 psig** and nitrous oxide is reduced to **38 psig**.

Oxygen Supply Failure Protection Devices

- Safety devices sense oxygen pressure via a small "piloting pressure" line that may be derived from the gas inlet or secondary regulator.
- Proportionately **reduce the pressure of nitrous oxide and other gases except for air.**
- They completely shut off nitrous oxide and other gas flow below a set minimum oxygen pressure (eg, 0.5 psig for nitrous oxide and 10 psig for other gases).

Flow Valves & Meters

- **Gas lines proximal to flow valves** are in the **high-pressure circuit**
- **Gas lines between the flow valves and the common gas outlet** are part of the **low-pressure circuit**
- To reduce the risk of providing a hypoxic gas mixture in case of leak, **oxygen flowmeters are *always positioned downstream*** to all other flowmeters (nearest to the vaporizer).

Minimum Oxygen Flow

- The oxygen flow valves deliver a minimum flow of **150 mL/min.**
- Some machines are designed to deliver minimum flow or low-flow anesthesia (< 1 L/min) and have minimum oxygen flows as low as of 50 mL/min (eg, Datex-Ohmeda Aestiva/5)

Oxygen/Nitrous Oxide Ratio Controller

- Ensure a minimum oxygen concentration of **21-25%.**
- Does not affect the flow of a third gas (eg, air, helium, or carbon dioxide).

- GA should never be administered without an oxygen analyzer in the breathing circuit.
- **Three types** are available: **polarographic (Clark electrode), galvanic (fuel cell), and paramagnetic.**

DELIVERY OF MEDICAL GASES

PIN INDEX SAFETY SYSTEM [PISS]

- Inter link between the anesthesia machine and gas cylinder.
- In **high pressure** system [valve outlets of cylinders]
- High pressure (H) cylinders are made of **Molybdenum Steel**.
- Chromium is added to decrease the weight of cylinders.
- Aluminium cylinders are MRI compatible
- Gas pipes are made of seamless copper tubing

Gases	Entonox	Air	CO_2 > 7.5%	Oxygen	CO_2 < 7.5%	N_2O	Cyclopropane
Pin index	Single central hole	1,5	1,6	2,5	2,6	3,5	3,6

Causes of failure of PISS:

- D/t multiple washers placed between the cylinder and yoke, which prevents proper engagement of the pins and holes.
- Also ineffective if yoke pins are damaged or the cylinder is filled with the wrong gas.

DIAMETER INDEX SAFETY SYSTEM [DISS]

- In **low pressure system** & in outlets of central piping systems.

COLOUR CODING SYSTEM

Cylinder	Colour
N_2O	Blue (Liquid form)
Cyclopropane	Orange
Oxygen	Black body with white shoulder (International code), Green (USA code)
Thiopentone	Yellow
CO_2	Grey
Entonox (O_2 & N_2O in equal volumes)	Blue body with blue and white shoulder
Halothane	Amber (Purple- Red)
Air	Grey body with Black & white shoulder
N_2	Black
Helium	Brown

OXYGEN DELIVERY SYSTEMS

Fixed performance masks

- Patient receives a constant inspired oxygen concentration (FiO2) despite any changes in minute
- Ventilation.
- These include:
  - Closed or semi-closed anaesthetic breathing systems with a reservoir bag, attached to
  - anaesthetic machine with pressurised gas supply.
  - **Head boxes for neonates**
  - High Air Flow Oxygen Enrichment (HAFOE) Devices e.g. **Venturi mask, delivers** an inspired
  - oxygen concentration between **24% and 40%.**
- **Venturi Mask**
  - High flow delivery system
  - Flow rate b/w 4 - 12 L/min
  - FiO2 can be set specifically with different flow rate and air ports
  - ~~FiO2 can be 24, 28, 31, 35, and 40%~~

- COPD patient that requires specific oxygen concentrations to be administered (Venturi)
  but not
- too high such that the hypoxic drive to breath is blunted; titrate to keep saturation about 88%.

Variable performance masks/devices

- The oxygen concentration delivered depends on patient minute ventilation, peak inspiratory flow rate and oxygen flow rate.
- Examples:
  - **Nasal Prongs:**
    - Low flow delivery system, > 6 L/min cause nasal mucosal drying
    - Flow rate: 1 - 6 L/min
    - FiO2 starts at 24% for 1L/min and increases 4% for each L/min up to 44% for 6 Lmin
    - Well tolerated
    - Use: minimal or no respiratory distress or oxygenation problem
  - **Nasal cannula:**
    - These do not increase dead space.
    - **Deliver 100% oxygen**, but because the patient also breathes room air, the oxygen
    - concentration ultimately delivered to the alveoli ranges from **24% to 44%.**
    - Inspiratory oxygen concentration depends on the flow rate
    - No rebreathing occurs.
  - **Nasal catheters,** 8FG
    - Can be inserted into the nose as far as the pharynx
    - A gas flow of 150m1/kg/min gives an inspired oxygen concentration of 50% in
    - children less than 2 years
    - No rebreathing occurs.
  - **Simple (Hudson) Face Mask (Rebreather)**
    - Have a small dead space.
    - There is usually a small amount of rebreathing.
    - Low flow delivery system
    - Flow rate b/w 5 - 8 L/min
    - FiO2: 5 - 6 is 40%, 6 - 7 is 50%, 7 - 8 is 60%
    - Mask doesn't need tight seal
    - Use: as per nasal prongs but require higher concentrations

BREATHING SYSTEMS

Insufflation

- Blowing of anesthetic gases across a patient's face.
- Avoids direct connection between a breathing circuit and a patient's airway.
- Valuable during pediatric inductions with inhalation anesthetics.
- There is no rebreathing of exhaled gases if the flow is high enough.
- Disadvantage: Ventilation cannot be controlled.

Open-Drop Anesthesia

- A highly volatile anesthetic—most commonly ether or halothane—is dripped onto a gauze-covered mask **(Schimmelbusch mask)** applied to the patient's face.
- The vaporization lowers mask temperature, resulting in moisture condensation and a drop in anesthetic vapor pressure
- May be used in locations or situations in which compressed medical gases are unavailable

Draw-Over Anesthesia

- In its most basic application, air is drawn through a low-resistance vaporizer as the patient inspires.
- Patients spontaneously breathing room air and a volatile, halogenated agent **(nitrous oxide is never used with draw-over devices)** often manifest an oxygen saturation (Sp02) < 90%

- The devices can be fitted with connections and equipment that allow intermittent positive pressure ventilation (IPPV) and passive scavenging, as well as continuous positive airway pressure (CPAP) and positive end-expiratory pressure (PEEP).

Properties of Draw-Over Devices

- Portable
- Robust
- Low resistance to gas flow
- Usable with any agent
- Controllable vapor output

Semi Closed Breathing System

Mapleson System

Mapleson A / Magill system Modified variant: LACK system	• Efficient for spontaneous ventilation **because fresh gas flow equal to minute volume is sufficient to prevent rebreathing** • **Most popular & widely used.** • Poor choice during controlled ventilation. • Enclosed Magill system is a modification that improves efficiency. • Coaxial Mapleson A (Lack breathing system) provides waste-gas scavenging. • Flow rate : about 5 L/min
Mapleson C system/ Water's system	Post operative recovery
Mapleson D system	**Most efficient for controlled ventilation, since fresh gas flow forces air away from patient and towards pressure relief valve.**
Mapleson E system/Ayre's T piece system	Primarily **used in infants & young children**. Main advantage of T piece is absence of resistance to expiration, a factor of crucial importance to children
Mapleson's F system/ **Jackson- Rees modification of Ayre's T piece.**	Popular in pediatric anesthesia, requires 2-3 times minute ventilation.
Efficiency of system with spontaneous respiration: A>D&E>C>B **Efficiency of system with IPPV :** D&E> B > C > A **Mapleson B & C are more efficient than Mapleson A during IPPV** **Most commonly used version of Mapleson-D: Bain Coaxial system**	

Mapleson Class	Other Names	Required Fresh Gas Flows	
		Spontaneous	Controlled
A	Magill attachment	Equal to minute ventilation (80 mL/kg/min)	Very high and difficult to predict
B		2 x minute ventilation	$2\text{-}2^{1/2}$ x minute ventilation
C	Waters' to-and-fro	2 x minute ventilation	$2\text{-}2^{1/2}$ x minute ventilation
D	Bain circuit	2-3 x minute ventilation	1-2 x minute ventilation
E	Ayre's T-piece	2-3 x minute ventilation	3 x minute ventilation (I:E =1:2)
F	Jackson-Rees' modification	2-3 x minute ventilation	2 x minute ventilation

Fresh Gas Flow = 1.5 times minute volume for controlled ventilation and 2.5 times of minute volume for spontaneous ventilation

	Insufflation and Open Drop	Mapleson	Circle
Complexity	Very simple	Simple	Complex
Control of anesthetic depth	Poor	Variable	Good
Ability to scavenge	Very poor	Variable	Good
Conservation of heat and humidity	No	No	Yes
Rebreathing of exhaled gases	No	No	Yes

Closed Breathing System/ Rebreathing system

- It is a circle system in which the CO_2 is absorbed by soda lime and the exhaled gases can be reused.
- **Eliminates exhaled CO_2.**
- **CO_2 absorbents:**
  - **Sodalime:**
    - 94% of $Ca(OH)_2$ + 5% NaOH + 1% KOH + 0.2% silica + 14-19% moisture.
    - Sodalime is **contraindicated with chloroform & trilene (forms phosphogene, a neuro poisonous gas)**
    - **Disadvantages:**
    - **Forms Carbon monoxide**
    - With sevoflurane, forms compound-A **(penta fluoro isopropenyl fluoro methyl ether), But sevoflurane is not contraindicated with sodalime**
    - Possibility of **fire in breathing circuit**
  - **Baralyme:**
    - 80% of $Ca(OH)_2$ + 20% BaOH + <1% KOH + moisture
  - **Amsorb:** $Ca(OH)_2$+ $CaCl_2$ + $CaSO_4$ & polyvinylpyrrolidone
    - **Disadvantage**: very costly, less CO_2 absorptive capacity [CO_2 absorption: soda lime> barylime> amsorb.

NOTE: Compound-A formation occurs more with barylime than sodalime

Comparison of Soda Lime and Barium Hydroxide Lime		
	Soda Lime	**Barium Hydroxide Lime**
Mesh size	4-8	4-8
Method of hardness	Silica added	Water of crystallization
Content	Calcium hydroxide, Sodium hydroxide & Potassium hydroxide	Barium hydroxide Calcium hydroxide
Usual indicator dye	Ethyl violet	Ethyl violet
Absorptive capacity (liters of CO_2/100 g)	14-23 [231/100gm]	9-18 [10.2 1/100gm]

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- Recommends limiting the room **concentration of nitrous oxide to 25 ppm and halogenated agents to 2 ppm (0.5 ppm if nitrous oxide is also being used)**
- The vacuum control valve on an active system should be adjusted to allow the **evacuation of 1015 L of waste gas per minute.**

Essential Safety Features on a Modern Anesthesia Workstation.	
Essential Features	**Purpose**
Diameter Index Safety System (DISS) with pressure gauges, filter, and check valve	Prevent incorrect pipeline attachments; detect failure, depletion, or fluctuation
Pin index safety system for cylinders with pressure gauges, and at least one oxygen cylinder	Prevent incorrect cylinder attachments; provide backup gas supply; detect depletion
Minimum oxygen/nitrous oxide ratio controller device (hypoxic guard)	Prevent delivery of less than 21% oxygen

Oxygen failure safety device (shut-off or proportioning device)	Prevent administration of hypoxic gas mixtures gases when the oxygen supply fails
Oxygen must enter the common manifold downstream to other gases	Prevent hypoxia in event of proximal gas leak
Oxygen concentration monitor and alarm	Prevent administration of hypoxic gas mixtures
Automatically enabled essential alarms and monitors (eg, oxygen concentration)	Prevent use of the machine without essential monitors
Vaporizer interlock device	Prevent simultaneous administration of >1 volatile agent
Capnography and anesthetic gas measurement	Guide ventilation; prevent anesthetic overdose
Oxygen flush mechanism that does not pass through vaporizers	Rapidly refill or flush the breathing circuit
Breathing circuit pressure monitor and alarm	Prevent pulmonary barotrauma and detect sustained positive, high peak, and negative airway pressures
Exhaled volume monitor	Assess ventilation and prevent hypo- or hyperventilation
Pulse oximetry, blood pressure, and ECG monitoring	Provide minimal standard monitoring
Mechanical ventilator	Control alveolar ventilation
Scavenger system	Prevent contamination with waste anesthetic gases

ASSESMENT OF AIRWAY

The 1-2-3 test:

- On opening the mouth, one should insinuate **one finger** in the temporo mandibular joint.
- There should be atleast **two finger** breadths distance between his incisors.
- There should be atleast **three finger** breadths distance between chin and thyroid cartilage of the patient.

MALLAMPATI TEST:

- Devised by Mallampati & Samson-Young
- Widely used & simpler classification of the pharyngeal view.
- Patient is made to sit upright, open his mouth wide and protrude his tongue.
- Failure to visualize posterior pharyngeal walls indicate difficult airway establishment.
  - Class: I- Uvula, Faucial pillars & soft palate visible.
  - Class: II- Faucial pillars & soft palate visible
  - Class: Ill- Soft palate & Hard palate visible
  - Class: IV- Only hard palate visible

Thyromental distance

- Normal thyromental distance is > 6.5 cms.
- If < 6cm – intubation is difficult

AIRWAY MANAGEMENT

NONDEFINITIVE AIRWAY MANAGEMENT

- Foreign body removal: blind finger sweep for foreign body is acceptable in adults but is NOT acceptable i pediatric cases.
- Maintenance of C-spine control imperative in trauma
- **Maneuvers:**
  - **Head tilt -** chin lift: NOT acceptable with possible C-spine injury
  - **Jaw thrust** - chin lift: acceptable with possible C-spine injury
  - **Heimlick**
- **Oropharyngeal Airway**
  - Use: temporary ventilation of unconscious patient while preparing to intubate

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- Not be tolerated by conscious patient (gag reflex, induces vomiting)
- Proper size: corner of mouth to external auditory canal

- **Nasopharyngeal Airway**
  - Use: temporary airway management in pt who would not tolerate an oropharyngeal airway or if it is difficult to insert (trismus, mouth trauma, etc); less likely to induce vomiting
- **Jet Insufflation (Needle Cricothroidotomy)**
  - Short term oxygenation until more definitive AW can be established
- **Other**
  - Esophageal Obturator AW (EOA), Esophogastric Tube AW (EGTA), Pharygotracheal Lumen AW (PTLA), Esophageal Tracheal Combitube, (ETC)

DEFINITIVE AIRWAY MANAGEMENT

- Endotracheal Intubation
  - Indications:
    - **For supporting ventilation in patient with pathologic disease:**
      - Upper airway obstruction,
      - Respiratory failure,
      - Loss of consciousness
    - **For supporting ventilation during general anaesthesia (most common):**
    - **Type of surgery:**
      - Operative site near the airway,
      - Thoracic or abdominal surgery,
      - Prone or lateral surgery,
      - Long period of surgery
    - **Patient has risk of pulmonary aspiration**
    - **Difficult mask ventilation**

Tracheal Tube

- Used to deliver anesthetic gases directly into the trachea and allow the most control of ventilation and oxygenation.
- Us are most commonly made from polyvinyl chloride.
- The shape and rigidity of TTs can be altered by inserting a stylet.
- Murphy tubes have a hole (the Murphy eye) to decrease the risk of occlusion should the distal tube opening abut the carina or trachea.
- Uncuffed tubes are usually used in children to minimize the risk of pressure injury and postintubation croup.

Airway Equipment for Pediatric Patients

	Premature	**Neonate**	**Infant**	**Toddler**	**Small Child**	**Large Child**
Age	0-1 month	0-1 month	1-12 months	1-3 years	3-8 years	8-12 years
Weight (kg)	0.5-3	3-5	4-10	8-16	14-30	25-50
Tracheal (ET) tube (mm i.d.)	2.5-3	3-3.5	3.5-4	4-4.5	4.5-5.5	5.5-6 (cuffed)
ET depth (cm at lips)	6-9	9-10	10-12	12-14	14-16	16-18
Suction catheter (F)	6	6	8	8	10	12
Laryngoscope blade	00	0	1	1.5	2	3
Mask size	00	0	0	1	2	3
Oral airway	000-00	00	0 (40 mm)	1 (50 mm)	2 (70 mm)	3 (80 mm)

Laryngeal mask airway (LMA)	—	1	1½	2	2½	3

Confirmation of placement:

- Is chest rising? Does reservoir bag fill?
- What is the pulsox?
- Is the tube fogging up?
- Listens over lung fields and epigastrium
- End - Tidal CO2
- CXR: tip should be 1/2 way b/w thoracic inlet and carina (at level of aortic knob)

Oral Tracheal Tube Size Guidelines

Age	Internal Diameter	Cut Length (cm)
Full-term	3.5	12
Child	4 + [Age/4]	14 + [Age/2]
Adult		
Female	7.0-7.5	24
Male	7.5-9.0	24

- **Nasotracheal Intubation**
  - Requires a spontaneously breathing patient
  - Good for pt with tightly clenched teeth, unstable C-spine injury
  - Contraindications: apneic patient, severe maxillofacial fractures, suspected basilar skull fracture (racoon eyes, battle signs, ottorhea, rhinorhea, hemotympanum, nasal fracture)
- **Surgical Cricothryoidotomy:** NOT recommended for children < 12yo b/c of potential damage to the cricoid cartilage which is the only circumferential support to the upper trachea
- **Tracheostomy**: time consuming but indicated for disrupted larynx or cervical trachea

OTHERS:

C-spine Immobilization

- Must protect C-spine
- Loosening of hard collar to allow for movement of the mandible will greatly facilitate visualization of the cords with minimal cervical mobility

Assume a full stomach

- Use sellick's maneuver to occlude the esophagus and decrease aspiration
- Also helps to visualize cords
- **BURP** to help visualize cords: Push **B**ack and **U**p with the **R**ight **P**ressure

Choose a method of intubation

- Rapid Sequence Induction (RSI) is easiest and most popular method and should be used unless a **difficult airway** is expected where there is suspicion that both intubation and bagvalve-mask ventilation after paralysis may be difficult.
- Awake oral intubation: preferred method if difficult airway suspected
- Unconscious patients for whatever reason (even cardiac arrest) do NOT require pretreatment, induction, or paralysis

NOTE:

- Gag reflex is an unreliable indicator of airway reflexes and should not be used.
- **BURP MANEUVER:** Manipulation of the thyroid cartilage, to improve laryngoscopic view
- **SELLICK'S MANEUVER:** Pressure on the cricoid ring to occlude esophagus, to decrease aspiration.
- Use the cricoid ring because it is the only complete tracheal ring.

LARYNGEAL MASK AIRWAY

Discovered by Dr.Archie Bain in 1980

Indications	Contraindications
• To facilitate ventilation & passage of & tube in patient • with a difficult airway • **Difficult airway** management during CPR • **Difficult intubation** is anticipated	• Oropharyngeal abscess or mass • High risk of aspiration • Pregnancy • Pharyngeal obstruction • Low pulmonary compliance
Advantage	**Disadvantage**
• Easy to insert • Does not require laryngoscope & muscle relaxants • Can be used in **cervical injuries** • **Protects the larynx from pharyngeal secretions** (but not gastric regurgitation) • Aids in ventilation during fiberoptic bronchoscopy as well as placement of the bronchoscope.	• **Does not prevent aspiration** • High incidence of **laryngospasm & bronchospasm**

Advantages & Disadvantages of the LMA compared with Face Mask Ventilation or Tracheal Intubation

	Advantages	Disadvantages
Compared with face mask	Hands-free operation Better seal in bearded patients Less cumbersome in ENT surgery Often easier to maintain airway Protects against airway secretions Less facial nerve and eye trauma Less operating room pollution	More invasive More risk of airway trauma Requires new skill Deeper anesthesia required Requires some TMJ mobility N_2O diffusion into cuff Multiple contraindications
Compared with tracheal intubation	Very useful in difficult intubations Less tooth and laryngeal trauma Less laryngospasm and bronchospasm Does not require muscle relaxation Does not require neck mobility No risk of esophageal or endobronchial intubation	Increased risk of gastrointestinal aspiration Less safe in prone or jackknife positions Limits maximum PPV Less secure airway Greater risk of gas leak and pollution Can cause gastric distention

ROCEDURE OF INTUBATION

- Preparation: good oxygenation, check equipment, explain to patient
- Anesthetize the airway: **4cc 4% lidocaine** spray liberally with xylocaine spray just before
- Sedate the patient with
  - **Midazolam 1 - 2mg**
  - **Fentanyl 50 - 100ug**
  - Propofol
  - Ketamine
  - Thipentothal
  - Etomidate

Subjective Criteria	Objective Criteria
Airway obstruction real or impending (epiglotitis, burn, tumors, etc)	**Oxygenation (Pa02 measures oxygenation)** • PaO2 < 70 mmHg with FiO2 at least 70% • A - a gradient > 350 mmHg (normal 15, up to 37 w/ age)
Aspiration real or impending (decreased LOC, drug OD, etc)	**Ventilation (PCO2 measures ventilation)** • PaCO2 > 60 mmHg in normal adults (not • COPD) • RR > 35/min in adults • PaCO2 > 35 mmHg in status asthmaticus
Clinical respiratory failure (tachypnea, tachycardia, AMU, indrawing, cyanosis, diaphoresis, decreased LOC, pulsus paradosus) Tracheal bronchial toilet (unable to clear secretions; COPD w/ pneumonia)	**Mechanics** • Vital capacity < 15 ml/kg (normal is 70
Shock not responsive to medical management w/I 30 min (resp muscles may use up to 25% of cardiac output; septic shock is an example)	
Anesthesia indications	

LARYNGOSCOPY

Direct laryngoscopy: Laryngoscope is inserted into the mouth on the right side and flipped to the left to trap and move the tongue out of the line of sight, and, depending on the type of blade used, inserted either anterior or posterior to the epiglottis and then lifted with an upwards and forward motion.

Indirect laryngoscopy: performed whenever the provider visualizes the patient's vocal cords **by fiberoptic bronchoscopes, video laryngoscopes, fiberoptic stylets and optically-enhanced laryngoscopes.**

Laryngoscope: consists of a handle (Patil-Syracuse handle) & blade

Types of blades:

Curved blade	Mac Intosh type	Used in adults
Straight blade	Miller type	Used in children & in adults with difficult airway

Size markings for laryngoscopes:

000	Small premature
00	Premature infant
0	Neonate
1	Small child
2	Child
3	Adult
4	Large adult
5	Extra large adult

PATIENT MONITORS

Cardiac Monitoring

Central Venous Pressure Monitoring:

- Normal CVP is **6-8mm of Hg**
- Monitoring of JVP / CVP is done from **Rt. Internal jugular vein** (valveless vein).
- Pulmonary artery catheterization is done by **Swan Ganz catheter**.

- Swan Ganz catheter measures mixed venous pressure
  - **Pressure in right atrium** (0-8 mm of Hg)
  - Pressure in **right ventricle** (15 – 25/0-8mm of Hg)
  - Pressure in **pulmonary artery** (15-25/5-15 mm Hg)
  - **Pulmonary capillary wedge pressure** (4 -12 mm Hg)
  - **Left atrium** (4-12mm Hg).
- The best indicator for tissue perfusion or cardiac output is **mixed venous O_2 saturation**.
- Best **clinical guide for cardiac output is urinary output.**

Transesophageal Echocardiography:

- Most sensitive for wall motion abnormalities and to detect ischemia and air embolism during intraoperative period.
- For detecting arrhythmias in ECG lead II is preferred.
- For detecting ischemia in ECG lead V5 is preferred.
- Inferior wall MI shows abnormality in lead II,III and aVF.

BP Monitoring:

- For invasive BP monitoring, **radial artery is most preferred**.
- **For radial artery cannulation, Allen's test** should be performed to assess the patency of ulnar artery.
- **Allen's Test:**
  - Hand circulation is stopped by occluding both radial and ulnar arteries.
  - The pressure over ulnar artery is released while maintaining pressure on radial artery.
  - Note the return of normal color of palm.
  - If color returns to normal in < 7 sec, then radial artery cannulation can be done.
  - If refill time is >15 sec then radial artery cannulation is contra-indicated.
  - 7 – 14 sec is borderline.

<u>Respiratory Monitoring</u>

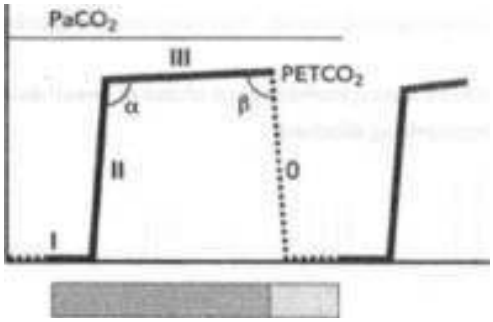
Pulse Oximeter:-

- It is used to detect hypoxia in intra – operative and post – operative period.
- Pulse oxymeter measures **percentage saturation** of oxygen.
- The normal O_2 saturation is 98%
- Oximetry depends on the observation that oxygenated and reduced hemoglobin differ in their absorption of red and infrared light **(Lambert–Beer law)**
- **Oxyhemoglobin** (HbO_2) absorbs more **infrared light (960 nm)**
- **Deoxyhemoglobin** absorbs more red light (660 nm) and appears blue or cyanotic to the naked eye.
- Change in light absorption during arterial pulsations is the basis of oximetric determinations.
- **Following factors lead to inaccurate reading in pulse oxymeter:**
  - Methemoglobin (shows 85% saturation always)
  - Carboxy hemoglobin (shows 95% saturation always, over read d/t Hb CO)
  - Fetal hemoglobin (at very high levels only)
  - Cyanide poisoning (higher values)
  - Anemia (lower values)
  - Hemoglobin S
  - Mal positioning of sensor
  - Poor peripheral pulsation
  - Skin pigmentation
  - Dyes- methylene blue, indocyanine green
  - Optical interference
  - Electrical interference
  - Nail polish & covering
- **Severe Hyperbilirubinemia does not affect readings of pulseoximetry.**

$ETCO_2$ (capnography):

- The most commonly used type of capnograph plots **Pco_2 versus time.**
- Capnography **uses infrared light which is absorbed by CO_2**

Phases:



- Phase 0: inspiratory phase
- Phase I: dead space and little or no CO_2
- Phase II: mixture of alveolar and dead space gas
- Phase III: alveolar plateau, with the peak representing end-expiratory (end-tidal) CO_2 ($PETCO_2$)
- Normal end-tidal PCO2 is approximately: **38 mmHg** (35-45 mm Hg) **or 5%**
- **Alpha angle** is the transition from Phase II to Phase III
- **Beta angle** is the transition from Phase III to Phase I (the start of inspiration)
- Additional **phase IV** (terminal upstroke before phase 0) may be seen in pregnancy.

Uses Of Capnography:

- Surest sign of correct intubation
- Diagnosis of malignant hyperthermia
- Detecting obstruction of Endotracheal tube
- Indicates cardiac output
- Diagnoses pulmonary embolism

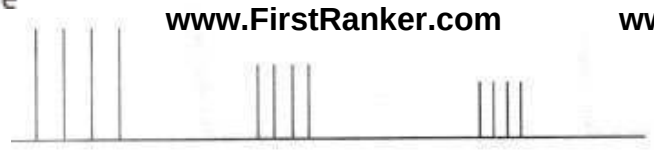
❖ **Persistent detection of CO_2 by a capnograph** is the best confirmation of tracheal placement of a TT (but it cannot exclude bronchial intubation)
❖ The earliest manifestation of bronchial intubation is an **increase in peak inspiratory pressure**.

Blood Gas Analysis:

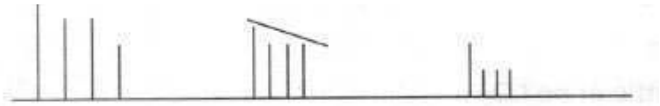
- The blood sample is taken from radial artery preferably in a heparinized glass syringe
- Normal values on room temperature.
  pH: 7.38 – 7.42
  - Partial Pressure of air: 96 - 98 mm Hg
  - Partial Pressure of Coe: 35 –45 mm Hg
  - Bicarbonate: 24 – 28 mEq / L
  - O_2 saturation: 95 – 98%
  - Base deficit: (-3 to + 3)

Neuro Muscular Monitoring

- M/c muscle used: **Adductor pollicis supplied by ulnar nerve**.
- Most accurate measurement for NM monitoring is **orbicularis oculi supplied by facial nerve**.
- Neuromuscular monitoring is **done clinically by train of 4.**
  - 4 stimuli are given each of 2 Hz with a gap of 0.Ssec between each stimuli and repeated every 10-12 sec, recording are taken.
  - Absence of Train 4 response means 75% receptors and blocked and is sufficient for most surgeries.
- Train of 4 is best utilized during **maintenance phase of anesthesia**.
- **Succinylcholine (Depolarizing Blocker)**



- Tubocurarine non – depolarizing blocker)



- Train of 4 differentiates depolarizing and non-depolarizing blockers
- **Fading** is property of non-depolarizing blockers.
- If a patient on succinyl choline shows fading, It is pathognomic of phase 2 block

Temperature Monitoring

- The most accurate measurement of **core body temperature** is provided by **pulmonary artery.**
- **Tympanic membrane** is the most accurate measure of **brain temperature.**
- **Hypothermia** is common thermal abnormality during anesthesia and temperature monitoring is mandatory.
- **Core body temperature > rectal temperature** > surface temperature.
- Hypothermia is temperature < 35°C.
  - < 28 - 35°C is mild hypothermia
  - 21 – 27° C is moderate hypothermia
  - < 20° C is severe / profound hypothermia.
- **Induced Hypothermia: O_2 consumption and metabolic rate falls by 7%** with each degree fall in temperature.
- Brain protection can be done for 10 mins at 30° C and for 60 mins at 15° C.
- Induced hypothermia protects against tissue ischemia during **cardiac surgeries**.

PNEUMOTACHOGRAPH

- **A fixed-orifice flowmeter** that can function as a spirometer.
- A parallel bundle of small-diameter tubes in chamber (Fleisch pneumotachograph) or mesh screen provides a slight resistance to airflow.
- Pneumotachographs measure the flow according to the Venturi principle.
- **Venturi principle:** gas particles accelerate when their circulation zone is reduced. At the same
- time a drop in pressure occurs.
- 2 types of pneumotachographs: Fleisch and Lilly.
- The Lilly type measures the difference in pressure over before and after a membrane with known
- resistance.
- Fleisch types (more reliable) use a series of parallel capillaries.
- Wall mountable type of pneumotachograph- venturi pneumotachograph

Operating room air conditioning efficiency:

- In surgical theatres, the concentration of bacteriologically contaminated air borne particles in the operation room averaged over any 5-min period should notexceedi80-per m3.
- **Minimum of 15 changes/hour [20/hr is satisfactory]**

POSITIONS

Trendelenburg's position	• Patient is supine on a bed with head end low (30-45°) • FRC & VC decreased • Preferred for abdominal surgery, Ryle's tube aspiration • Increase ICP & lOP
Reverse trendelenburg	• Patient is supine on bed with head up
Fowler's position	• Head end of patient's bed is raised about 11/2 feet (46 cm)) & knee are
Sitting position	• Used for neurosurgery

Prone position	• Hypotension may occur • Increased WOB, increased total lung compliane
Sim's position	• Position for PR examination • Pt rests on left lateral side with right knee & thigh drawn well up above left
Rose position	• Tonsillectomy
Sniffing position	• Intubation (flexion at neck 5 extension at atlantooccipital joint)
Lithotomy position	• Used for gynaecolocial and urological procedure • Maximum decrease in vital capacity • Increased likelihood of aspiration • Increased preload and cardiac output

Physiological Effects of Common Patient Positions.

Position	Organ System	Effects
Supine		
Horizontal	Cardiac	Equalization of pressures throughout the arterial system; increased right-sided filling and cardiac output; decreased heart rate and peripheral vascular resistance.
	Respiratory	Gravity increases perfusion of dependent (posterior) lung segments; abdominal viscera displace diaphragm cephalad. Spontaneous ventilation favors dependent lung segments, while controlled ventilation favors independent (anterior) segments. Functional residual capacity decreases and may fall below closing volume in older patients.
Trendelenburg	Cardiac	Activation of baroreceptors, generally causing decreased cardiac output, peripheral vascular resistance, heart rate, and blood pressure.
	Respiratory	Marked decreases in lung capacities from shift of abdominal viscera; increased ventilation/perfusion mismatching and atelectasis; increased likelihood of regurgitation.
	Other	Increase in intracranial pressure and decrease in cerebral blood flow because of cerebral venous congestion; increased intraocular pressure in patients with glaucoma.
Reverse	Cardiac	Preload, cardiac output, and arterial pressure decrease. Baroreflexes
Trendelenburg		increase sympathetic tone, heart rate, and peripheral vascular resistance.
	Respiratory	Spontaneous respiration requires less work; functional residual capacity increases.
	Other	Cerebral perfusion pressure and blood flow may decrease.
Lithotomy	Cardiac	Autotransfusion from leg vessels increases circulating blood volume and preload; lowering legs has opposite effect. Effect on blood pressure and cardiac output depends on volume status.
	Respiratory	Decreases vital capacity; increases likelihood of aspiration.
Prone	Cardiac	Pooling of blood in extremities and compression of abdominal muscles may decrease preload, cardiac output, and blood pressure.
	Respiratory	Compression of abdomen and thorax decreases total lung compliance and increases work of breathing.
	Other	Extreme head rotation may decrease cerebral venous drainage and cerebral blood flow.
Lateral	Cardiac	Cardiac output unchanged unless venous return obstructed (eg, kidney
decubitus		rest). Arterial blood pressure may fall as a result of decreased vascular resistance (right side > left side).

	Respiratory	Decreased FRC and dependent lung; increased perfusion of dependent lung. Increased ventilation of dependent lung in awake patients (no V/Q mismatch); decreased ventilation of dependent lung in anesthetized patients V/Q mismatch). Further decreases in dependent lung ventilation with paralysis and an open chest.
Sitting	Cardiac	Pooling blood in lower body decreases central blood volume. Cardiac output and arterial blood pressure fall despite rise in heart rate and
		systemic vascular resistance.
	Respiratory	Lung volumes and functional residual capacity increase; work of breathing increases.
	Other	Cerebral blood flow decreases.

POST ANESTHESIA DISCHARGE SCORING SYSTEM (PADSS)

Criteria	Points
Vital signs Within 20% of preoperative baseline	2
Within 20-40% of preoperative baseline	1
> 40% of preoperative baseline	0
Activity level	
Steady gait, no dizziness, at preoperative level	2
Requires assistance	1
Unable to ambulate	0
Nausea and vomiting	
Minimal, treated with oral medication	2
Moderate, treated with parenteral medication	1
Continues after repeated medication	0
Pain: minimal or none, acceptable to patient, controlled with oral medication	
Yes	2
No	1
Surgical bleeding	
Minimal: no dressing change required	2
Moderate: up to two dressing changes	1
Severe: three or more dressing changes	

VENTILATION MODES

Controlled	CMV
Fully or partially assisted	SIMV, SIPPV, A/C / PTV, PSV, SIMV + PSV, SIPPV + PSV

CONTROLLED MECHANICAL VENTILATION (CMV)

- Every breath is fully supported by the ventilator
- **In classic control modes**, patients were unable to breathe except at the controlled set rate
- **In newer control modes**, machines may act in assist-control, with a minimum set rate and all triggered breaths above that rate also fully supported.

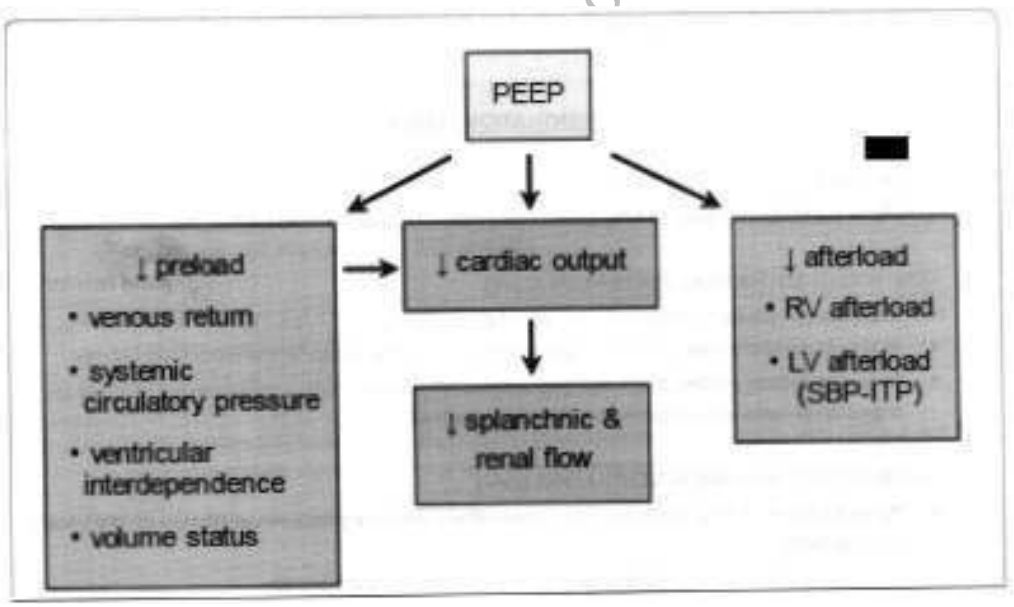
INTERMITTENT MECHANICAL VENTILATION (IMA)

- **Patient triggered (PTV)/ Synchronous intermittent positive pressure ventilation (SIPPV)/assist control (A/C):**
  - Patient triggers a positive pressure inflation with each breath

- **Synchronized Intermittent Mandatory Ventilation (SIMV):**
  - Patient is able to trigger only a pre-set number of positive pressure inflations.

POSITIVE END EXPIRATORY PRESSURE (PEEP)

- Mechanical ventilatory maneuver of exerting a supra-atmospheric pressure in the lungs at end exhalation.
- PEEP is not a ventilator mode by itself.
- It is an **adjunctive treatment that can be applied to all forms of mechanical ventilation;** controlled, assisted or spontaneous.
- Creation of a positive pressure at end exhalation **increases the functional residual capacity (FRC)** of the lungs **by decreasing the collapse** of the small airways thus, reducing atelectasis.
- The **major effect of PEEP on the lungs is to increase FRC.**
- Recruitment (reexpansion) of collapsed alveoli occurs at PEEP or CPAP levels above the inflection point.
- **Indications of PEEP:**
  - Physiological PEEP
  - Pulmonary edema
  - Best value of PEEP is at which P02> 60mm Hg.
  - Shunt fraction is minimum & C.0 is minimally depressed
  - ARDS
  - Cardiothoracic surgery
- **Significance:**
  - **Shifts the tidal volume to a more compliant portion of the pressure volume curve.**
  - **Prevents the intermittent loss of compliance during mechanical ventilation.**
  - **Reduces the work of breathing.**
  - Capable of increasing arterial oxygenation.
- **Hazards of inappropriate application of PEEP:**
  - Impaired gas exchange
  - Decreased cardiac output, splanchnic and renal blood flow.



Key Effects of PEEP

Beneficial	Adverse
• Usually improves oxygenation	• May worsen gas exchange
• Stabilizes and recruits lung units	• Decreases cardiac output
• Improves lung compliance	• Can cause barotrauma
• Minimizes potential for ventilator-induced lung injury	• Interferes with assessment of hemodynamic pressures

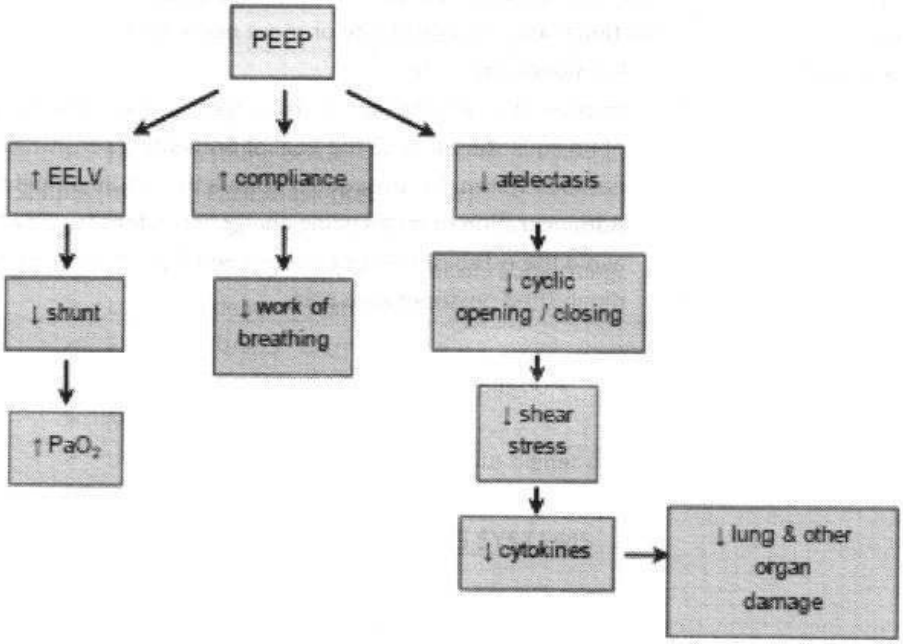


Figure 1: PEEP; positive end expiratory pressure, EELV; end expiratory reserve volume, $Pa0_2$; partial pressure of arterial oxygen; ↑ increase; ↓ decrease.

Key Contraindications of PEEP

- Pneumothorax without pleural catheter
- Intracranial hypertension
- Hypovolemia (unless concomitantly treated)
- Bronchopleural fistula
- Recent pulmonary resection surgery

Term	Description
Allodynia	Perception of an ordinarily nonnoxious stimulus as pain
Analgesia	Absence of pain perception
Anesthesia	Absence of all sensation
Anesthesia dolorosa	Pain in an area that lacks sensation
Dysesthesia	Unpleasant or abnormal sensation with or without a stimulus
Hypalgesia (hypoalgesia)	Diminished response to noxious stimulation (eg, pinprick)

Hyperalgesia	Increased response to a painful stimulus
Hyperesthesia	Increased response to mild stimulation
Hyperpathia	Presence of hyperesthesia, allodynia, and hyperalgesia usually associated with overreaction, and persistence of the sensation after the stimulus
Hypesthesia (hypoesthesia)	Reduced cutaneous sensation (eg, light touch, pressure, or emperature)
Neuralgia	Pain in the distribution of a nerve or a group of nerves
Paresthesia	Abnormal sensation perceived without an apparent stimulus
Radiculopathy	Functional abnormality of one or more nerve roots
Preemptive analgesia	• Formulated by Crile. • Involves the introduction of an analgesic regimen before the onset of noxious stimuli, with the goal of preventing sensitization of the nervous system to subsequent stimuli that could amplify pain. • Administration of long-lasting analgesics before surgery to help to avoid the establishment of a sensitized state and result in diminished postoperative pain.

STAGES OF ANESTHESIA (Guedel's staging based on ether)

- **Stage I: Analgesia:**
  - Loss of pain sensation results from interference with sensory transmission in the Spinothalamic tract.
  - The patient is conscious and conversational.
  - Amnesia and a reduced awareness of pain occur as Stage II is approached.
- **Stage II: Excitement:**
  - The patient experiences delirium and possibly violent, combative behavior.
  - There is a rise and irregularity in blood pressure.
  - The respiratory rate may increase.
  - To avoid this stage of anesthesia, **a short-acting barbiturate, such as thiopental,** is given intravenously before inhalation anesthesia is administered.
- **Stage III: Surgical anesthesia:**
  - Regular respiration and relaxation of the skeletal muscles occur in this stage.
  - Eye reflexes decrease progressively, until the eye movements cease and the pupil is fixed.
  - Surgery may proceed during this stage.
- **Stage IV: Medullary paralysis:**
  - Severe depression of the respiratory and vasomotor centers occurs during this stage.
  - Death can rapidly ensue unless measures are taken to maintain circulation and respiration.

CLASSIFICATION OF GENERAL ANESTHETICS

Inhalational agents			**Intravenous agents**	
Gaseous	**Volatile**		**Inducing agent**	**Slower acting**
Nitrous oxide Xenon	**Alkanes:** Halothane	**Ethers:** Ether, Enflurane, Desflurane, Isoflurane, Sevoflurane	Propofol Methohexitone Thiopentone Etomidate	Benzodiazepines **Dissociative anesthesia:** Ketamine **Neurolept analgesia:** Fentanyl + Droperidol

INHALATION ANESTHETICS

IMPORTANT FACTS:

- **IDEAL GAS Obeys Charles, Boyle's & Avogadro's law**
- **Charles's law:** at constant pressure V a T.
- **Boyle's law: at** constant temperature V a 1/P.
- **Unitary hypothesis:** all inhalation agents share a common mechanism of action at the molecular level.
- **Meyer—Overton rule:** Anesthetic potency of inhalation agents correlates directly with their lipid solubility.
- General anesthesia typically reduces both VO_2 and VCO_2 by about 15%.
- The greatest reductions are in cerebral and cardiac O_2 consumption.
- Three factors affect anesthetic uptake:
  - Solubility in the blood
  - Alveolar blood flow
  - Difference in partial pressure between alveolar gas and venous blood.

MINIMAL ALVEOLAR CONCENTRATION

- MAC is alveolar concentration of an inhaled anesthetic that prevents movement in 50% of patients in response to a standardized stimulus (eg:- surgical incision)
- MAC is a useful measure as it **measures the potency** of inhalational agents.
- **0.3 to 0.4 MAC** is associated with awakening from anesthesia **(MAC awake)**
- There is 6% decrease in MAC per decade of age.

Anaesthetic	MAC (Vol %)	Blood gas partition coefficient
Halothane	0.74	2.3
Enflurane	1.68	1.8
Isoflurane	1.15	1.4
Desflurane	6.0	0.42
Sevoflurane	2.05	0.69
Cyclopropane	9.2	0.44
Nitrous oxide	104	0.47
Trilene	0.2	9
Ether	1.92	12
Chloroform	0.8	8
Methoxyflurane	0.16	15

- MAC for nitrous oxide is 104%, and it must be given in a pressurized chamber due to safety considerations.

Factors Increasing MAC	Factors Decreasing MAC	Factors does not affect MAC
• ↑CNS metabolic activity • ↑CNS neurotransmission • ↑CNS neurotransmitter levels • Up-regulation of CNS response	• ↓CNS metabolic activity • ↓CNS neurotransmission • ↓CNS neurotransmitter levels • Down-regulation of CNS response	• Thyroid disease • Gender (M/F)
• Young patient • Chronic alcohol abuse • Hypernatremia • Acute amphetamine poisoning • Cocaine • Ephedrine	• Elderly patient • Acute alcohol intoxication • Hyponatremia • Chronic amphetamine • Hypercalcemia, Hypokalemia • Hypo and hyperthermia • L.A , I.V induction agents • Opioids, Clonidine • Anemia • Lithium, Methyl dopa, Reserpine • MAP < 40mm of Hg • Pregnancy • Hypoxia (pao2 < 40m of Hg) & hypercarbia (paco2 > 90mg Hg)	

PARTITION CO-EFFICIENT

- Measures the **solubility** of the gas.
- Blood gas partition coefficient: **measures solubility of general anesthetic**
- Oil-gas partition coefficient: **measures anesthetic potency.**

EFFECT OF INHALATIONAL AGENTS

Respiratory System

- All Inhalational agents are **bronchodilators** and **depress the respiratory system.**
- Maximum bronchodilation: **Halothane (agent of choice in asthmatics)**
- Maximum respiratory depression: **Enflurane**.
- Maximum blunting of ventilatory response is with halothane.

Cardiovascular System

- All inhalational agents **decrease cardiac output except isoflurane and desflurane**.
- Maximum decrease in C.O- **halothane**
- C.0 is best maintained by isoflurane because of reflex tachycardia.
- All inhalational agents are pulmonary vasodilators **except N_2O** which is pulmonary vasoconstrictor
- All inhalational agents reduce mucociliary activity of airways **except ether**.
- **Maximum inhibition of baroreceptor reflexes is with Halothane.**
- All inhalational agents reduce BP except cyclopropane.
- **Isoflurane** is the agent of choice for **controlled hypotension**.
- **Isoflurane** is agent of choice for **cardiac patients** because of maintenance of C.O and minimum response on baroreceptor reflexes.
- Maximum **inhibition of myocardial contractility - Halothane**.
- Halothane sensitizes the heart to arrhythmogenic action of adrenaline
- Halothane is contraindicated in patients with Pheochromocytoma

Central Nervous System

- **All inhalational agents increase intracranial tension.**
- Maximum increase in intracranial tension is with enflurane.
- Minimum increase in ICT is isoflurane and Desflurane < 6%
- Inhalational agent of choice for **neurosurgeries is Isoflurane**.

Kidneys

- **Nephrotoxicity** is d/t **fluoride content.**
- Anesthetics are fluorinated to make them **non-inflammatory**.
- Maximum fluoride content is seen in **methoxyflurane** (maximum nephrotoxicity)
- Methoxyflurane produces vasopressin resistance, polyuric renal failure

Others

- N_2O can cause bone marrow suppression, Vitamin B12 deficiency and megaloblastic anemia
- **All inhalational agents relaxes the uterus.**
- Maximum uterine relaxation - halothane and thus **halothane** is agent of choice for **internal version and manual removal of placenta.**
- Hyperglycemia is produced by **ether, cyclopropane and desflurane.**
- **All inhalational agents increase intra ocular pressure**
- All inhalational agents are good skeletal muscle relaxants **except N_2O**.
- Maximim **skeletal muscle relaxation is by ether**
- **Ether and cyclopropane are highly inflammable**. Cautery should not be used with these agents.
- All inhalational agents undergo **metabolism by oxidation**.
- **Halothane** is metabolized by **reduction and oxidation**.

Extent of metaholism of inhalational anesthetics

- **Methoxyflurane > 70%** (maximum metabolism)
- Halothane > 40%
- Enflurane 8%
- Sevoflurane 2-5%
- Isoflurane < 2%
- **Desflurane < 0.05% (least metabolism)**
- **N_2O does not undergo any metabolism**

NITROUS OXIDE (laughing gas)

- Has **second gas effect** during induction & **diffusion hypoxia** after discontinuation of anesthesia in recovery phase.
- As N_2O is used in high concentration (70-80%) it leads to entry of N_2O in blood at a rate higher than minute (1 lit/min) volume.
- N_2O has low blood solubility. So it rapidly diffuse into alveoli & dilutes the alveolar air-Partial Pressure of O2 in alveoli is reduced i.e. diffusion hypoxia
- **Diffusion hypoxia** is prevented by administering 100% oxygen for 5-10 min after discontinuing N_2O
- **Poynting effect:** Entonox (50% O_2 & 50% N_2O) & mixture of gases (O_2 & N_2O) keeps them in gaseous form.
- If another potent anesthetic eg. Halothane is added, it also will be delivered to the blood at a rate higher than minute volume & the induction will be faster.
- **N_2O is a good analgesic but weak anaesthetic and poor muscle relaxant. Hence it is not a complete anaesthetic.**
- **N_2O has blood gas coefficient of 0.47 and has fast induction**
- It has MAC value of 104; Hence Potency is low
- N_2O is used as a carrier gas given in a mixture of 33% O_2 and 66% N_2O
- **Contraindications for N_2O :**
  - Middle ear surgeries and tympanoplasty
  - Laparoscopic surgeries, Eye surgeries
  - Acute intestinal obstruction and volvulus
  - Microlaryngeal surgeries
  - Pneumothorax, pneumoperitonium
  - Pneumoencephalos.
- It should be avoided in patients with pulmonary hypertension
- **Adverse effects:** bone marrow depression (agranulocytosis, **megaloblastic anemia)** and even neurological deficiencies **(peripheral neuropathies** and **pernicious anemia).**

ENTONOX

- 50-50 mixture of N_2O & O_2
- Cylinder is blue coloured with white shoulder
- Uses - analgesia for wound dressing, chest physiotherapy, removal of chest drains labour analgesia, & dental surgery
- It is good analgesic (d/to N_2O)

XENON

- Manufactured by fractional distillation of air →costly
- MAC → 71% [more potent that NO]
- Blood gas partition coefficient → 0.14 [emergence is rapid than with desflurane/propofol]
- Minimal cardiovascular & hemodynamic side effects
  - **Cardio protective & Neuro protective**
  - **Non teratogenic**
  - **Not metabolized in liver/ kidney**
  - **No malignant hyperthermia**
- Density of xenon → 5.887g/dl (more than N2O & air)
  - Increases pulmonary resistance & breathing
  - Cautiously used in moderate to severe COPD, morbidly obese & premature infants

Advantages of Xenon (Xe) Anesthesia	**Disadvantages of Xenon (Xe) Anesthesia**
Inert (probably nontoxic with no metabolism)	High cost
Low blood solubility	Low potency (MAC = 70%)
Rapid induction and recovery	No commercially available anesthesia equipment
Environmentally friendly, Nonexplosive	

HALOTHANE (2, bromo, 2 chloro, 1, 1, 1 trifluoroethane)

- Least expensive & least pungent.
- Potent anesthetic, no analgesia.
- Dissolve rubber and corrodes metals.
- **Drager Narko test** is done for halothane.
- Contains **0.01% thymol** for stability.
- Decomposed by light but is **stable in amber** coloured bottles.
- 15-20% is metabolized.
- May **persist in the liver upto 12 days & not given in same patient within 3 months (potent hepato toxic).**
- Relaxes skeletal and uterine muscle & blood vessels.
- Not hepatotoxic in children and combined with its pleasant odor, suitable in children for inhalation induction.
- Causes 5'H'
  - Malignant Hyperthermia,
  - Hepatitis (centrilobular necrosis) extremely rare (1 per 35,000 cases)
  - Hypotension
  - Hypercapnia
  - Heart rate decreases (myocardial depression)
- Decreases 10P, but ICT is increased
- **Shivering & tremors** common (H-shakes) in early post-operative period
- Myocardial depression of halothane is exacerbated by β-blockers and calcium channel-
- blocking agents.
- The combination of halothane and aminophylline → serious ventricular arrhythmias.

Contraindications for halothane:

- **Pregnancy** because it increases the risk of post -partum hemorrhage
- **Liver dysfunction & Previous use within 3 months:** due to halothane hepatitis
- **Hypovolemia & severe cardiac disease (aortic stenosis);** due to negative ionotropic effect
- **Pheochromocytoma** & exogenous catecholamines administration as it sensitize heart to catecholamines.

❖ **Best uterine relaxant is Halothane followed by ether.**
❖ **Best muscle relaxant is ether followed by halothane.**

FLURANES

- **Enflurane**
  - **Contraindicated in epilepsy**
  - Increases cerebral blood flow, secretion of CSF, resistance to CSF flow & intra cranial pressure
  - High voltage high frequency EEG changes can progress to spike & wave pattern that culminates in **frank tonic clonic seizures.**
  - This epileptiform activity is exacerbated by high anesthetic concentrations & hypocapnia, so hyperventilation is not recommended to attenuate Enflurane induced intracranial hypertension.
- **Isoflurane**
  - AOC in **neurosurgery**
  - Causes coronary steal syndrome
  - Least effect on myocardial contractility **[most cardio stable volatile agent]**
- **Enflurane & Halothane:** myocardial depressants
- **Desflurane:** transient sympathetic activation, **broken down to carbon monoxide by dry barium hydroxide → carbon monoxide poisoning.**
- **Sevoflurane**
  - Sweet odour
  - Metabolized to **HFIP [Hexa flour !so propyl]**
  - Induction agent of choice in **children**
- **Halothane and isoflurane: sensitizes the heart to circulating catecholamines (adr/NA)**
- **Seizures are seen in enflurane & desflurane** (lesser extent)

- **Depends on**
  - Gender (Female> male)
  - Age (middle age adults)
  - Obesity
  - Enzyme induction
  - Prior anesthetic exposure
  - Genetics
- Hepatotoxicity of inhalational agents is due to TFA **[Tri flour acetyl] metabolite.**
- Therefore, hepatotoxicity is proportional to the percentage of metabolism.
- % metabolism: halothane (20%) > Sevoflurane (2-5%)> Enflurane (2-4%)> Isoflurane (0.2%)>desflurane (0.02%)
- But **sevoflurane does not cause hepatotoxicity** because its metabolite is HFIP (not TFA)

NEPHROTOXICITY OF ANESTHETIC AGENTS:

- **Methoxyflurane:**
  - Most potent inhalation agent, but its high solubility and low vapor pressure limited its rate of induction and emergence
  - Highly nephrotoxic (high fluoride content)
  - Causes polyuric (High output), vasopressin-resistant renal failure
  - Tendency of oxalate stone formation
- **Prolonged use of Enflurane:** Leads to significant fluoride production and nephrotoxicity.
- Though **sevoflurane** produces fluoride, **nephrotoxicity is rare** in usual therapeutic doses
- Halothane, Isoflurane Desflurane: fluoride production is negligible, Can be used in Renal failure.
- Halothane & Isoflurane decreases renal blood flow, GRF & urinary output but Desflurane do not.

TRICHLOROETHYLENE (TRILENE)

- It is potent nerve poison.
- Vth & VII th CN are most commonly involved
- Produces analgesia in distribution of 5th cranial nerve & relieves trigeminal neuralgia.
- It is not used in closed circuit (Soda lime) because toxic product may be formed
- At 125°C or in presence of O_2 as by cautery it decomposes into phosgene ($COCl_2$) & Hcl
- Does not depress myocardium & respiration (like N_2O)
- Not inflammable.
- Disadvantage : Sensitizes heart to adrenaline (Occasional dysrhythmia)
- Highly potent analgesic because MAC is low 17% (MAC $\alpha \frac{1}{potency}$)
- Used for labour analgesia

ETHER

- Ether has **slow induction with slow recovery** and is very unpleasant.
- **Induces laryngeal spasm** and makes induction even slower.
- **Stimulates salivary and bronchial secretions. So atropine pre medication is required.**
- **Highly inflammable and explosive**, it should not be used when **diathermy** is needed in the airway
- Muscle relaxants need no to be used as **ether itself produce excellent relaxation**.
- Ether **liberates catecholamines** and tends to maintain blood pressure.
- No sensitization of myocardium to circulating catecholamines.
- It is a **complete anaesthetic** nearer to ideal anaesthetic.
- **Ether does not affect the mucociliary action and** is good **bronchodilator**.
- **Ether has good anaesthetic, good analgesic, good skeletal muscle relaxant.**
- Ether does not cause depression of myocardium but instead causes **tachycardia and hypertension**.
- Ether has **highest instance of nausea and vomiting** among inhalational agents.
- Ether **causes hyperglycemia and** is contraindicated in **diabetes**
- **Guedel's 4 stages of anaesthesia were based on ether.**
- Ether is safe in unskilled professionals and is very economical.

Preservatives

- Halothane: 0.01% thymol
- Ketamine: Benzethonium chloride
- Thiopentone: Anhydrous sodium carbonate (6%) & nitrogen gas
- Ether: propyl galate/ hydroquinone/ diphenylamine

NONVOLATILE ANESTHETIC AGENTS

PROPOFOL

Cardiovascular	Neurologic	Metabolic
• Depresses entricular systolic function • **Vasodilatation results from calcium channel blockade.** • In patients undergoing coronary artery bypass surgery, it **decreases mean arterial blood pressure, stroke volume and increases heart rate**	• **Reduce neuronal damage** by depressing cerebral metabolism. • **Decreases cerebral oxygen consumption, cerebral blood flow and cerebral glucose use**	• The emulsion used as the vehicle for propofol contains soybean oil and egg lecithin and supports bacterial growth; iatrogenic contamination leading to **septic shock.** • Currently available preparations contain **EDTA, metabisulfite, or benzyl alcohol as a bacteriostatic agent.** • Because EDTA chelates trace metals, particularly zinc, serum zinc levels should be measured daily during continuous infusions • **Hyperlipidemia** may occur in infants and small children

- Water-soluble phosphorylated prodrug: **fospropofol** [hydrolyzed by endothelial cell surface alkaline phosphatases]
- Hypnotic agent associated with **pleasant emergence and little hangover.**
- 1% xylocaine is also given along with it to reduce pain on injection.
- **Preferred agent for sedation and hypnosis** and in particular for patients with altered level of consciousness.
- **Anesthetic of Choice**
  - **Malignant hyperpyrexia**
  - **Day care surgery**
  - **Total IV anesthesia (used along with alfentanil)**
- **Has anti-oxidant, anti- emetic, anti convulsant, bronchodilator & anti pruritic property.**
- The **rapid recovery of neurologic** status makes it a good sedative in ICU patients.
- **Diprivan** (1% formulation): contains 10% soya oil, 1.25% egg phophatide & 2.25 %glycerol.

PROPOFOL INFUSION SYNDROME-PRIS:

- Occurs if given at the rate of **4mg/kg/hour** or more for 48hrs or longer.
- Lethal disorder as it interferes with mitochondrial oxidation.
- Features:
  - Acute **refractory bradycardia** leading to asystole
  - Metabolic acidosis
  - Rhabdomyolysis
  - Hyperlipidemia
  - Enlarged/fatty liver
  - Cardiomyopathy with acute cardiac failure, skeletal myopathy

THIOPENTONE

- Ultra short acting barbiturate used for induction.
- The duration of action of highly lipid-soluble barbiturates (thiopental, thiamylal, and methohexital) is determined **by redistribution**, not metabolism or elimination.
- Although thiopental is **highly protein bound (80%),** its great **lipid solubility** and **high nonionized fraction (60%)** account for maximal brain uptake within 30 s.

Actions:

CNS:

- Cerebro protective
- Decreases cerebral blood flow & intra cranial tension.
- Decreases cerebral O_2 consumption & increases the perfusion pressure.
- Anti-analgesic (can produce hyperalgesia by reducing the threshold of pain)
- It has anticonvulsant / anti-epileptic property

Eye:

- Pupils first dilate & then constrict.
- Decrease in IOT
- Loss of eye lash reflex- **sign of adequate induction**

Musculo - skeletal system: Tremors, twitching, respiratory excitation including cough, hiccup
Respiratory system: Transient apnea, respiratory depression **[double apnea],** upper airway obstruction
Larynx: Laryngospasm & hiccups

Other Features:

- It is not a muscle relaxant.
- Has **anti-thyroid** properties because it has thiourilene structure.
- **Ringer lactate should not be used** for reconstitution as it gets precipitated with it.
- IV agent of choice for cerebral protection.
- It crosses BBB and Placental barrier

Complications:

- Induces ALA synthetase → **acute intermittent porphyria.**
- Perivenous and IM injections cause **tissue necrosis and ulcerations** due to high alkalinity
- **Intra-arterial injections lead to arterial spasm** which is prevented by using 2.5% solution, injecting very slowly and in incremental doses.
- Thiopentone should be avoided in asthmatics, hypotension, and shock, patients on Beta blockers, hypokalemia, heart blocks, valvular stenosis and dystrophia myotonia.

METHOHEXITONE

- Ultra short acting barbiturate. More potent than thiopentone.
- Induces seizures and is the agent of choice for electroconvulsive therapy

ETOMIDATE

- Used to induce anesthesia.
- Hypnotic agent but lacks analgesic activity.
- Water solubility is poor, so etomidate is formulated in a propylene glycol solution.
- Induction is rapid, and the drug is short-acting.
- **Only** used for patients with **coronary artery disease or CVS dysfunction**, such as shock.
- Etomidate is hydrolyzed in the liver, no effect on the heart and circulation.
- Adverse effect: decrease in plasma cortisol and aldosterone levels due to **inhibition of 11-α-ahydroxylase**.

KETAMINE

- A short-acting, non barbiturate anesthetic
- Structural analogue of **phencyclidine**
- **N-methyl-D-aspartate receptor (NMDA) a subtype of the glutamate receptor antagonist.**
- Causes profound analgesia, **dissociative anesthesia** and catatonia
- **Anesthesia of choice in shock.**
- It is associated with **emergence psychoto mimetic** side effects "**DISSOCIATIVE ANESTHESIA"** (delirium, illusions, **hallucination**) it is less common in children and pretreatment with **lorazepam (drug of choice)**
- Only IV anesthetic agent with **both anesthetic and analgesic** activity

It is a sympathetic stimulant

- Cardiac stimulation (sensitizes the heart to adrenaline) → Increased HR, BP, Oxygen demand & cardiac output.
- **Increases all pressure** → ABP, 10T, ICT
- Increased muscle tone → myalgia
- Potent **bronchodilator**→ AOC in bronchial asthma
- **Upper airway reflexes are intact** (beneficial in patients with either hypovolemic or cardiogenic shock as well as in patients with asthma)
- Salivation is increased so anticholinergic (atropine)is always given in premedication
- **Contraindicated in raised intracranial pressure & intracranial pathology with mass effect.**
- **Avoided in:** CHF, coronary artery disease, **hypertension**, CVA & Arterial aneurysm.

FENTANYL

- More potent analgesic than morphine
- Rapid onset & rapid recovery so used for **day care surgery**
- Produces significant musculoskeletal rigidity **(Wooden chest syndrome)**
- Can be given in hepatic & renal disease
- Fentanyl "lollipop" is an effective method of producing analgesia and sedation.
- Provides rapid onset (10 min) of analgesia and sedation in children and adults
- Low molecular weight and high lipid solubility → transdermal absorption **(fentanyl patch).**
- Serum concentrations reach a plateau within 14-24 h of application and remain constant for 72 h.
- A high incidence of **nausea** and variable blood levels have limited the acceptance of fentanyl patches for postoperative relief of pain.

ANESTHETICS CAUSING

Increased ICT	Sevoflurane, Desflurane, Isoflurane, Enflurane, Methoxyflurane, Halothane, Ketamine, Nitrous Oxide (N_2O), Althesin, Succinyl choline
Decreased ICT	Barbiturates, Cyclopropane, Droperidol, Etomidate, Lidocaine, Propofol
Increased IOT	Barbiturates, Cyclopropane, Etomidate, Succinyl Choline, Ketamine,N_2O
Decreased IOT	Morphine, Thiopentone, Halothane, Hexamethonium, Trimethaphan
Increased BP	Ketamine, Pentazocine, Pancuronium
Bronchodilatation	**(preferred in asthmatics)** Ketamine (most potent), Halothane, Promethazine, d-TC
Broncho spasmodic	(contraindicated in asthmatics):Ether, N_2O,Thiopentone

Effects of Anesthetic Agents on Cerebral Physiology

Agent	Metabolic rate	Blood flow	Blood volume	Intracranial tension
Halothane	↓↓	↑↑↑	↑↑	↑↑
Isoflurane	↓↓↓	↑	↑↑	↑
Desflurane	↓↓↓	↑	↑	↑↑
Sevoflurane	↓↓↓	↑	↑	↑
Nitrous oxide	↓	↑	±	↑
Barbiturates	↓↓↓↓	↓↓↓	↓↓	↓↓↓
Etomidate	↓↓↓	↓↓	↓↓	↓↓
Propofol	↓↓↓	↓↓↓↓	↓↓	↓↓
Benzodiazepines	↓↓	↓	↓	↓
Ketamine	Little or no effect	↑↑	↑↑	↑↑
Opioids	**Little or no effect**			
Lidocaine	↓↓	↓↓	↓↓	↓↓

- When combined with intravenous agents, nitrous oxide has minimal effects on CBF, CMR, and ICP.

- On intra arterial injection: **Thiopental**
- On intravenous injection
  - With Thrombophlebitis: **Etomidate (80%)**
  - Without Thrombophlebitis: **Propofol (40%), Methohexitol (20%), Thiopental (10%)**
- Incidence is greatly reduced if a large vein is used, if a small dose of lidocaine (10mg) is injected shortly before.

ANAESTHETIC AGENTS OF CHOICE FOR VARIOUS CONDITIONS

Day care	Propofol
Ischemic heart disease	Etomidate
Congenital heart disease -Left to right shunt -Right to left shunt	 Isoflurane Ketamine
CH F	Ketamine
Shock	Ketamine
To produce deliberate hypotenion	Isoflurane
Asthma and COPD	Ketamine
Epilepsy	Thiopentone
For electroconvulsive therapy	Methohexitone
Thyrotoxicosis	Thiopentone
Cardiac surgery	Isoflurane
Neurosurgery	Isoflurane

- **Liver disease:**
  - Induction agent: **Isoflurane** (least effect on hepatic blood flow)
  - Relaxant: Cisatracurium, atracurium (unique nonhepatic metabolism)
- **Renal Disease:**
  - Induction agent: Isoflurane
  - IV anesthetics: thiopental & propofol.
  - Opioids – Remifentanil, fentanyl, sufentanil
  - Relaxant: Cisatracurium, atracurium
- **Renal Disease:**
  - Induction agent: halothane, sevoflurane, ketamine
- **Neurosurgery:**
  - Total intravenous anesthesia **(TIVA)** is preferred – **propofol with opioids** in anesthetic of choice.
  - Among volatiles, isoflurane is agent of choice

Anesthetic drugs contraindicated in

- **Acute intermittent porphyria:** Thiopentone
- **Acute asthma & Acute intermittent porphyria (ATP) :** Althesin (Steroidal)
- **Renal failure:** Methoxyflurane, Galamine, Morphine, Metocurine
- **Hepatic Failure:** Chloroform, Halothane

BALANCED ANESTHESIA

- Thiopental: induction
- N_2O: amnesia
- Meperidine: analgesia
- Curare: muscle relaxation

General anesthesia

- **Inducing agents:** Propofol, Methohexital, Thiopentone, etomidate
- **Muscle relaxant:** Mivacurium (agent of choice) , Succinyl choline
- **Analgesic:** Alfentanyl, Remifentanyl, Fentanyl
- **Volatile inhalation agent**: Isoflurane, Sevo/Desflurane
- **Total intravenous anesthetic technique**: Propofol/ Remifentanil/ Alfentanil/ Sufentanil
- **Switch technique**: Induction with Propofol, maintenance with Isoflurane, Sevoflurane, change to Propofol or Desflurane at the end for rapid emergence.

Monitored Anesthesia

- Initial sedation & anxiolysis with a Benzodiazepine (Midazolam) followed by Propofol then local anesthesia
- For breast biopsy, ophthalmic procedure & minor plastic surgery.

- ❖ No Analgesia = Halothane
- ❖ Only Analgesia = N_2O
- ❖ Profound Analgesia = Ketamine
- ❖ Best / Maximum analgesia = Trilene

MUSCLE RELAXANTS

Directly acting	Neuro muscular blocking agent	Centrally acting agent
• Dantrolene • Quinine	**Depolarizing (Non-competitive):** • Succinyl choline/ Scoline/ Suxamethonium • Decamethonium **Non depolarizing (competitive):** • Gantacurium [Ultra-short acting] • Mivacurium [Short acting] • Vecuronium, Rocuronium, Atracurium, Cisatracurium [intermediate acting] **Others:** Galamine, d-tubo curarine, Pancuronium, Pipecuronium, Doxacurium	Acts on cerebrospinal axis without altering consciousness • Benzodiazepine • Mephensin • GABA derivatives as **Baclofen**

DIRECT ACTING SKELETAL MUSCLE RELAXANTS

- Dantrolene inhibits release of Ca^{2+} from sarcoplasmic reticulum, by **inhibiting Ryanodine** receptors.
- Dantrolene is **DOC for malignant hyperthermia and neurolept malignant syndrome.**
- S/E of Dantrolene – Muscle weakness and hepatitis
- Quinine is used to treat nocturnal leg cramps.

NEURO MUSCULAR BLOCKING AGENT

- **Maximum histamine release, contraindicated in Asthma: d-TC**
- **Minimum histamine release, used in Asthma: Vecuronium**
- Shortest acting non-depolarizing muscle relaxant = **Mivacurium**
- Shortest acting depolarizing muscle relaxant = Succinyl choline
- Overall shortest acting muscle relaxant = Succinyl choline
- Longest acting Neuromuscular blocker = Pancuronium
- Most commonly used muscle relaxant = Vecuronium
- Most potent skeletal muscle relaxant = Doxacurium
- Least potent skeletal muscle relaxant = Succinyl choline
- Least potent Non-depolarising skeletal relaxant = Rocuronium
- Metabolized by **pseudo cholinesterase: Succinyl choline & Mivacurium**
- Muscle relaxant of choice in obstetrics & to decrease BP: **d-Tubo curare (does not cross placenta)**
- Muscle relaxant of choice to increase BP: **Pancuronium**

- Muscle relaxant with ganglion block - **Curare, Gallamine, Trimethaphan & Pancuronium**
- Fastest acting non-depolarising neuromuscular blockers - **Rocuronium**
- Vagal & Ganglion stimulation caused by Succing choline
- Maximal vagal block & Tachycardia- Pancuronium
- Histamine release & maximal vagal blockagle- d – Tubocuramine

	Depolarizing block	**Non depolarising block**
Effect on single twitch height	Depression	Depression
Train of four fade	Absent	Present
Tetanic fade	Absent	Present
Post tetanic facilitation	Absent	Present
Effect of anti cholinesterase	Potentiation of block	Reversal of block
Effect of non depolarizing agent	Less blockade	More blockade

SUCCINYL CHOLINE

- The **only depolarizing (noncompetitive) muscle relaxant in use.**
- **Rapid onset of action (30-60 seconds)**
- **Over all shortest duration of action** (3-5 min) due to rapid hydrolysis by pseudo choline esterase.
- Succinylcholine is two acetylcholine molecules linked end-to-end.
- Scoline is **metabolized completely** into **succinic acid + choline**
- Dibucaine inhibits pseudo choline esterase activity.
- The percentage of inhibition of pseudo choline esterase activity is termed the **dibucaine number**.
- % of abnormal /normal pseudo choline esterase is determined by **Dibucaine number & fluoride number**.
- Under standardized test conditions, dibucaine inhibits the normal enzyme by 80% and the abnormal enzyme by only 20%.
- **Dibucaine-resistant (variant) gene, is m/c recognized abnormal pseudocholinesterase** genes.
- Normal Dibucaine no = 75 – 85.

Drugs Known to Decrease Pseudocholinesterase Activity

Description	**Drug**
Organophosphate use for glaucoma	Echothiophate
Cholinesterase inhibitors	Neostigmine,Pyridostigmine
Monoamine oxidase inhibitor	Phenelzine
Antineoplastic agent	Cyclophosphamide
Antiemetic/prokinetic agent	Metoclopramide
β-Blocker	Esmolol
Nondepolarizing muscle relaxant	Pancuronium
Various agents	Oral contraceptives

- Scoline transiently increases muscle tone in the masseter muscles
- Causes dual or biphasic block with doses more than 500 mg [or > 6mg/kg]

Phase I Block	Features of classical depolarization block
Phase II Block	Results from desensitization of receptor to Ach. & resembles competitive / non depolarization block and partially antagonized by anticholinesterases

Clinical Responses and Monitoring of Phase I and Phase II Neuromuscular Blockade by Succinylcholine Infusion

Response	Phase I	Phase II
End-plate membrane potential	Depolarized to –55 mV	Repolarization toward –80 mV
Onset	Immediate	Slow transition
Dose-dependence	Lower	Usually higher or follows prolonged infusion
Recovery	Rapid	More prolonged
Train of four and tetanic stimulation	No fade	Fade*
Acetylcholinesterase inhibition	Augments	Reverses or antagonizes
Muscle response	Fasciculations → flaccid paralysis	Flaccid paralysis

*Post-tetanic potentiation follows fade.

Side effects:

- Increases muscle tone, Intraocular pressure, Intra-abdominal pressure
- Muscle fasciculation/Muscle soreness or ache
- **Hyperkalemia → diastolic cardiac arrest.**
- **Sudden Cardiac Arrest After Intubation And Succinylcholine → Hyperkalemia**
- Increases temperature i.e. Malignant Hyperpyrexia

Conditions causing susceptibility to Succinylcholine-induced Hyperkalemia

•	Burns	•	Parkinson's disease , Polyneuropathy
•	Massive trauma	•	Tetanus
•	Severe intraabdominal infection	•	Prolonged total body immobilization
•	Spinal cord injury	•	Ruptured cerebral aneurysm
•	Encephalitis	•	Closed head injury
•	Stroke	•	Hemorrhagic shock with metabolic acidosis
•	Guillain-Barre syndrome	•	Myopathies (eg, Duchenne's dystrophy)

NONDEPOLARIZING MUSCLE RELAXANTS

Relaxant	Chemical Structure	Metabolism	Primary Excretion	Histamine Release	Vagal Blockade
Atracurium	Benzyl-isoquinolone	+++	Insignificant	+	0
Cisatracurium		+++	Insignificant	0	0
Mivacurium		+++	Insignificant	+	0
Doxacurium		Insignificant	Renal	0	0
Pancuronium	Steroidal	+	Renal	0	++
Pipecuronium		+	Renal	0	0
Vecuronium		+	Biliary	0	0
Rocuronium		Insignificant	Biliary	0	+

ATRACURIUM

A. Hofmann Elimination: [depends on pH & temperature]

- Inactivated in plasma by spontaneous non enzymatic degradation & by choline esterases.
- Major metabolite - **laudanosine (CNS stimulant) produce epileptiform fits.**
- It's duration of action is not altered in patients with **hepatic and renal in sufficiency**
- Muscle relaxant of choice **in renal failure, anephric patients & liver disease**

B. Histamine release leading to flushing of skin.

CISATRACURIUM

- Undergoes Hoffman elimination & also metabolized by kidneys.
- 4-5 times more potent than atracurium
- Laudanosine production is 5 times lesser than atracurium

PANCURONIUM

- Causes vagal blockade and releases noradrenaline.
- Produces tachycardia and hypertension.
- It is **muscle relaxant of choice in shock and hypotension.**
- It is metabolized by the kidney, so avoided in renal failure.

VECURONIUM

- **Most commonly used** muscle relaxant for routine surgery.
- **Most cardio stable**. It is the muscle relaxant of choice for **cardiac patients**.
- Contraindicated in liver disease and in biliary obstruction.
- Causes polyneuropathy on long term use.

PIPECURONIUM

- Long acting
- No vagolytic activity (or) ganglion blockade activity.

ROCURONIUM

- Earliest onset of action among non-depolarising muscle relaxant.
- Muscle relaxant of choice for pre-curarization
- Non- depolarizing muscle relaxant of choice for intubation.

ASYMMETRIC MIXED-ONIUM CHLOROFUMARATES (GANTACURIUM)

- Ultra short acting muscle relaxant.
- Degraded by two chemical mechanisms, neither of which is enzymatic:
  - Rapid formation of an apparently inactive cysteine adduction product, with cysteine replacing chlorine.
  - Slower hydrolysis of the ester bond adjacent to the chlorine substitution, presumably to inactive hydrolysis products.

SUGAMMADEX

- Sugammadex is the first **selective relaxant** binding agent
- Sugammadex exerts its effect by forming very tight complexes in a 1: 1 ratio with steroidal neuromuscular blocking agents (rocuronium > vecuronium >> pancuronium).

- ❖ Tubocurarine, the first muscle relaxant used clinically, produces hypotension and tachycardia through histamine release.
- ❖ Patients allergic to **iodine** (eg, shellfish allergies) could exhibit hypersensitivity to **metocurine** preparations as they too contain iodide.
- ❖ **Gallamine** has potent vagolytic properties and is entirely dependent on **renal function** for elimination.
- ❖ **Rapacuronium is not used anymore because of severe bronchospasm.**

DISEASES WITH ALTERED RESPONSES TO MUSCLE RELAXANTS

Disease	Response to Depolarizers	Response to Non depolarizers
Amyotrophic lateral sclerosis	Contracture	Hypersensitivity
Autoimmune disorders (SLE, polymyositis, dermatomyositis)	Hypersensitivity	Hypersensitivity
Cerebral palsy	Slight hypersensitivity	Resistance
Hemiplegia	Hyperkalemia	Resistance on affected side
Muscular dystrophy (Duchenne type)	Hyperkalemia and malignant hyperthermia	Hypersensitivity

Myasthenia gravis	Resistant to depolarizing agents; sensitive to phase II block	Hypersensitivity
Myasthenic syndrome	Hypersensitivity	Hypersensitivity
Myotonia (dystrophica, congenita, paramyotonia)	Generalized muscular contractions	Normal or hypersensitivity
Severe chronic infection (tetanus, botulism)	Hyperkalemia	Resistance

Sequence of muscle blockade after muscle relaxants therapy

- First muscle to be blocked: Central muscles **(muscles of face)** followed by jaw → pharynx larynx → respiratory muscles → peripheral muscles
- In general, larger muscles (eg, abdominal, trunk, paraspinous, diaphragm) are more resistant to neuromuscular blockade and recover more rapidly than smaller muscles (eg, facial, foot, hand).
- The diaphragm is usually the last muscle to be paralyzed
- **Recovery occurs in the reverse order.**
- **Muscle monitored for activity during blockade: Adductor pollicis**

Reversal of Muscle Relaxation

- Depolarizing (Non- competitive) agents are not antagonized
- Non-Depolarizing (Competitive) MR are antagonized by **Acetyl choline or Anti Choline EsteraseNeostigmine, Pyridostigmine and Edrophonium.**
- **Atropine** is given to prevent muscarinic effects.
- **Recent drug: Sugammadex** [sugar, gamma cyclo dextrin]
  - **Causes quick & complete recovery, reverses profound neuromuscular blockade**
  - Has hydrophobic cavity with hydrophilic exterior [soluble in water → traps drug in the center]

MALIGNANT HYPERTHERMIA

- Drug- or stress-induced hypermetabolic syndrome.
- Vigorous muscle contractions, an abrupt increase in temperature, subsequent cardiovascular collapse
- Uncontrolled release of Ca^{2+} from the sarcoplasmic reticulum due to **defect in the ryanodine receptor (RYR1) is the initiating event**
- Inherited as **autosomal dominant fashion**, with variable penetrance & expressivity.
- **Triggers**: Stress, excitement, anoxia, viral infections, lymphoma, ischemia or hypoxia.

Drugs known to trigger malignant hyperthermia	Drugs safe in malignant hyperthermia
• Halothane • Methoxyflurane • Enflurane, isoflurane • Succinylcholine • Decamethonium • Gallamine • Diethyl ether, Ethylene, Ethyl chloride • Trichloroethylene • Ketamine • Phencyclidine • Cyclopropane	• Nitrous oxide • Barbiturates • Diazepam • Tubocurarine • Pancuronium, vecuronium • Opiates

- **Early signs:** masseter muscle contracture, muscle rigidity, metabolic acidosis, sinus tachycardia, supraventricular tachyarrhythmias, mottling or cyanosis of the skin, increased cot production, and hypertension.
- **Two signs** helpful in making a **prehyperthermic diagnosis**
  - **Increased end-tidal CO_2**
  - **Masseter spasm**
- **M/C with combination of depolarizing blocking agent and anesthetic.**

- Discontinue volatile anesthetic and succinylcholine.
- Hyperventilate with 100% O_2 at high flows.
- Administer sodium bicarbonate, 1-2 mEq/kg intravenously.
- Mix **dantrolene sodium** with sterile distilled water and administer 2.5 mg/kg iv
- Institute **cooling measures** (lavage, cooling blanket, cold intravenous solutions).
- **Administer additional doses of dantrolene if needed.**
- Treat severe hyperkalemia with dextrose, 25-50 g IV, and regular insulin, 10-20 U intravenously (adult dose).

NEUROLEPTIC MALIGNANT SYNDROME

- Rare complication of **antipsychotic therapy, meperidine and metoclopramide**
- Mechanism: dopamine blockade in the basal ganglia and hypothalamus and impairment of thermoregulation.
- **Muscle rigidity, hyperthermia, rhabdomyolysis, autonomic instability, altered consciousness**
- **Laboratory findings:** increased WBC count and increased levels of creatinine phosphokinase, liver enzymes, plasma myoglobin and myoglobinuria
- Deaths occur primarily as a result of renal failure or arrhythmias

Diagnostic criteria:

A. Developmental of severe **muscle rigidity & elevated temperature** associated with use of neuroleptic medication.
B. Two or more of the following
   1. Diaphoresis (sweating)
   2. Dysphagia
   3. Tremors
   4. Tachycardia
   5. Incontinence
   6. Mutism
   7. **Change of level of consciousness from confusion to coma**
   8. Elevated or labile B.P
   9. Leucocytosis
   10. Laboratory evidence of muscle injury (e.g. elevated CPK), renal function test

C. Symptoms **are not due to phencyclidine, viral encephalitis or mood disorder with catatonic features.**

Treatment: Dantrolene (drug of choice) or Bromocriptine/Amantadine

LOCAL ANESTHETICS

- Interfere with the excitation process in a nerve membrane in one or more of the following ways:
- Altering the basic resting potential of the nerve membrane
- Altering the threshold potential (firing level)
- Decreasing the rate of depolarization
- Prolonging the rate of repolarization

Classification of Local Anesthetics according to Biological site and Mode of action

Type	Definition	Chemical substance
A	Acting at receptor site on external surface of nerve membrane	Biotoxins (tetrodoxins, saxitoxins)
B	Acting at receptor site on internal surface of nerve membrane .	Quaternary ammonium analogs of lidocaine, Scorpion venom
C	Acting by a receptor independent physico-chemical mechanism	Benzocaine
D	Acting by combination of receptor and receptor- independent mechanisms	Most LA's (articaine, lidocaine, mepivacaine, prilocaine)

- LA's are weak bases carrying a positive charge at the tertiary amine group at physiological pH.
- **Mechanism of action:** Blocks voltage gated Na+ channels from inside of cell membrane by binding to a-subunit.
- Nerve block produced by local anesthetics is called a ***nondepolarizing nerve block.***

Classification of Local Anesthetics based on chemical structure

ESTERS		AMIDES	Quinoline
Esters of benzoic acid	**Esters of para-aminobenzoic acid**	Articaine Bupivacaine Dibucaine Etidocaine Lidocaine Mepivacaine Prilocaine Ropivacaine	Centbucridine
Butacaine Cocaine Ethyl aminobenzoate (benzocaine) Hexylcaine Piperocaine Tetracaine	Chloroprocaine Procaine Propoxycaine		

	Local anesthetic	
	Ester linked	**Amide linked**
Metabolism	By pseudocholinesterase	N-dealkylation and hydroxylation by microsomal P-450 enzymes in the liver.
Shorter duration (< 30 min)	Procaine (low potency) Chlorprocaine (intermediate potency)	
Intermediate duration & potency (30-90 min)	-	Lidocaine, Mepivacaine, Prilocaine
Long duration & potency (> 120 min)	Tetracaine, Benzocaine	Bupivacaine, Ropivacaine, Dibucaine, Etidocaine

Alkalinization of local anesthetics by adding **sodium bicarbonate**

- Speeds onset
- Improves the quality of the block
- Prolongs blockade by increasing the amount of free base available.
- Most useful for agents such as **lidocaine, mepivacaine, and chloroprocaine.**
- **Sodium bicarbonate** is usually **not added to bupivacaine, which precipitates above a pH of 6.8**.

Sensitivity of nerve fibres for local anesthetics

- **Small myelinated** axons **(Ay motor & Aδ sensory fibers)** are **most susceptible** to local anesthetics.
- Next in order of block are the **large myelinated (Aα and Aβ) fibers**
- **Least susceptible** are the small, **nonmyelinated C fibers.**
- Among sensory fibres **temperature** (cold > heat) > pain > touch > deep pressure > proprioception

Effects of addition of a Vasoconstrictor to Local Anesthetic

(Eg: adrenaline, **Concentration**: 1:50,000 to 1:200,000)

- **Prolongs duration of action** by decreasing their rate of removal from the local site
- **Reduces systemic toxicity** of LAs: rate of absorption is reduced
- Makes the injection **more painful**
- Provides a more bloodless field for surgery.
- Increases the chances of subsequent **local tissue edema** and necrosis as well as delays wound healing by reducing oxygen supply and enhancing oxygen consumption in the affected area

- Lignocaine **should not** be used in patients with history of **malignant hyperthermia**
- Lignocaine is used for **ventricular fibrillation** specially after MI
- Lignocaine can produce cauda equina syndrome
- Preservative free lignocaine called as **xylocard** is preferred for **IV injection**.
- Lidocaine transdermal patch: (**LIDODERM**) - relief of pain associated with postherpetic neuralgia.

Lignocaine dose:

- With adrenaline: 7 mg/kg
- Without adrenaline: 4 mg/kg

Concentration of Lignocaine

- IV Regional anaesthesia 0.5%
- Nerve block 1%
- Epidural / Jelly 2%
- Topical 4%
- Spinal 5%

Lignocaine with adrenaline SHOULD NOT be used for:

- Areas with end arteries e.g. for **ring block of fingers, toes, penis, pinna** (absolute contraindication)
- When an **inhalational agent** especially **halothane** which sensitizes myocardium to adrenaline is used
- Myocardial ischemic patients
- **Hyperthyroid** patient
- **Severe hypertensives**
- Intravenous regional anaesthesia **(Bier's block)**

Anticonvulsive Blood Levels of Lidocaine:

Clinical Situation	Lidocaine Blood Level µg/mL
Anticonvulsive level	0.5-4
Preseizure signs and	4.5-7
Tonic—clonic seizure	>7.5

DOSE OF ADRENALINE:

Condition	Route of administration	Adrenaline dose
Branchial asthma	Inhalational	1 in 100
Anaphylactic shock	I.M, S.0	1 in 1000
	I.V	1 in 10,000
Cardiac arrest	Intra-cardiac	1 in 10,000
With Local anaesthesia	Subcutaneous	1 in 2,00,000

Epinephrine 1:1000 contains 1 mg of epinephrine per ml. 1:1000 solution adrenaline
= ig adrenaline in 1000m1 solution
= 1000mg adrenaline per 1000mIsolution
= 1mg per ml

OTHER LOCAL ANESTHETIC AGENTS Cocaine:

- First discovered LA
- Only naturally occurring LA
- Vasoconstrictor action
- **Not to be used with adrenaline d/t cardiac arrhythmias & ventricular fibrillation.**

Prilocaine:

- Safest
- Maximum **Methemoglobinemia**
- **O-Toludine metabolites** accumulate after large doses & convert hemoglobin to methemoglobin
- Treatment of Methemoglobinemia: **IV methylene blue** (1-2mg/ kg of 1% solution) which reduces methemoglobin **(Fe^{3+}) to hemoglobin (Fe^{2+})**
- Most suitable for **Bier's IV block**

Bupivacaine:

- **Most potent**
- Best for **isobaric anesthesia** and regional block
- Contraindicated in regional IV anesthesia
- **Long duration** of action plus its **differential blockade (sensory> motor)** has made it a popular drug for providing prolonged analgesia during **labor** or the postoperative period.
- **Bupivacaine** is a racemic mixture of (R) & (S) isomers while **Levobupivacaine** (Chirocaine) contains single (S) stereoisomer, both containing **butyl groups**.
- The most common ECG finding with bupivacaine intoxication is slow idioventricular rhythm with **broad QRS complexes** and eventually, electromechanical dissociation.
- Bupivacaine is the **most cardiotoxic local anesthetic - should not be used for Bier's block.**
- Recent recommendation for treatment of **bupivacaine induced cardiotoxicity**: **20% intralipid [4m1/kg followed by 0.5m1/kg/min infusion]**
- **Bupivacaine** is LA of choice for isobaric spinal anesthesia.
- It is most commonly used for a carpal tunnel release.
- Newer drug: **Depobupivacaine**- multivesicular liposomal formulation of bupivacaine with long lasting effect (72 hours).

Procaine:

- LA of choice in **malignant hyperthermia**
- 15t synthetic LA

Chlorprocaine:

- When injected into the **subarachnoid space or intradurally it may cause paraplegia, d/t** preservative, sodium bisulfate (now replaced with an antioxidant, a derivative of EDTA).
- Severe back pain following epidural administration.

Mepivacaine: not metabolized by neonates so C/I neonates & labour

- ❖ Shortest acting LA – **Chlorprocaine**
- ❖ Longest acting LA – **Dibucaine** > Tetracaine > Bupivacaine
- ❖ All LAs are vasodilators except lignocaine (no vasogenic action) & Cocaine (vasoconstrictor)

LA used in surface anesthesia	Never used as surface anesthetic
Hexycline, Lignocaine,Dibucaine, Tetracaine	Procaine, Mepivacaine
Prilocaine, Cocaine	Bupivacaine

- **Articaine (Septocaine)** is a recently introduced **amino amide, approved in the U.S. for dental and periodontal** procedures. It exhibits a rapid onset (1-6 minutes) and duration of action of –1 hour.
- **Benzocaine** a common ingredient in local anesthetic sprays also can cause Methemoglobinemia.
- **Ropivacaine**: contains propyl group, made of single (S) stereoisomer
- Compared to **bupivacaine, Ropivacaine** is less cardiotoxic, less potent with shorter duration of action
- LA's are myotoxic (bupivacaine > lidocaine > procaine, Least with Ropivacaine), if injected directly into a muscle

EMLA cream (Eutectic [easily melted] Mixture of Local Anesthetics):

- 5% emulsion **containing 2.5% lidocaine and 2.5% prilocaine**
- Used as an anesthetic prior to **venipuncture, skin graft harvesting, laser removal of portwine stains, lithotripsy and circumcision.**
- EMLA cream should not be used on mucous membranes, broken skin, infants less than 1 month old, or patients with a predisposition to methemoglobinemia

ADJUNCTS TO ANESTHESIA

General principles

- Stop ACEI/ ARB 24 hours before surgery.
- Stop metformin 24 hours before surgery.
- Stop sulfonylureas the night before surgery.
- Stop diuretics once the patient is NPO.
- Continue statins.
- Continue CNS-active drugs.
- Insulin may require adjustment.
- Stop OCPs and HRT four weeks before surgery, if possible.
- Stop nonselective NSAIDs two to three days before surgery, but continue COX-2 inhibitors.
- Continue outpatient dosing of corticosteroids and add a stress dose.
- Stop DMARDs and biologics one week before surgery.
- Stop herbal medicines one to two weeks before surgery.

PRE ANAESTHETIC MEDICATION

- Opioids - Morphine
- Anxiolytics – Diazepam
- Hypnotic – Barbiturate
- Anti cholinergics- Atropine, Hyoscine
- Neuroleptic – chlorpromazine

ADJUNCTS FOR ANESTHESIA

- H2 blocker - Metoclopramide, Ondansetron: reduce the risk of aspiration pneumonia.
- **Diphenhydramine:** antimuscarinic or atropine-like activity or antiserotonergic activity (antiemetic)
- **Metoclopramide** increases lower esophageal sphincter tone, speeds gastric emptying, and lowers gastric fluid volume.
- Serotonin 5-HT3 receptor blockers like **Ondansetron, granisetron, dolasetron** - anti emetic effects.
- **Clonidine**: an adjunct for epidural infusions in pain management. Most useful in neuropathic pain.
- **Dexmedetomidine** is a parenteral selective a2-agonist with sedative properties.
- Selective activation of carotid chemoreceptors by low doses of **doxapram** stimulates hypoxic drive, producing an increase in tidal volume and a slight increase in respiratory rate.
- Patients are at risk if their gastric volume is greater than 25 mL (0.4 mL/kg) and their gastric pH is less than 2.5.

Post Anesthetic Muscular Complications

- **Catatonia**: Droperidol
- **Muscle spasm & Rigidity:** Fentanyl (opioids)
- **Fasciculation, Soreness and Ache:** Suxamethonium
- **Increased muscle tone:** Ketamine & Suxamethonium

IMPORTANT FACTS

- Post operative shivering: treated by pethidine/pentazocine.
- **Intravenous meperidine (25 mg) -** most effective opioid for decreasing shivering.
- Inhalational anesthetic that boils at room temperature: Desflurane
- Primary site of action of ketamine: Thalamoneocortical projection
- Abnormal spike discharges in epileptic patients: Methohexitone
- Steroid anesthetic: Althesin, Minaxolone

- Heid brink meter indicates: flow rate of gases
- Armoured ET tube: used in neurosurgery
- Aspiration of gastric contents: **Mendelson's syndrome**
- First reflex to appear during recovery from anesthesia: swallowing
- **5 % CO_2** is used for creating pneumoperitoneum during laparoscopy
- A mixture of 80% helium and 20% O_2 is used for tracheal obstruction.
- M/C complication in pediatric anesthesia: laryngospasm.
- M/C complication in adult patients under GA: **Dysarhythmias & Hypotension**
- **Neurolept analgesia:** Fentanyl + Droperidol
- Neurolept anesthesia: Fentanyl + Droperidol + 65% N_2O + 35% O_2

Baricity of Anesthetic Agents

- Higher the dosage or site of injection, the higher the level of anesthesia obtained.
- Migration of the drug in CSF depc.t.ius on its **specific gravity** relative to CSF (baricity).
- A hyperbaric solution is denser (heavier) than CSF, whereas a hypobaric solution is less dense (lighter) than CSF.
- Solutions can be made **hyperbaric by adding glucose or hypobaric by adding sterile water**.
- In head-down position, a hyperbaric solution spreads cephalad and a hypobaric anesthetic solution moves caudad; and vice-versa in head-up position
- Anesthetic agents are mixed with CSF (at least 1:1) to make their solutions isobaric.
- **Hyperbaric bupivacaine and tetracaine** are most commonly used agents for spinal anesthesia.
- **Both are relatively slow in onset (5-10 min) and have a prolonged duration (90-120 min).**
- **Hyperbaric spinal anesthesia is more commonly** used than the hypobaric or isobaric techniques.
- The level of anesthesia is dependent on the patient's position during and immediately following the injection.
- In the sitting position, **"saddle block"** can be achieved by keeping the patient sitting for 3-5 min following injection so that only the lower lumbar nerves and sacral nerves are blocked.

INTRAVENOUS REGIONAL ANESTHESIA (BIER'S BLOCK)

- It consists of injection of LA in a vein of a tourniquet occluded limb.
- **0.5% Lidocaine** is most commonly used in drug
- Mainly used for **upper limb orthopedic procedures** as it is most difficult to obstruct blood supply of lower limb.

SPINAL ANESTHESIA

- The principal **site of action** for neuraxial blockade is the **nerve root.**
- **Neuraxial anesthesia does not block the vagus nerve.**
- The drug is injected in **subarachnoid space (piamater and arachnoid membrane)**
- Injection **below L1 in adults** and **L3 in children** avoids trauma to the spinal cord.
- **Quincke needle** is a cutting needle with end injection.
- **Blunt tip** (pencil-point) needles decrease the incidence of postdural puncture headache.
- Heavily myelinated, small preganglionic sympathetic fibers and pain fibers are blocked first.
- Motor fibers are blocked last.
- The level of motor block is two to four dermatomes lower than the level of sensory anesthe
- Sequence of blockade autonomic → sensory → motor

Confirmation of spinal needle: **feel of two "pops".**

- The first is penetration of the ligamentum flavum
- The second is penetration of the dura-arachnoid membrane.

Factors Affecting the Level of Spinal Anesthesia

Most important factors	Other factors
• **Baricity** of anesthetic solution • Position of the patient during & • Immediately after injection • Drug dosage • Site of injection	• Age, Patient height, Pregnancy • Cerebrospinal fluid • Curvature of the spine • Drug volume • Intra -abdominal pressure • Needle direction

- MOA- Local anesthetic acts on spinal nerves and dorsal ganglia
- Unconsciousness, apnea, and hypotension resulting from high levels of spinal anesthesia are referred to as a **"high spinal" or "total spinal."**

- Complications of SAB:
  - **Hypotension –M/c complication of SAB**. Preventive measures are head low position to increase venous return, fluid preloading with RL, prophylactic vasopressor, oxygen supplementation
  - Bradycardia **–M/c arrhythmia**
  - Apnea
  - Cardiac arrest
  - Anaphylaxis
  - Nausea & Vomiting
  - **6th cranial nerve** is M/c nerve involved due to longest intracranial course.
  - **Transient neurological symptoms** (TNS), also called as transient radicular irritation
  - Post Dural puncture Headache (PDPH)

Post Dural Puncture Headache (PDPH)

- Presents **12-24hrs** after spinal block
- Usually occipital but can also be frontal
- **Increases on sitting** & relieved on lying down
- Lasts for 7-10 days but may be for 3 weeks
- Cause – Due to CSF leakage through dural rent
- Treatment:
  - Small size needle
  - Adequate hydration
  - Prone or supine position
  - Analgesic
  - Oral or I/V caffeine
  - **Autologous epidural blood patch (most effective):** stop further leakage of CSF by either mass effect or coagulation

Factors that may increase the incidence of Post–spinal Puncture Headache	
Age	Younger more frequent
Gender	Females > males
Needle size	Larger > smaller
Needle bevel	Less when the needle bevel is placed in the long axis of the neuraxis
Pregnancy	More when pregnant
Dural punctures (no.)	More with multiple punctures

Factors not increasing the incidence of Post–spinal Puncture Headache
Continuous spinals
Timing of ambulation

Contraindications to spinal anaesthesia

Absolute	**Relative**
• Raised intracranial pressure • Patient refusal • Shock: Hypotension and hypovolemia • Infants and children- control of level is difficult. • Bleeding disorders • Patient's on anticoagulants • Infection of the local site and • Septicemias • Vertebral abnormalities (kyphosis, lordosis, etc.)	• Aortic and mitral stenosis • MI • Heart block • Spinal deformities • Psychiatric and CNS disorders

- Bupivacaine: 0.5% in 8.25% dextrose, 0.5% plain
- Lidocaine: 2% plain, 5% in 7.5% dextrose
- Procaine: 10% plain, 2.5% in water
- Tetracaine: 0.5% in water, 0.5% in D5W

Parameter	Spinal Anesthesia	Epidural Anesthesia
Level performed	Lumbar	Any Level
Cost	Cheaper	Expensive
Onset of Effect	2- 3 minutes	15 – 20 minutes
Duration of Effect	Lesser	Prolonged
Quality of block	Total	Patchy
Post spinal head ache	Present	Absent
Epidural hematoma	Less common	More common
Total spinal	Rare	High chances
Intravascular injection	Rare	High chances
Drug toxicity	Less common	More common
Catheter complication	Absent	Present

EPIDURAL BLOCK

- Drug is injected in the epidural space **between the ligamentum flavum and the duramater.**
- The **standard (Tuohy needle, directional needle)** epidural needle has a blunt bevel with a gentle curve of 15-30° at the tip.
- Straight needles without a curved tip (**Crawford needles**): higher incidence of dural puncture but facilitate passage of an epidural catheter.
- Methods to locate epidural space (negative pressure test)
  - Hanging drop technique
  - Loss of resistance (**preferred**)
  - Macintosh extradural space indicator
- **Indications for Epidural Anesthesia:**
  - Mainly used for controlling post – operative pain & Chronic cancer pain
  - Painless labor
  - Can be used for all surgeries done by spinal anesthesia
- **Advantages of epidural anaesthesia**
  - Less hypotension
  - No postspinal headache
  - Level of block can be extended
  - Any duration of surgery can be performed

CAUDAL BLOCK (EPIDURAL SACRAL BLOCK)

- Sacral epidural anesthesia is referred to as a caudal block.
- Drug **penetrates the sacrococcygeal ligament** covering the sacral hiatus that is created by the **unfused S4 and S5 laminae.**
- Also employed for labor and postoperative analgesia.
- Mainly used in **children for perineal and genitourinary surgery**.
- Within the sacral canal, the anesthesia bathes the S2–S4 spinal nerve roots, including the pain fibers from the uterine cervix and superior vagina, and the afferent fibers from the pudendal nerve.
- The entire birth canal, pelvic floor, and majority of the perineum are anesthetized
- Lower limbs are not usually affected.
- The pain fibers from the uterine body (superior to the pelvic pain line) ascend to the inferior thoracic-superior lumbar levels; these and the fibers superior to them are not affected by the anesthetic, so the mother is aware of her uterine contractions.
- With epidural anesthesia, no " spinal headache" occurs because the vertebral epidural space is not continuous with the cranial extradural (epidural) space

- Peripheral nerve block that provides local anesthesia over the **S2-S4 dermatomes.**
- **Blocks the majority of the perineum and the inferior quarter of the vagina.**
- Does not block pain from the superior birth canal (uterine cervix and superior vagina), so the mother is able to feel uterine contractions.

INFILTRATION ANESTHESIA

- Lidocaine (0.5-1%), procaine (0.5-1%), and bupivacaine (0.125-0.25%).
- When used without epinephrine, up to 4.5 mg/kg of lidocaine, 7 mg/kg of procaine, or 2 mg/kg of bupivacaine can be employed in adults.
- When epinephrine is added, these amounts can be increased by one-third.

CERVICOTHORACIC (STELLATE) BLOCK

- Used in patients with head, neck, arm and upper chest pain.
- The paratracheal technique is most commonly used.
- **Confirmation of block: increase in the skin temperature** of the **ipsilateral arm** and the **onset of Horner's syndrome.**
- **Complications:** hematoma, pneumothorax, epidural anesthesia, brachial plexus block, hoarseness due to blockade of the RLN and rarely, osteitis or mediastinitis following esophageal puncture.

Advantages of post operative analgesics:

- Patient comfort
- Increase mobility
- Fewer pulmonary and cardiac complications
- Reduced risk of DVT
- Less likelihood of developing neuropathic pain
- reduced cost of care

PATTERNS OF REFERRED PAIN

Location	Cutaneous Dermatome
Central diaphragm	C4
Lungs	T2—T6
Heart	T1—T4
Aorta	T1—L2
Esophagus	T3-18
Pancreas and spleen	T5—T10
Stomach, liver and gallbladder	T6—T9
Adrenals	T8—L1
Small intestine	T9—T11
Colon	T10—L1
Kidney, ovaries, and testes	T10—L1
Ureters	T10—T12
Uterus	T11—L2
Bladder and prostate	S2—S4
Urethra and rectum	S2—S4

Jannetta procedure: Microsurgical decompression of the trigeminal nerve for **trigeminal neuralgia** (tic douloureux).

Average Blood Volumes

Age	Blood Volume
Neonates	
Premature	95 mL/kg
Full-term	85 mL/kg
Infants	80 mL/kg
Adults	
Men	75 mL/kg
Women	65 mL/kg

Characteristics of Neonates and Infants that differentiate them from Adult Patients

Physiological	Anatomical
• Heart-rate-dependent cardiac output • Faster heart rate • Lower blood pressure • Faster respiratory rate • Lower lung compliance • Greater chest wall compliance • Lower functional residual capacity • Higher ratio of body surface area to body weight • Higher total body water content	• Noncompliant left ventricle • Residual fetal circulation • Difficult venous and arterial cannulation • Large head and tongue • Narrow nasal passages • Anterior and cephalad larynx • Long epiglottis • Short trachea and neck • Prominent adenoids and tonsils • Weak intercostal and diaphragmatic muscles • High resistance to airflow
Pharmacological	
• Immature hepatic biotransformation • Decreased protein binding • Rapid rise in FA/FI (Fractional alveolar concentration/fractional inspired concentration) • Rapid induction and recovery • Increased minimum alveolar concentration • Larger volume of distribution for water-soluble drugs • Immature neuromuscular junction	

Anatomical dead space is increased by	Anatomical dead space is decreased by	Alveolar dead space is increased by
• Old age • Neck extension • Jaw protrusion • Bronchodilators (Atropine) • Halothane • Increased lung volume • Anesthesia mask & Circuits • IPPV • PEEP	• Intubation • Tracheostomy • Hyperventilation • Neck flexion • Bronchoconstrictors • Massive pleural effusion	• IPPV • PEEP • General anesthesia • Hypotension • Lung pathologies affecting diffusion like interstitial lung disease, Pulmonary embolism, pulmonary edema, ARDS

Physiological dead space is decreased by

- Supine posture
- Neck flexion
- Bronchoconstrictor

- Artificial airway (Eg: intubation, tracheostomy).

❖ Induction of anesthesia consistently produces 15-20% reduction in FRC (400m1 in most patients).
❖ M/C cause of airway obstruction in unconscious patients - **tongue falling back** against posterior pharynx.

FLUID MANAGEMENT & TRANSFUSION

CRYSTALLOIDS	COLLOIDS
• **RL** (slightly hypotonic) • **NS & 5% Dextrose** (isotonic) • DNS & Hypertonic saline (Hypertonic) • Intravascular half life – 30 mins. Expands plasma volume for less time • For replacing blood loss **3 times** the lost fluid should be given	• **Albumin, Gelatin, Dextran, Hydroxyethyl starch, blood –** Hypertonic • Expands plasma volume for 2 - 4 hours • **Given in 1:1 ratio**

- **NS** – preferred over RL for **hypochloremic metabolic alkalosis, brain injury** (as calcium ions increase neuronal injury), **hyponatremia, to maintain BP in hypovolemia**
- **DNS** – best used maintenance fluid **intraoperatively**
- **Hypertonic saline** – hyponatremia, **cerebral and pulmonary edema**
- **Dextran** – LMW dextran improves microcirculation; can interfere with blood grouping and cross matching
- **Blood** - the ideal fluid to be used in hemorrhagic shock.

Composition of Crystalloid Solutions

Solution	Tonicity (mOsm/L)	Na^+ (mEq/L)	Cl^- (mEq/L)	K^+ (mEq/L)	Ca^{2+} (mEq/L)	Glucose (g/L)
5% dextrose in water (D_5W)	Hypo (253)					50
Normal saline (NS)	Iso (308)	154	154			
$D_5$1/4 NS	Iso (355)	38.5	38.5			50
$D_5$1/2 NS	Hyper (432)	77	77			50
D_5NS	Hyper (586)	154	154			50
Lactated Ringer's (RL)	Iso (273)	130	109	4	3	
D_5LR	Hyper (525)	130	109	4	3	50
1/2NS	Hypo (154)	77	77			

INTRAOPERATIVE FLUID THERAPY

- Fluid loss due to starvation: **2mL/kg/hr**
- Maintenance fluid: **2mL/kg/hr**
- Third space losses – fluid accumulation in the tissues in the form of edema
  - **4mL/kg/hr** – for surgeries with minimum dissection. e.g: Herniorrhaphy
  - **6mL/kg/hr** – moderate dissection. e.g: **Gastrojejunostomy and vagotomy**
  - **8mL/kg/hr** – heavy dissection.e.g: **Whipple's procedure**
- Blood loss to be replaced by compatible blood transfusion, when the hematocrit falls below **25%**

OBSTETRIC ANESTHESIA

- **Ephedrine: vasopressor of choice** for hypotension during pregnancy
- a-adrenergic agonists (**phenylephrine** and metaraminol) - less **fetal acidosis** than ephedrine.

- The greatest strain on the parturient heart occurs immediately after delivery (Increase in cardiac output as much as 80% above prelabor values)
- Caesarean section in CVS disease complicating pregnancy - mainly done for obstetric indications
- In coarctation of aorta, elective CS - to prevent rupture of the aorta or mycotic cerebral aneurysm.
- Needle for epidural block: **Tuohy's needle.**
- Average blood loss during vaginal delivery is 400-500 mL (800-1000 mL in cesarean section)
- Blood volume does not return to normal until 1-2 weeks after delivery.

Induction in Pediatric patients

Inhalation	Intravenous	Intramuscular
Single Breath induction **Sevoflurane in N_2O** for rapid induction Classical method N_2O & O_2 & Sevoflurane / halothane is added	Rapid acting **barbiturate or Propofol** followed by non **depolarizing muscle relaxant** (eg; rocuronium, atracurium, mivacurium) or Succinyl choline	**IM Ketamine** –combat children

CONTROLLED HYPOTENSION

- Elective lowering of arterial blood pressure.
- Maintaining the mean arterial pressure at the level of 50-65 mmHg.
- Reduction in baseline MAP by 30%.
- Advantages: minimization of surgical blood loss and better surgical visualization
- **Methods:**
  - Positioning: elevation of the surgical site → blood pressure at the wound is selectively reduced
  - Positive-pressure ventilation
  - **Ganglion blockers: Trimethaphan** is the drug of choice.
  - Due to their rapid onset and short duration of action, **sodium nitroprusside** and **nitroglycerin** have the advantage of precise control.
  - Creation of a high sympathetic block with an epidural or spinal anesthetic.
  - Hypotensive anesthetics like **propofol** can be used clinically
- **Indications:** cerebral aneurysm repair, brain tumor resection, total hip arthroplasty, radical neck dissection, radical cystectomy and other operations associated with significant blood loss.
- **Contraindications:** Severe anemia, hypovolemia, atherosclerotic cardiovascular disease, renal or hepatic insufficiency, cerebrovascular disease, or uncontrolled glaucoma.

CARDIOPULMONARY RESUSCITATION

THE 2010 AHA GUIDELINES FOR CPR

- Recommend a **change** in the BLS sequence of steps **from A-B-C (Airway, Breathing, Chest compressions) to C-A-B (Chest compressions, Airway, Breathing)** for adults, children, and infants **(excluding the newly born).**
- **Continuous quantitative waveform capnography is recommended** for confirmation and monitoring of endotracheal tube placement.
- **Atropine is no longer recommended** for routine use in the management of pulseless electrical activity (PEA)/asystole.
- Increased emphasis on **physiologic monitoring** to optimize CPR quality.
- **Adenosine is recommended as a safe and potentially effective therapy** in the initial management of stable undifferentiated regular monomorphic wide-complex tachycardia.

New Recommendations

- **Hands Only CPR.**
- **CPR is the only treatment for sudden cardiac arrest.**
- **Don't stop pushing**. Every interruption in chest compressions interrupts blood flow to the brain, which leads to brain death if the blood flow stops too long.
- **Defibrillation** using **biphasic** electrical current works best.
- Bretylium is no longer recommended.
- **Glucose & calcium solutions are to be avoided → hypercalcemia & hyperglycemia results in neuronal damage.**
- Vasopressin has been added and amiodarone has gained new emphasis in these newest guidelines.

CHEST COMPRESSION

- At least **100 compressions per minute** (30 compressions in 18 seconds)
- **Chest compression to ventilation ratio is 30:2**
- Sufficient force is applied to **depress the sternum 4-5 cm (1 $_{1/2}$ to 2 inches)**
- In newborns, the depth of chest compressions should be **one third of the AP diameter** of the chest.
- Allow complete recoil of chest
- Switching rescuers every 2 mins

	< 2 months	**Infants & children**		**Adult**
Compression	90/min	100/min	100/min	>100/min
Compression ventilation ratio	2 Rescuer: 3:1	Single rescuer: 30:2	Two rescuer: 15:2	**30:2**

High quality CPR:

- Minimize interruptions during compressions
- Avoid hyperventilations
- Higher the CPR - Better the survival
- Not > 10 secs for pulse check
- EtCO2 <10 mm Hg - No ROSC
- EtCO2 <20 mm Hg – Inefficient compression
- Tidal volume 500-600 ml

❖ In CPR, breaths are delivered slowly with a smaller tidal volume of 700-1000m1, smaller (400-600m1) if supplemental 0 2 is used.

❖ A rescuer's exhaled air has an oxygen concentration of only 16-17% and contains significant CO_2

❖ Cricoid pressure **(Sellick's maneuver)** decreases the possibility of regurgitation and aspiration during intubation.

Cardiac Massage :

- Adults: Compressions over **lower third of sternum** (2 fingers above xiphoid process)
- Children: Two thumbs technique for compressions
- Newborns: Two thumbs with encircled chest technique for compressions.
- Pregnant: External cardiac massage with lateral tilt..

Airway management

- **Laryngoscope:**
  - The most commonly used laryngoscope is **Macintosh** which has curved blades.
  - Position of head and neck during laryngoscopy is "Extension at atlanto occipital joint 7585 degrees and flexion at cervical spine 15-25 degrees – **Magill position"**
  - **Complication – MC injury during laryngoscopy is damage to upper incisors**

- **Endotracheal tubes:**
  - **Increases dead space in adult** (by 70mL)
  - **Decreases dead space in children**.
  - In small children **< 10 years uncuffed tube** should be used but with the advent of newer cuffs, cuffed tubes can be used even for children.

Size of endotracheal tubes:

Premature baby	2.5 mm
0 -6 Months	3 to 3.5 mm
6 Months –1 Year	3.5 to 4 mm
Children < 6 Year	$\frac{\text{Age in years}}{3}$ + 3.5 mm
> 6 years – 15 year	$\frac{\text{Age in Years}}{4}$ + 4.5 mm
Adult females	7.5 to 8 no.
Adult males	8.5 to 9 no.

- **Reflex response to intubation –** tachycardia, hypertension, laryngospasm, ↑ICT, ↑ Cortisol and catecholamines
- Methods to inhibit reflex response – xylocaine spray, xylocard injection, opioids, Ca Channel blockers
- **RAE tube** – used for oral and dental surgeries like cleft lip and cleft palate
- **Robert Shaw and Carlen tube**
  - **Used for thoracic surgeries** or single lung ventilation.
  - To prevent spillage of pus and malignant cells during bronchopleural lavage
  - The major side effect is hypoxia due to malposition and ventilation perfusion mismatch.
  - Confirmation is done by bronchoscopy.

Indications for Nasal intubation	Contraindications of nasal intubation	Contraindications for both oral and nasal intubation
• Oral surgeries • Fracture of Mandible • Awake intubation • Prolonged intubation	• Basal skull fractures • CSF Rhinorrhea • Nasal mass • Adenoids • Any coagulopathies	• Laryngeal edema • Epiglottitis • Laryngeo – tracheo bronchitis - In such pt's tracheostomy is preferred

Advantages of nasal over oral intubation	Blind nasal intubation is done in
• Better fixation • Less chances of extubation • Better tolerated	• Temporo – mandibular joint ankylosis • Christmas or locked jaw • Neck contractures

Breathing / Ventilation :

- Mouth to Mouth
- Mouth to airway – Safar or Brook airway
- Bag and mask – **Increases aspiration, increases dead space, exhaustive**
- Advanced methods – Endotracheal tube (Best method), LMA, Combitube, Tracheostomy tube
- Automatic ventilators

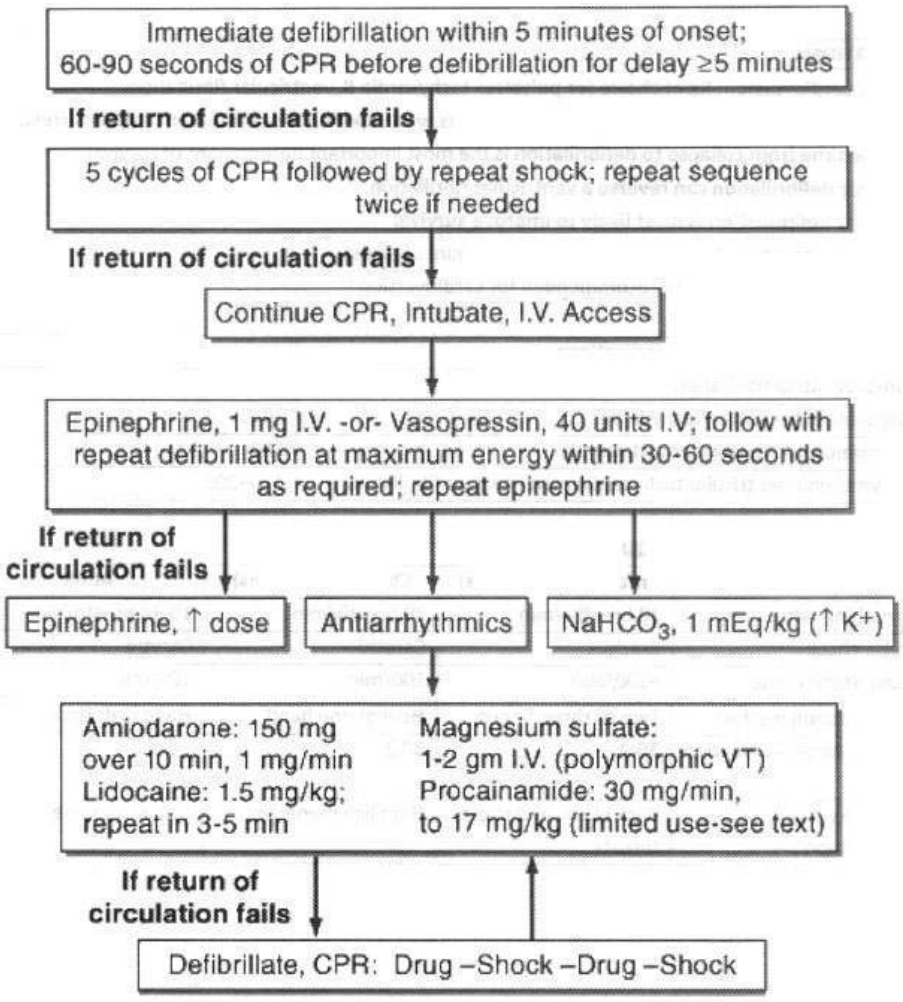
Contra-Indications for Bag and Mask Ventilation :

- Full stomach
- Aspiration Risk (Pregnancy, Hiatus Hernia)
- Intestinal Obstruction
- Unconscious / Semiconscious patients
- Diaphragmatic Hernia
- Tracheo – Esophageal fistula
- Meconium aspiration

Monitoring of CPR

- **Capnography – Most reliable, best indicator**
- Palpation of Carotid pulse – Most effective clinical indicator
- Invasive blood pressure
- Central venous oxygen saturation

VENTRICULAR FIBRILLATION OR PULSELESS VENTRICULAR TACHYCARDIA



Complications of CPR

- Rib fracture
- Pneumothorax, pneumomediastinum, pneumopericardium
- Injury to diaphragm, stomach, lungs, major vessels, abdominal organs.

Drugs Used in CPR

- Vasopressors - Adrenaline, Noradrenaline
- Inotropes - Dopamine, Dobutamine
- Beta Blockers
- Anticholinergics
- Vasodilators
- Anti-arrhythmics

Drugs Contraindicated in CPR :-

- **Calcium –** only indications: Hypocalcemia, Hyperkalemia
- **Sodium bicarbonate –** only indications: metabolic acidosis, Hyperkalemia

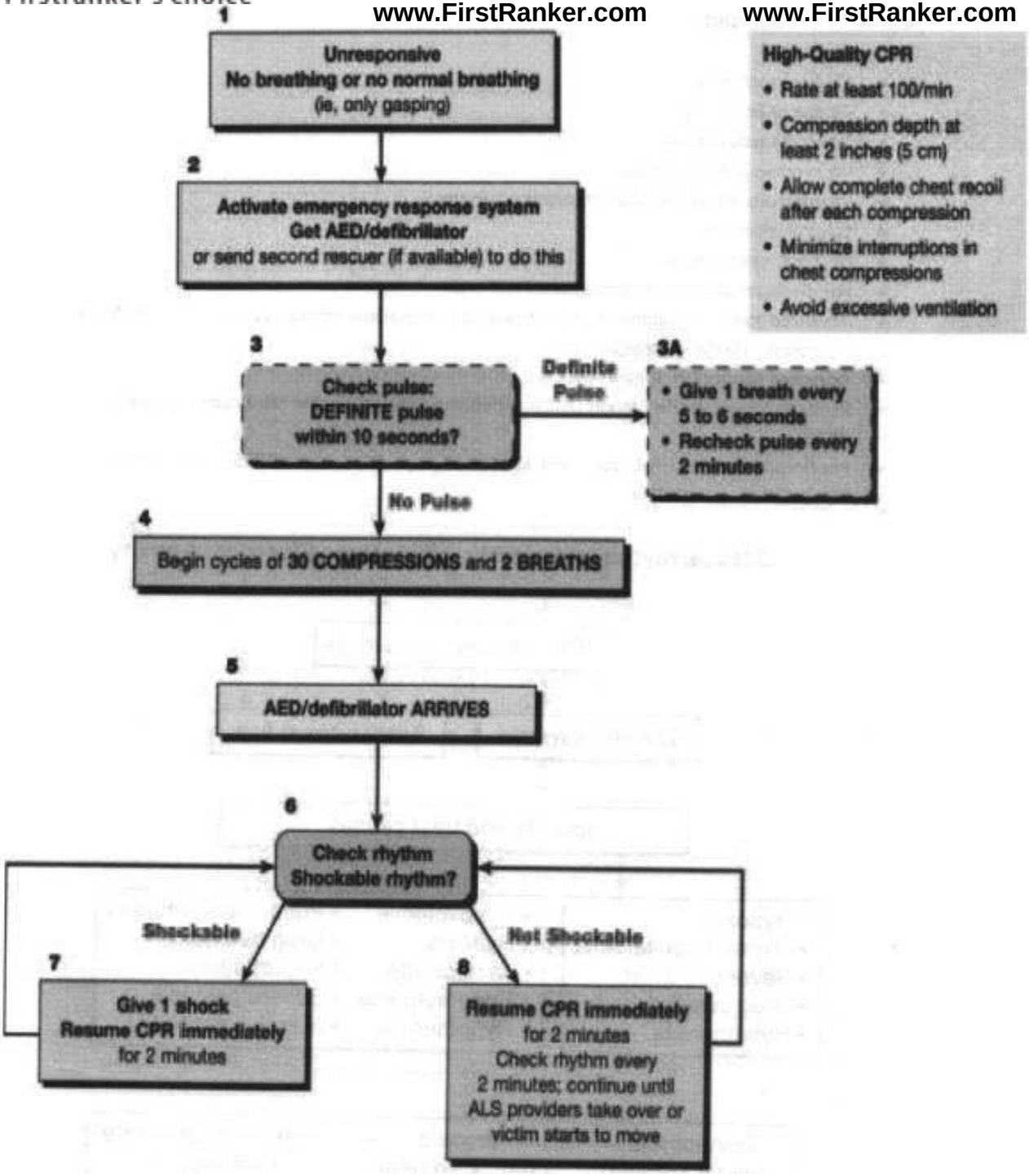
DEFIBRILLATION

- **DC cardioversion: Rx of choice for pulseless tachycardia & ventricular fibrillation.**
- **Ventricular fibrillation** - most common in adults who experience nontraumatic cardiac arrest.
- The **time from collapse to defibrillation** is the most important determinant of survival.
- **Only defibrillation can reverse a ventricular fibrillation.**
- **Early defibrillation is most likely to improve survival**
- Shock should be **delivered within 3 min** (± 1 min) of arrest.
- **Biphasic** waveforms are recommended for cardioversion.

Indications	**Shocks (J)**
Unstable atrial fibrillation	50-100
Unstable atrial flutter/tachycardia	30-50
Monomorphic ventricular tachycardia	100
Polymorphic ventricular tachycardia or ventricular fibrillation	120-200

BASIC LIFE SUPPORT TECHNIQUES

	Infant (1-12 months)	**Child (>12 months)**	**Adult**
Breathing rate	20 breaths/min	20 breath/min	10-12 breath/min"
Pulse check	Brachial	Carotid	Carotid
Compression rate	>100/min	100/min	100/min
Compression method	Two or three fingers	Heel of one hand	Hands interlaced
Compression/ventilation ratio	30:2	30:2	30:2
Foreign body obstruction	Back blows and chest thrusts	Heimlich maneuver	Heimlich maneuver

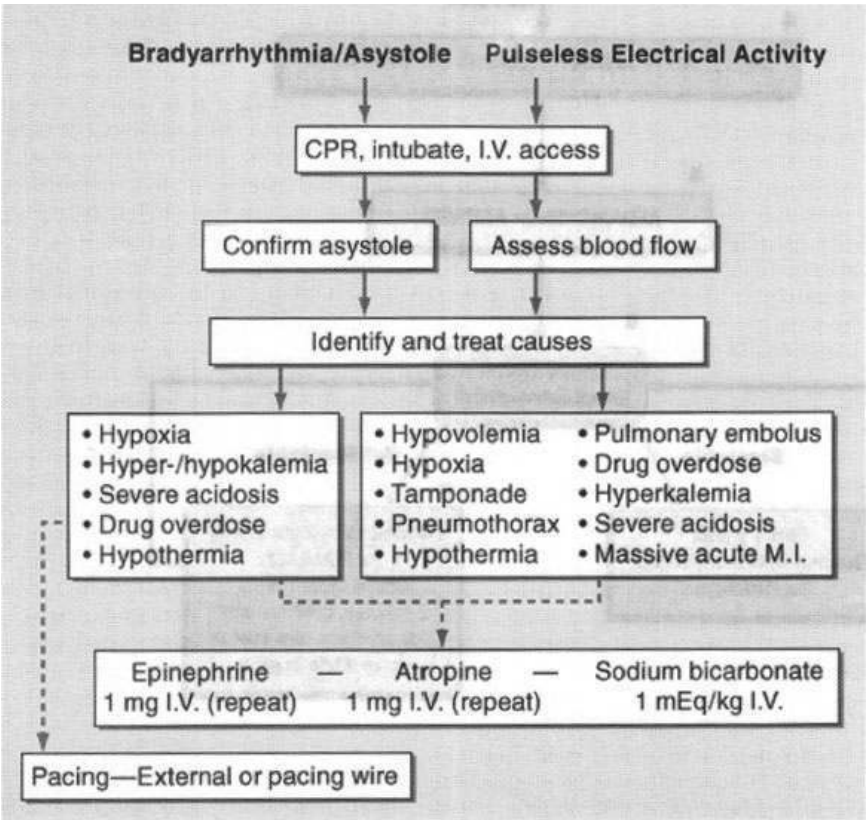


ADVANCED LIFE SUPPORT

Components of ALS

- Cardiac monitoring
- Cardiac defibrillation
- Transcutaneous pacing
- Intravenous cannulation (IV)
- Intraosseous (10) accPss and intraosseous infusion
- Surgical cricothyrotomy
- Needle cricothyrotomy
- Needle decompression of tension pneumothorax
- Advanced medication administration through parenteral and enteral routes (IV, 10, PO, PR, ET,

- SL, topical, and transdermal)
- Advanced Cardiac Life Support (AILS)
- Pediatric Advanced Life Support (PALS) or Pediatric Emergencies for Pre-Hospital Providers
- (PEPP)
- Pre-Hospital Trauma Life Support (PHTLS), Basic Trauma Life Support (BTLS) or International
- Trauma Life Support (ITLS)



Forms of potentially reversible causes for cardiac arrest, commonly abbreviated as "6Hs & 5Ts"	
Hs	**Ts**
• Hypoxia: • Hypovolemia: • Hyperkalemia or hypokalemia • Hypothermia/Hyperthermia • Hydrogen ions (Acidosis) • Hypoglycemia:	• Tension pneumothorax • Tamponade • Toxic and/or Therapeutic • Thromboembolism and related • mechanical obstruction

INVASIVE RESPIRATORY SUPPORT	
Intermittent positive-pressure ventilation (IPPV)	May be given with positive end-expiratory pressure (PEEP)
Continuous positive airway pressure (CPAP)	Given via endotracheal tube
Synchronized intermittent mandatory ventilation (SIMV) (volume or pressure controlled)	May be given with pressure support and CPAP
Pressure support ventilation (PSV)	Usually given with CPAP
'Lung-protective' ventilatory strategies to minimize ventilator-associated lung injury	Low tidal volume, reduced airway pressures. Used with SIMV, PEEP and prolonged inspiratory phase
High-frequency jet ventilation (HFJV)	May be useful in those with lung leak (e.g. bronchopleural fistula)

Extracorporeal techniques	Salvage therapy for severe acute respiratory failure
NON-INVASIVE RESPIRATORY SUPPORT	
Continuous positive airway pressure (CPAP)	Inspiratory and expiratory pressures the same
Non-invasive positive support ventilation	± CPAP
Bilevel positive airway pressure (BiPAP)	Inspiratory and expiratory pressures set separately

WEANING METHODS:

- The most useful weaning parameters are
  - **Arterial blood gas tensions**
  - **Respiratory rate**
  - **Rapid shallow breathing index (RSBI).**
- The most common techniques to wean a patient from the ventilator include
  - SIMV
  - Pressure support
  - Periods of spontaneous breathing alone on a T- Piece or on low levels of CPAP.
  - Noninvasive positive-pressure ventilation
- The traditional method is to allow the patient to breathe entirely spontaneously for a short time, following which respiratory support is reinstituted.

MANAGEMENT OF PRE EXISTING DRUG THERAPIES DURING ANAESTHESIA

Oral Hypoglycemic Drugs	Omit morning dose in case of minor surgery For major surgeries: shift to Insulin 48 hrs before surgery
OCP's	**Stop** 4 weeks before to decrease thromboembolism
Oral Anti-coagulants	**Stop 4 days ahead of surgery & shift to LMW heparins. Heparin should be stopped** one day before surgery. In case of emergency Vit K is given if at least 6 hrs are available. If the surgery is to be performed immediately fresh frozen plasma is to be given.
Unfractionated heparin	stop 6 hrs before surgery
LMWH	stop 12 hrs before surgery
Anti hypertensive drugs	**Should be continued**. For ACE inhibitors and ARBS's morning dose is withheld
Anti Anginal Drugs Antithyroid Drugs, Anti Epileptic Drugs Levodopa Anticholinesterases	**Should be continued** and even morning dose is given.
Antiplatelet Drugs	Clopidogrel- stop 1 week before surgery. In emergency platelet transfusion should be given prior to surgery. Aspirin can be continued on the day of surgery.
Lithium	Should be stopped 48 -72 Hrs before.
Smoking	Should be ideally stopped 6-8 weeks before (complete **ciliary recovery)**
Antitubercular Drugs	Should be continued with monitoring of liver function test
Aminoglycosides	Has neuromuscular blocking activity so it is shift to another antibiotic 48 hrs prior to surgery

Fasting guidelines before surgical procedures

Adults	**Children**
• Clear fluids – 2 hours • Semisolids – 4 hours • Solid foods – 6hours	• Clear fluids – 2 hours • Breast milk – 4 hours • Formula milk, solid foods – 6 hours

Pulmonary artery catheterization (with coagulopathy)	**External jugular vein**
Hemodialysis **Plasmapheresis** **Preoperative preparation** **Fluid management of ARDS (CVP monitoring)**	**Internal jugular vein**
Pulmonary artery catheterization [with pulmonary compromise or high-level positive end-expiratory pressure (PEEP)] **Emergency transvenous pacemaker**	**Right internal jugular vein**
Total parenteral nutrition (TPN) **Hypovolemia,** inability to perform peripheral catheterization **General purpose venous access, vasoactive agents, caustic medications, radiologic procedures**	**Subclavian vein**
Cardiopulmonary arrest **Hypovolemia,** inability to perform peripheral catheterization **Emergency airway management** **Inability to lie supine** **Central venous oxygen satuation monitoring**	**Femoral vein**

*****END*****