Structured Notes According to

ANAESTHESIA

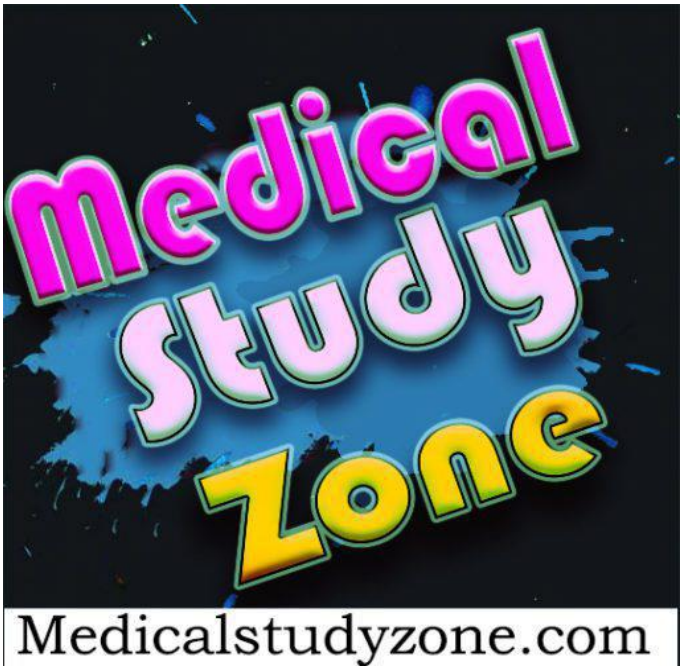
Revision friendly **Fully Colored Book/Structured Notes**

For Best results, watch the video lectures along with reading notes

© Dr. Swati Singh (Author)

For best result you are advised to study these books/structured notes along with Dr. Swati Singh's videos on PrepLadder app. For maximum gain, revision of these books/structured note/books multiple times.

In case of any discrepancy between book and videos, Dr. Swati Singh's videos on PrepLadder should be considered.



CONTENTS

ANAESTHESIA

LIST OF IMPORTANT TOPICS

PHARMACOLOGY OF ANESTHESIA

1. Inhalational Anesthetic Agents
2. Intravenous Anesthetic Agents
3. Neuromuscular Blocking Agents
4. Local Anesthetics

EQUIPMENT PART OF ANESTHESIA

5. Airway Management devise - Endotracheal tube , Larygeal Mask Airway
6. Anesthesia Circuits - Mapelson circuit and circle system
7. Anesthesia Machine

TECHNIQUES

8. Introduction of Anesthesia and conduit of general Anesthesia
9. Central Neuraxial Blockade

MISCELLANEOUS TOPICS

10. Perioperative fluid
11. Modes of Ventilation
12. Oxygen therapy

CONCEPTUAL TOPICS

13. Cardiopulmonary cerebral resuscitation
14. Difficult airway algorithm

LEARNING OBJECTIVES

- Anesthesia has a very rich, interesting history, will learn history, some important names and different stages of anesthesia
- Anesthesia is broadly classified into General and Regional . Will get introduced with general and regional anesthesia
- Before giving any sort of anesthesia to any patient, always do pre-anesthestic evaluation
- Whether giving general or regional anesthesia, there are few standard monitors which needs to be attached to every patient and there are few special monitor which needs to attach on special circumstances
- For giving general anesthesia, need an anesthesia machine, which will be discussed in brief
- Anesthesia machine is connected to the patient for giving different gases to the patient through something called Anesthesia Circuit
- There are various type of circuit, which will be discussed in brief
- In general anesthesia, patient is unconscious and paralyzed , need to protect a natural airway of the patient against aspiration or need airway in place not only to protect from aspiration but also needs for mechanical ventilation
- The airway used to insert in the natural airway of the patient, is called artificial or advanced airway
- The drugs used in anesthesia like inhalational , intravenous anesthetic agents will be discussed
- Neuromuscular blockers are the drugs which are used to paralyze the patient during general anesthesia
- Different drugs, pharmacokinetics , pharmacodynamics and clinical aspects will be discussed
- Under regional anesthesia falls local anesthetics (LA). LA are drugs which are used in regional anesthesia, whether it is peripheral nerve block or central neuraxial blockade
- LA are those drugs which are inserted locally near the nerve fiber, which needs to be blocked
- Fluids used during anesthesia, which circumstances and their importance will be discussed
- In cardiopulmonary cerebral resuscitation (CPCR) will discuss basic cardiac life support and advanced cardiac life support
- There are few scoring system developed to discharge patient either from post postoperative care unit to a level II care unit or from ambulatory care unit, to discharge patient to home
- Follow post operative care and discharge scoring

- If oxygen needs to be given, the devices need to attach to patient during post op or in ICU
- Devices need to use in oxygen therapy
- Discuss how to diagnose brain death

1 HISTORY OF ANESTHESIA

00:15:59

- **17th century:** Joseph Priestley separated nitrous oxide and oxygen
- **Humphrey Davy:** Discovered laughing gas potential of nitrous oxide
- **1844:** Dr. Horace Wells (Dentist) - discovered the analgesic property of nitrous oxide. But he failed to demonstrate the anesthetic effect. Inspite of having anesthetic potential, anesthetic property, analgesic property, it is not complete anesthetic agent
  - It cannot provide complete unconsciousness to the patient during surgery
  - It can act as adjuvant analgesic but cannot take away surgical pain completely

Dr. Horace Wells

Important Information

- In 1845 nitrous oxide was given straight but it was a failure

- **1846:** Dr. WTG Morton (dentist) made similar announcement that he has discovered a gas which will take away the pain and awareness of the patient during surgery
  - He used to use Ether during tooth extraction and which used to provide very good analgesia and for few minutes during tooth extraction patient was not aware of the procedure. So, he thought he can use during bigger surgeries as well
- **On 16th October 1846:** In Massachusetts general hospital Boston, he demonstrates anesthesia through Ether and on this day the demonstration was successful. The patient was comfortable under Ether anesthesia with no complaint of pain
- **On 16 October:** We celebrate World Anesthesia Day or World Ether Day

- This figure shows first demonstration of Ether. Patient was lying, WTG Morton on the head end of the patient, surgeon was standing beside patient and WTG Morton was ready with his Ether anesthesia

Dr. WTG Morton

Important Information

- Dr. WTG Morton was the first successful person to demonstrate Ether anesthesia. He made Ether anesthesia popular. On 16 Oct we celebrate world anesthesia day or World Ether Day

- There is a controversy in Father of Anesthesia. It was said that since Dr. Horace Wells was the first person to say something about anesthesia, so he should be considered the Father of Anesthesia

- Few people say that Dr. WTG Morton, demonstrates first successful anesthesia so he should be considered as Father of Anesthesia. So, there are several fathers of anesthesia
- **1847:** An obstetrician JJ Simpson introduced gas called Chloroform
  - He used it during normal delivery and cesarean section of patient
  - He used Chloroform to take away the labor pain of patient. He used in few of his patient but Chloroform was made popular by Dr. John Snow

- **Dr. John Snow:** Also called Father of Epidemiology because he described the cholera epidemiology
  - He was one of the Fathers of Anesthesia and was the first practicing anesthetic. He made Chloroform popular. After Ether next gas became popular was Chloroform and Chloroform was very popular when it came in use because it took away 2 major problem of the Ether
    - → It took away the bad smell of the Ether. Ether had very bad smell but Chloroform has very good smell
    - → Ether was slow in providing anesthesia, it was a slow agent but Chloroform was very fast agent
- It took over the Ether but the problem with Chloroform was that it causes ventricular arrhythmia in any patient,
- Lot of deaths were seen and other problem with Chloroform was that single use of Chloroform cause hepatotoxicity
- Later on, the use of Chloroform got restricted and Ether became to be known as safe anesthetic agent
- **Dr. John Snow** practicing anesthetic was using Chloroform. He made it popular because he gave it to the Queen of England (Queen Victoria) during her childbirth and took away the pain. So, the Queen made this very popular

Important Information

- **Dr. John Snow gave Chloroform to the Queen of Victoria during her childbirth and took away the pain so Queen made it popular**

- When anesthetic were making the patient unconscious, the airway of the patient was being compromised and sometimes the ventilation of patient were also being compromised
- They needed something called an airway, to secure for the securement of the natural airway of the patient, to ventilate the patient and also to prevent any aspiration during general anesthesia

- **1878**: Macewan (surgeon) did the first elective oral intubation under general anesthesia. He was a Glasgow surgeon
- **1885**: Dr. Joseph O' Dwyer, intubated Pediatric patients by metallic tubing during polio epidemic
- Dr. Ivan Magill did 1st blind Nasal Intubation
  - **1920:** He designed first Mapleson A circuit also called Magill circuit
- Dr. Arthur Guedel introduced cuff in endotracheal tube
- **1913:** Dr. Chevalier Jackson was the first person who introduced Laryngoscope which did not had the light source proximal (the part introduced in the oral cavity) but had lights on the distal part of Laryngoscope
- It did not give a very good vision. This Laryngoscope was modified by Magill, Miller and Macintosh
- **1943:** Dr. Macintosh introduced the curved blade Laryngoscope
- Now there was a need of device which would give gaseous to the patient so that patient continuously remains unconscious during surgery.
- **1914:** Gwathmey gave the concept of anesthesia machine
- **1917:** Dr Edmund Gaskin Boyle gave a basic design of machine and Boyle's machine was popularized and modern anesthesia machine is also based on the design of this Boyle's machine
- **1920:** Dr. Ivan Magill discovered Mapleson A circuit / Magill circuit
- **1930:** Circle system was introduced and it was attached to the Boyle's machine
  - **Circle system**: Was the circuit with a carbon dioxide absorbable
  - The inhalational anesthetic agents recycle and the wastage was being prevented
- **1930**
  - Circle system being attached to Boyle's machine
  - Continuous inhalational agents were given to the patient
  - Respiratory gases were also recycled
- One major problem with inhalational agent induction was that patient was not very comfortable.
- Ether was slow, Chloroform though fast but risky. So needed fast induction for inhalation, so that the patient discomfort would be less
- **1934**: Dr. John Lundy introduced Thiopentone which was an IV anesthetic agent that produces a very fast induction (unconsciousness)
  - It was the first IV anesthetic
  - **Dr Lundy** used it for induction and later on he maintained anesthesia with Ether
  - He came with the concept of Balanced Anesthesia which we are practicing even today

Important Information

- **Balanced Anesthesia: multiple drug in a titrated way with the different component of general anesthesia**

- **1943:** Dr. Harold Griffith introduced: 1st neuromuscular blocker - D tubocurarine
  - Tubocurare is the extract of curare plant
  - Dr Griffith noticed that tribal people use bow and arrow to kill victim. Their arrow is coated with extract of curare plant, which when reaches in the blood of victim, the victim gets paralyzed, and he dies by hypoxia
  - When he noticed he thought that this extract which they are using to produce immobilization and paralysis can be use in surgery to provide immobilization and paralysis
  - It was a first natural neuromuscular blocker
- After Ether and Chloroform the third important inhalational agent was Halothane
- **1950**: Halothane was introduced which was a halogenated alkane. Halothane became very popular but the problem was that it causes hepatotoxicity. So, need a safer inhalational anesthetic agent
- **1965**: Stevens introduced Ketamine (IV) anesthetic agent
- **1970**: Isoflurane was introduced
- **1977**: Propofol was introduced. Most popular (IV) anesthetic agent used now a days. Brought the concept of day care surgery
- **1990**: Desflurane & Sevoflurane was introduced

Previous Year's Questions

Q. Which of the following is used for daycare surgery? (FMGE Jun 2019)

A. Ketamine
B. Thiopentone
C. Propofol
D. Etomidate

REGIONAL ANESTHESIA

00:50:49

- **1884**: Dr. Karl Kohler introduced 1st local anesthetic Cocaine. Cocaine is coca plant extract
  - Dr. Karl Kohler was a friend with Sigmond who used this Cocaine in psychiatry patients and once by accidentally they discovered that when this Cocaine extract fell on skin surface or mucous membrane, numbness of skin and tongue was noticed
  - Dr. Karl Kohler extracted this liquid called Cocaine from coca plant and used it for ocular surgery producing a very good surface anesthesia
- **1885**: Dr. William Halstead did 1st peripheral brachial plexus block
- **1885**: Dr. James Corning injected cocaine between spinous process for blocking spinal nerves but whether it was epidural or subarachnoid block not clear. He was the first person to give local anesthetic
- **1893**: Dr. August Bier (Father of Regional Anesthesia) gave drug in subarachnoid space clearly by demonstrating and 1st spinal anesthesia was given and reported. He also introduced Bier's block (Intravenous Regional Anesthesia)

Dr. August Bier

- **1937**: Dr. Arthur Ernest Guedel defined stages of anesthesia on Ether anesthesia
  - As the Ether anesthesia was given different stages of anesthesia came one after the other
  - He was a person who was in charge of giving the anesthesia to the American army during war and he was using lay person for giving anesthesia, so he needed a safety devices to describe how to give Ether anesthesia
  - He described the first safety system of anesthesia in the form of stages of anesthesia
  - He gave the first safety description of the giving anesthesia
  - He use this stages of anesthesia in 1914 but he published a book (Guedel stages of anesthesia) in 1937

STAGES OF ANESTHESIA

00:55:50

- Dr. Guedel described 4 stages of anesthesia. This was one of the first monitoring system established in anesthesia
  - **Stage I and II:** did not provide the adequate depth of anesthesia
  - **Stage III:** was the depth required for surgical anesthesia to get the surgeries done (Surgical Anesthesia Plane)

- **Stage IV**: takes the patient toward coma and death. So, this was the dangerous stage where irreversible anesthesia and death of coma can happen

Stage I (Stage of Analgesia or Disorientation)

- This can be initiated in the pre-operative holding area, when the patient has still not shifted to operation room.
- When start giving inhalational anesthetic agents patient is disoriented but still not unconscious and when the patient become unconscious, the stage I ends
- Starts from beginning of induction to unconsciousness
- Loss of eyelash reflex

Stage II (Stage of Excitement or Delirium)

- Features like Disinhibition, Delirium, Hypertension, Tachycardia seen because of Sympathetic stimulation
- Airway manipulation is avoided because reflexes are intact except eyelash reflex
- Respiration is rapid irregular
- Modern anesthetic agents has minimized the time spent in stage II
- Stage II time is very limited, straight away from stage I patient goes to stage III
- Stage I and stage II can only be very clearly seen with Ether anesthesia not with modern anesthetic and both stages are the stages of induction and in stage II airway manipulation has to be avoided because reflexes are still intact

Stage III (Stage of Surgical Anesthesia)

- This is the target stage for surgery
- Divided into 4 planes
  - **Plane 1**
    - → Conjunctival reflex is lost, eyelid reflex lost and swallowing reflex is lost
    - → Marked eyeball movement
  - **Plane II**
    - → Intermittent cessation of respiration
    - → Loss of eyeball movement
    - → Laryngeal reflex lost
    - → Lacrimation increases (increased tear)
  - **Plane III**
    - → Complete relaxation of intercostal & abdominal muscles
    - → Loss of pupillary light reflex (pupils dilated)
    - → This is true surgical anesthesia plane
  - **Plane IV**
    - → Irregular respiration
    - → Paradoxical ribcage movement to complete diaphragmatic paralysis
    - → Diaphragm paralysis

Stage IV (overdose)

- Respiratory cessation to potential death
- Skeletal muscle becomes flaccid, weak pulse, decreased blood pressure

Important Information

- Plane III of the stage III is the true surgical anesthesia plane
- Stage I and stage II were not providing the adequate depth of anesthesia, which could also cause problem, so that could be potentially harmful for the patient
- Stage IV potentially harmful for the patient

SHIMMEL BUSCH MASK

- This was the mask which was used for giving Ether anesthesia
- Metallic mask on which gauge pieces were kept and Ether was poured and at room temperature liquid of the Ether become vapor and the patient can inhaled from gauge pieces kept on the Schimmel Busch Mask

2 INTRODUCTION OF ANESTHESIA

ANESTHESIA IS DIVIDED INTO 2 BROAD DIVISIONS

00:00:20

I. General anesthesia
II. Regional anesthesia

I. General Anesthesia

00:01:00

- **Components of general anesthesia**
  - **Loss of consciousness:** Make patient unconscious. It is must during general anesthesia but it is not required in regional anesthesia
  - **Loss of reflex response:** Take away all the sympathetic and parasympathetic reflexes of the patient and provide a smooth plane for the surgeon to operate
  - **Amnesia:** Surgery is very stressful situation so provide anterograde amnesia to the patient. The time period in which the patient is under anesthesia and does not remember anything of that time period
  - **Muscle relaxation:** Relax all the muscles of the body by either paralyzing or by using agents which decreases the tone depending upon the surgical demand
    - → If the surgery requires paralysis like abdominal surgery, gave neuromuscular blocker and paralyze the patient
    - → If surgery does not require paralysis, little bit relaxation can be achieved with other anesthetic agents as well
  - **Analgesia:** Drugs which we use for producing loss of consciousness is not necessarily the drug providing analgesia. The path of consciousness and path of pain are different
    - → The drug may act on path of consciousness may not act on path of pain
    - → Patient may become unconscious, but may feel the pain
    - → Need drugs which provide analgesia
    - → It is not one drug which is used to provide all these 5 components
    - → Multiple drugs are used for multiple components of general anesthesia

Important Information

Previously (Historical)	At present
Triad of Anesthesia • Narcosis • Relaxation • Analgesia	Pentad of Anesthesia • Loss of consciousness • Loss of reflex response • Amnesia • Relaxation • Analgesia

Lundi: came up with the concept of Balanced Anesthesia and this we are practicing today also

BALANCED ANESTHESIA

00:07:32

- **Balanced Anesthesia:** When using multiple drugs for providing all the 5 components of anesthesia
  - By Lundi
  - Multiple drug given in a titrated way for producing different component of general anesthesia
  - Multiple drugs using for 5 components
    - → Loss of consciousness: Inhalational or IV anesthetic agents.
    - → Loss of reflex response: Inhalational or IV anesthetic agents
    - → Amnesia: Inhalational or IV anesthetic agents
    - → Muscle relaxation: Neuromuscular blockers are used which causes paralysis and get a very good muscle relaxation
    - → Analgesia by opioids

Important Information

- **All the drugs which produce loss of consciousness, also produces loss of reflex response and amnesia**

Important Information

- If giving neuromuscular blocker, always have to ventilate the patient from outside because apart from other muscle, it will also paralyze the respiratory muscle and patient will not be able to breathe
- Neuromuscular blockers never produce loss of consciousness. They only produces muscle paralysis by which we get muscle relaxation.

STEPS OF GENERAL ANESTHESIA 00:11:19

I. Attach mandatory monitors

- ECG
- Pulse oximetry
- Temperature probe
- Blood pressure cuff for non- invasive BP monitoring
- Capnography

II. Securement of intravenous canula

- After securing IV line inject drug and the patient become unconscious

III. Induction

- Intravenous anesthetic agent: means loss of consciousness (i.e. patient has been made unconscious) by giving IV anesthetic agent or
- Inhalational anesthetic agent: Incase patient doesn't have canula or some other reason cannot give IV anesthetic agent than go for inhalational anesthetic agents
  - Through the mask
  - **A**nesthesia **M**achine → **C**ircuit → **F**acemask → **S**ystemic **C**irculation → **P**atient **U**nconscious
- To maintain the unconsciousness, have to secure an airway so that continuously some anesthetic agent and gases can be given throughout course of anesthesia

IV. Bag and mask ventilation: 100% oxygen

V. IV Neuromuscular blocker: Patient becomes paralyzed

VI. Laryngoscopy and intubation: Secure an airway

VII. Maintenance of anesthesia

- Continuous inhalational anesthetic agent
- Continuous IV anesthetic agent
- Induction can be done by inhalational and IV and maintenance can be done by inhalational and intravenous
- When we use intravenous both for induction and maintenance, then it called TIVA (Total Intravenous Anesthesia).

VIII. Reversal of anesthesia

- Unconsciousness → Consciousness
- Stop the infusion of intravenous anesthetic agent or stop the inhalational agent
- Can use reversal agents for some particular drugs

Important Information

General anesthesia comprises of 3 components

- **Induction**
- **Maintenance**
- **Reversal**

REGIONAL ANESTHESIA 00:23:06

- By using local anesthetic
- Local Anesthetic is deposited locally (never intravenously) near the nerve fiber to be blocked
- The drug blocks the autonomic, sensory and motor outflow of the nerve fiber
- Area supplied by the particular nerve fiber gets anesthetized

Regional anesthesia is basically divided into

I. Central neuraxial blockade
II. Peripheral nerve block

I. Central neuraxial blockade: Blockage of spinal nerves either by spinal anesthesia or epidural

- Spinal anesthesia
- Epidural anesthesia

II. Peripheral nerve blocks

- Brachial plexus block
- Femoral nerve block
- Sciatic nerve block

3 PRE-ANESTHETIC EVALUATION

00:00:13

- Before taking any patient for general anesthesia or for regional anesthesia, always pre-anesthetic evaluation needs to be done
- It is necessary because pre-anesthetic evaluation would be helpful in 2 very important things

2 goals of pre-anesthetic evaluation 00:00:55

1. To reduce patient's risk and morbidity associated with surgery
2. To formulate a patient contoured anesthetic plan

PRE-OPERATIVE EVALUATION

Components of Pre-Anesthetic Evaluation 00:01:55

I. History of patient
II. General examination
III. Systemic examination
IV. Routine Investigation (ASA Grading, Airway Evaluation)

I. To take a focused history

- Previous anesthetic history in which apart from patients own history, his medical records will be helpful
- Previous medication and allergy history
- History of surgical condition for which he is being operated

II. General examination

III. Systemic examination: Screening patients using systemic approach 00:05:19

- **Cardiovascular system**
  - Recognize sign and system of uncontrolled HTN, any other cardiac disease
  - History of ongoing ischemia
  - Physical and systemic examination of the CVS
- **Neurological system**
  - Simply observing and talking to the patient, gets an idea of his neurological status
- **Respiratory system**
  - History of smoking
  - History of exercise tolerance (capacity of patient to tolerate exercise or stress)

Important Information

- Exercise tolerance is one of the best measure of cardiovascular & respiratory status of the patient

IV. Airway evaluation: Very important both for adult and pediatric patients 00:10:42

- **History**
  - Patient is nasal breather or not
  - History of known or anticipated obstructive sleep apnea
- **Evaluation:** To evaluate the patient for any anticipated difficulty in mask ventilation and intubation

1. Inspect oral cavity: Inspect for any abnormal dentition or no dentition or any mass in the oral cavity
2. Measure thyromental distance and hyomental distance
3. Assess mouth opening
4. Neck circumference and neck movement
5. Atlanto-occipital joint movement
6. Mallampati grading

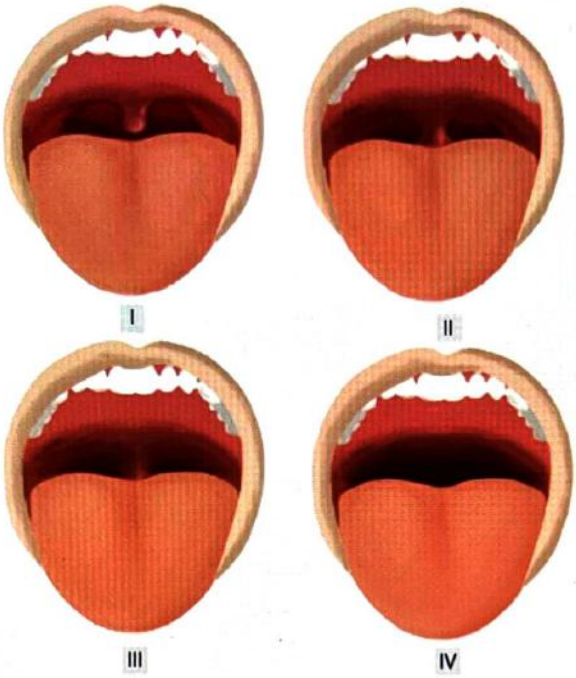
MALLAMPATI GRADING/CLASSIFICATION

00:17:12

- Patient is asked to open the mouth and take tongue out without vocalize or without any sound
- Inspect inside the oral cavity and see the structures of oral cavity to assess the size of tongue with respect to oral cavity

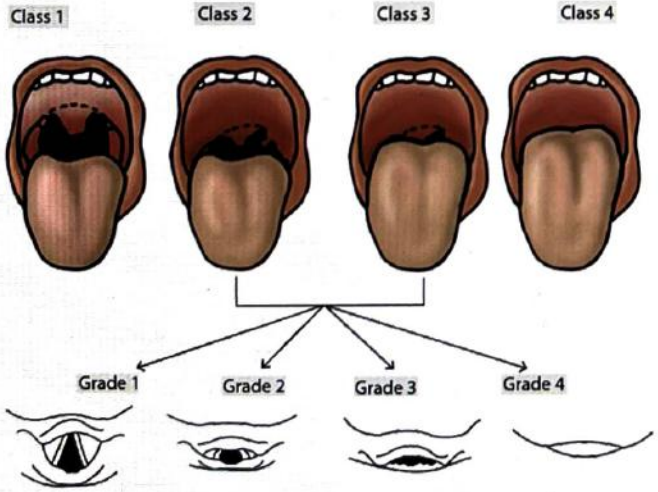
Class I	Class II	Class III	Class IV
• Hard palate • Soft palate • Uvula • Fauces • Tonsillar • Pillars	• Hard palate • Soft palate • Uvula • Fauces	• Hard palate • Soft palate • Base of uvula but not tip of uvula	• Hard palate only

- **Class 1** - All structures visible
- **Class II** - If unable to see one or two structures
- **Class III** - Few structures seen
- **Class IV** - Only hard palate visible



In this figure assessing the size of tongue with respect to oral cavity

- **Class I& II** - Tongue is of normal size
- **Class III & IV** - Tongue is big, in that case Laryngoscopy and intubation can be difficult
- It does not have very good sensitivity and specificity in predicting the difficult airway
- It is not the one grading system which can tell exactly that airway can be difficult
- There has been found some correlation in patient having high Mallampati scoring and difficulty in intubation



- The top shows tongue grading system which is pre-anesthetic evaluation of airway i.e Mallampati grading
- Below is laryngoscopic view of glottic opening. when we do Laryngoscopy for endotracheal tube, which is called Conmark Lehane Grading (CL)

CONMARK LEHANE GRADING

00:25:42

- It is the laryngoscopic view of glottic opening i.e through larygoscopy how much glottic opening is visible
  - **Grade I**: The visualization of entire laryngeal aperture is visible
  - **Grade II**: Only post commissure is visible
  - **Grade I &II**: Able to see glottic opening, to pass the endotracheal tube
  - **Grade III**: Only epiglottis is visible
  - **Grade IV**: Only soft palate, hard palate and epiglottis is visible in CL grading
- So Mallampati class III and class IV has been correlate with higher grade of CL
- It does not have very high sensitivity and specificity
- Some correlation has been found that patient having higher Mallampati grading, which is pre-anesthetic evaluation of airway, might have a difficult intubation while doing laryngoscopy & intubation
- The below grade shown is laryngoscopic view of difficult airway and called CL grading
- It is not pre-anesthetic evaluation of airway
- It is done in operating room, once patient is paralyzed

Apart from Mallampati, there are few more grading which has been developed. One of them is LEMON grading

LEMON GRADING

00:28:43

How to remember

L - Look
E - Evaluate
M - Mallampati score
O - Obstruction
N - Neck movement

- It is important grading for difficult airway
- Max point is 10 and higher the level of scoring, more difficulty is anticipated
- **L- Look** for facial trauma or large incisor, beard or moustache, large tongue. Presence of any, 1 point is given
- **E- Evaluate 3-3-2**
  - Ask the patient to open mouth, take 3 fingers and put between upper & lower incisor
  - If 3 fingers easily goes, than the patient has adequate mouth opening
  - Inter-incisor distance should be 3 fingers width
  - Distance between thyroid & mentum should be 3 finger width and distance between thyroid bone and mentum should be 2 finger width
  - If any of these not present, 1 point is given

- **M- Mallampati score:** If the score ≥ 3 than 1 point is given
- **O-Obstruction:** evaluate oral cavity and see any obstruction in epiglottis, tumor in oral cavity, 1 point is given
- **N- Neck movement:** patient is asked to touch his chin to the chest. If no adequate neck movement 1 point is given
- This whole constitutes total 10 points. Higher the LEMON score, more difficulty is anticipated

Important Information

- High LEMON score corresponds to difficult intubation
- More sensitive than Mallampati grading

CONGENITAL CONDITIONS

00:37:18

- Especially in Pediatric patient, there are some congenital condition, which can make the airway difficult i.e. Airway Compromising Condition

1. **Pierre Robin's Syndrome**
   - Micrognathia
   - Macroglossia
   - Cleft Palate
2. **Treacher Collins syndrome**
   - In this, intubation is not difficult but mask ventilation is difficult which makes the airway difficult
   - Because of mandibular and malar hypoplasia, seal of the mask is not properly achieved
3. **Goldenhar's Syndrome**
   - Because of mandibular and malar hypoplasia, seal of the mask is not properly achieved
4. **Down's syndrome**
   - Macroglossia
   - Poorly formed nasal bridge
5. **Klippel – Feil syndrome**
   - Fused neck joint
   - Restricted neck movement
6. **Congenital goitre**
   - Causes deviation of trachea

ASA GRADING (AMERICAN SOCIETY OF ANAESTHESIOLOGIST GRADING)

00:42:33

After completing the evaluation of a normal patient, we do ASA grading

- To assess present physical status of the patient
- To assess the risk associated with surgery
- **6 ASA grades**
  - I
  - II
  - III
  - IV
  - V
  - VI

Important Information

- ASA grades I to VI
  - Elective surgery
  - Emergency surgery
- We mention IE to VIE
  - Where E stands for Emergency

ASA grades

- I - Patient has no co-morbidity (healthy patient)
- II - Controlled co-morbidity. No physical limitation
- III - Co-morbidity with "moderate" limitation
- IV - Co-morbid condition is constant risk on patient's life
- V - Surgery is the only option for survival
- VI -Comatose patient (brain dead patient) for organ transplantation

PRE-ANESTHETIC EVALUATION IN PATIENTS WITH KNOWN CARDIO VASCULAR DISEASE

00:52:45

Goals

1. To assess the risk associated and measure the risk
2. Required for further testing apart from routine evaluation

Goldman cardiac risk score

- It is a risk index to evaluate the risk of surgery in a cardiac patient

I. Done for any cardiac patient presenting with high risk type surgery (major surgery)
II. Done in patient with history of ischemic heart disease
III. Done in patient with history of congestive cardiac failure
IV. Done in patient with history of cerebrovascular disease
V. If there is pre-operative insulin requirement by the patient
VI. If pre-operative creatinine level >2.0mg/dl

- This score is developed for >50 yrs cardiac patient coming for non- cardiac surgery

Investigations

01:00:25

1. **ECG**
   - 12 lead ECG

2. **Stress ECG**
- Holter ECG monitoring

3. **Echocardiography**
- Exercise Stress echocardiography
- Pharmacological stress echocardiography (Thallium, Dobutamine can be used)

Role of coronary angiography in a cardiovascular patient
- It is invasive test
- Does not have much role in pre-anaesthetic evaluation
- Not done routinely

Pre-Anaesthetic Orders 01:08:02
- **Nil per oral (NPO) order**

Adult patient	Paediatric patient
• 6 hrs NPO: for liquids & semi-solid feed	• 6 hrs NPO: for semi-solid, formula feed
• 2 hrs NPO: for clear fluids	• 4 hrs NPO: for breast milk
	• 2 hrs NPO: clear fluids

- **Pre-medications**
  - Benzodiazepines
    - → Good anxiolytic
    - → Less sedation
  - Midazolam, Diazepam, Lorazepam

Important Information
- Midazolam
  - Fastest onset • shortest duration
- Diazepam
  - Longest duration
- Before prescribing anxiolytic patient should be screened for contraindication/risks to anxiolytics
  - Extremes of age
  - Head injury
  - Decreased consciousness in a patient (due to any head injury trauma)

ANTICHOLINERGICS
- Role of anticholinergics as pre-medication
  - Antisialagogue (to ↓se the secretions)
  - Vagolytic (to ↑se the HR)
  - Sedation and amnesia
- Atropine
  - Glycopyrrolate
  - Scopolamine

Important Information
- Glycopyrrolate
  - Quaternary amine
  - Does not cross blood-brain barrier
- Atropine, Scopolamine
  - Cross BBB

	Atropine	Glycopyrrolate	Scopolamine
Vagolytic effect	+++	+	++
Antisialogue	+	+++	+
Sedation+ amnesia	+	x	++

ORDERS REGARDING PREVIOUS MEDICATIONS 01:20:48

1. **Oral antihypertensive drugs**
- To be continued till the day of surgery

2. **Oral hypoglycaemic agents**
- For minor / moderate surgery
  - Stop the last dose of oral hypoglycaemic agents
- For major surgery
  - Stop the last dose of oral hypoglycaemic agents & put the patient on insulin

3. **Antipsychotics, antidepressants, antiepileptics**
- Continue till the day of surgery
- **Except**
  - Tricyclic antidepressant: stop 3 weeks prior to surgery
  - Lithium: stop 24-48 hrs prior to surgery

4. **Anticoagulants**
- Aspirin: continued till the day of surgery
- Clopidogrel: stopped 5-7 days prior to surgery
- Ticlopidine: stopped 14 days prior to surgery
- Warfarin: stopped 3-4 days prior to surgery
- Low molecular weight heparin: stopped 12 hrs prior to surgery

Important Information

Patient with coronary stent posted for any surgery:

- **There should always be a gap between stenting and elective surgery**
  - → **Bare metal stent: gap of one month is required**
  - → **Medicated stent: gap of one year is required**

5. Steroids

- Continue steroids with per-operative supplementation
- If patient is on steroids for > 3 days, the hypothalamic pituitary axis will be inhibited and steroid production will be inhibited.
- 3 conditions where we need to stop steroids
  - Diabetes
  - Active infection
  - Immune compromised state
- In these 3 mentioned conditions
  - Patient wait for the NPA
  - Continue surgery once the serum cortisol levels are stable

6. Herbal medication

- Stop 4-6 weeks prior to surgery

7. Hormone replacement therapy

- Stopped 4-8 weeks prior to surgery
- High estrogenic concentration can ↑se the risk of thromboembolism

ANTIBIOTIC PROPHYLAXIS PRIOR TO SURGERY

01:38:01

- It is recommended to give IV antibiotics 1 hr prior to surgical incision
- If prior to surgical incision is not given in the options then go for prior to induction of anaesthesia
- If surgical procedure is prolonged
  - Depending on the half-life of the antibiotic, the antibiotic has to be repeated intra-operatively

2 exceptions to above rule

1. IV Vancomycin given 2 hrs prior to surgical incision
2. In case of tourniquet application, antibiotics given prior to the inflation of tourniquet

CLINICAL QUESTIONS

Q. A 45 year old male who is a chronic smoker and alcoholic on treatment for systemic hypertension for the past 2 years. He was posted for aortobifemoral bypass under general anesthesia with epidural analgesia. His preoperative risk stratification for perioperative cardiac events do not include?

A. History of ischemic heart disease
B. History of preoperative treatment with insulin
C. History of preoperative serum creatinine >2.0 mg/dL
D. Age > 40 years

Answer: D

Solution

Goldman cardiac risk score

- It is a risk index to evaluate the risk of surgery in a cardiac patient
  I. Done for any cardiac patient presenting with high risk type surgery (major surgery)
  II. Done in patient with history of ischemic heart disease
  III. Done in patient with history of congestive cardiac failure
  IV. Done in patient with history of cerebrovascular disease
  V. If there is pre-operative insulin requirement by the patient
  VI. If pre-operative creatinine level >2.0mg/dl
- This score is developed for >50 yrs cardiac patient coming for non- cardiac surgery

Reference: Barash clinical Anesthesia 7th edition, page 329
Miller's textbook of Anaesthesia, 9th edition, page 933

Q. A 45 year old female who is a known case of hypertensive, diabetic and hypothyroidism on T. Amlodipine 5 mg BD, subcutaneous short acting Insulin and T. Thyroxine 100 µg OD. She was posted for ventral hernia repair. The preoperative instruction to be advised for this patient would be?

A. Thyroid medications need not be stopped before surgery
B. Insulin should be continued on the day of surgery
C. Clopidogrel should be discontinued 14 days before surgery
D. Antihypertensives should be discontinued on the day of surgery

Answer: A

Solution

1. Oral antihypertensive drugs
   - To be continued till the day of surgery
2. **Oral hypoglycaemic agents**
   - For minor / moderate surgery
     - Stop the last dose of oral hypoglycaemic agents
- For major surgery

- Stop the last dose of oral hypoglycaemic agents & put the patient on insulin

3. **Antipsychotics, antidepressants, antiepileptics**
   - Continue till the day of surgery
   - **Except**
     - Tricyclic antidepressant: stop 3 weeks prior to surgery
     - Lithium: stop 24-48 hrs prior to surgery
4. **Anticoagulants**
   - Aspirin: continued till the day of surgery
   - Clopidogrel: stopped 5-7 days prior to surgery
   - Ticlopidine: stopped 14 days prior to surgery
   - Warfarin: stopped 3-4 days prior to surgery
   - Low molecular weight heparin: stopped 12 hrs prior to surgery

Drugs that should be discontinued on the day of surgery

- Insulin
  1. Discontinue all short acting insulin (regular) on the day of surgery (unless continuous infusion pump).
  2. Patients with type 2 DM should take none or one half of their dose of long acting or combination (e.g. 70/30 preparation) insulin on the day of surgery.
  3. Patients with type 1 DM-should take small amount (1/3 of the morning dose) of long acting insulin on the day of surgery
  4. Patients who are on Insulin pump, should take their basal rate only.

Reference: Miller's Anesthesia 9th edition, Page no: 989

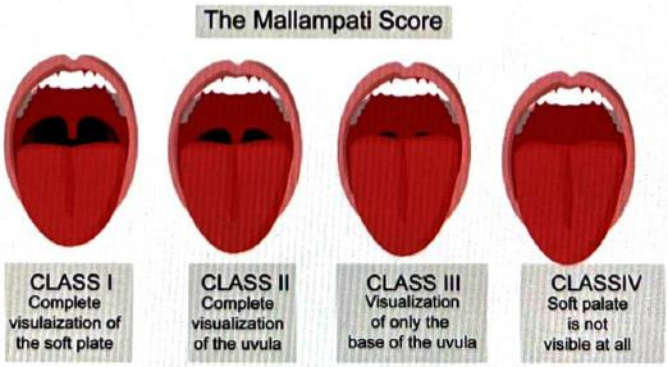
Q. A 50 year old male who was a case of diabetes mellitus on treatment for the past 10 years, planned for laparotomy for subacute intestinal obstruction under general anesthesia. Preoperative airway examination showed modified mallampatti score of 2, upper lip bite test negative, neck circumference 15 inches and limited neck movements. Not a predictor of difficult airway in this patient would?

A. Cervical joint immobility
B. Neck circumference-15 inches
C. Upper lip bite test negative.
D. Interincisor gap of <3 cm

Answer: B

Solution

- Modified mallampati classification 1 and 2 no difficulty
- Modified mallampati classification 3 and 4 difficulty in intubation.
- **Mallampati classification**: Standard for assessing the relationship of the tongue size relative to oral cavity



Airway assessment: Predictors of difficult airway

- One of the most predictive factors for difficult intubation is history of previous difficult intubation. History of previous easy airway does not exclude the possibility of difficult ventilation or intubation.
- Facial deformities, neoplasms of face or neck, facial burns, large goitre, short or thicker neck, receding mandible are associated with difficulty in airway management. Presence of beard associated with difficult mask ventilation. Cervical collar or cervical traction devices are associated with difficulty in mask ventilation and laryngoscopy.
- Neck circumference >17 inches-more predictive of difficult tracheal intubation than high BMI
- Eduntulousness is associated with easy laryngoscopy but difficulty with mask ventilation.Long upper incisors can impair laryngoscopy. Poor dentition and loose teeth increase the risk of dental trauma and aspiration
- Sternomental distance < 12.5 cm associated with difficult intubation
- Interincisor gap of <3 cm indicates inadequate mouth opening.
- Thyromental distance<6.5 cm-reduced mandibular space results in difficult laryngoscopy and intubation.
- Upper lip bit test-negative again the predictor of difficult airway
- Restriction of extension at atlando-occipital joint and flexion of cervical vertebrae as in cases of diabetes mellitus, ankylosing spondylosis indicates difficulty in positioning.

Reference: Miller's Anesthesia 9th edition, Page no. 1378-1380

Q. A 42 year old male patient posted for Lap Cholecystectomy had drug eluting stent placed two years back. Patient has no symptom since then. Which of the following set of investigation should be done in this patient?

A. ECG, CBC, RFT, LFT
B. ECG, CBC, RFT, LFT, Coronary angiography, Echocardiography
C. ECG, CBC Stress echocardiography, Coronary angiography
D. Coronary angiography, Thallium echocardiography

Answer: A

Solution

- Patients with intermediate to high risk surgery and moderate clinical risk factors with drug eluting stent > 12 months and no symptoms of poor exercise tolerance requires no need for stress echocardiography or coronary angiography and proceed to surgery.
- If the coronary artery disease is unable to assess and poor exercise tolerance with drug eluting stent<12 months and on dual antiplatelet therapy requires cardiology consultation,stress testing and coronary angiography

Pre-anesthetic Check up

1. Always take a history
2. General examination
3. Systemic examination
4. Investigations
   - Routine Investigation: CBC, RFT (Urea, Creatinine, Serum Electrolytes), LFT
   - If Male and above 40 years: Do ECG, Chest Xray
   - If Female above 45: ECG, Chest Xray
   - History of PTCA and Medicated stent: Elective surgery should be done after one year, if not medicated stent then surgery is done after one month.
   - If patient is having no symptoms: Invasive monitoring should be avoided for eg: Coronary angiography.
   - Always in a cardiac patient ECG and Echo is done (Noninvasive), stress echo can also be done.
5. ASA Grading
6. Airway evaluation

Reference: Stoelting's pharmacology and physiology in Anesthetic practice, 5th edition, page 21

4 MONITORING IN ANESTHESIA

00:00:13

- Whether giving general anesthesia or giving regional anesthesia, needs to attached to certain monitors in every patient
- This electronic monitoring system has increased our ease by providing more frequent and constant readings
- Expertise in monitoring has been greatly improved
- In spite of these monitoring systems. It is mandatory that one experienced person should be present around the patient in the operating room for monitoring, when any kind of anesthesia is given

AMERICAN SOCIETY OF ANESTHESIOLOGISTS (ASA)

- Has laid following standards of monitoring 00:02:21
  - **Standard I**: requires the presence of a qualified person during general anesthesia, regional anesthesia and monitored anesthesia care to respond to any change present in a patient due to anesthetic drug or due to surgery
  - **Standard II**: Focuses its attention on continuously evaluating persons under anesthesia for adequate ventilation, circulation, oxygenation and temperature monitoring
- There are different monitors present which would monitor ventilation, circulation, oxygenation (by pulse oximetry) and temperature (anesthesia effects thermoregulation of patient)

According to ASA there are 5 mandatory monitors

00:06:56

I. ECG
II. NIBP (Non- invasive blood pressure monitoring)
III. Pulse oximetry
IV. Capnography
V. Temperature monitoring

- **Indian Society of Anesthesiologist** also follows the American Society for recommendations but since Capnography is not much available so **according to Indian society**, Capnography is a desirable monitor

Important Information

- **According to ASA there are 5 mandatory monitors and according to ISA there are 4 mandatory monitors**
- **Capnography is a desirable monitor**

Apart from 5 monitors, there are a few other monitors

VI. BIS monitor (Bispectral Index Monitoring): Depth of anesthesia is desirable to monitor in both ASA and ISA. It may be included in mandatory monitoring

VII. Neuromuscular monitoring: desirable monitor

- All these 7 monitors can be attached to any normal patient under general anesthesia
- Apart from 7 monitors, there are a few more monitors that are not to be attached with every patient under general anesthesia. They are attached only when they are indicated
  - Central venous pressure monitoring: attach with the patient with CVD, renal failure, attach with a special group of patients as indicated
  - Pulmonary artery pressure monitoring: CABG surgery
  - Transesophageal echocardiography: recommended for cardiovascular surgery or cardiovascular risk
  - Evoked potential monitoring: recommended for special neural surgery

INVASIVE AND NON-INVASIVE MONITOR

00:14:22

- **Invasive monitor:** whenever we placed a monitor in the bloodstream
- **Non-invasive monitoring:** whenever we placed the monitor on the skin like ECG, pulse oximetry
- **Minimally invasive:** Whenever we placed a monitor in a natural opening, not touching any bloodstream like transesophageal cardiography. They may sometimes cause bleeding, so they are minimally invasive
- **All 7 monitors** (5 mandatory + 2 desirable are non-invasive monitors)

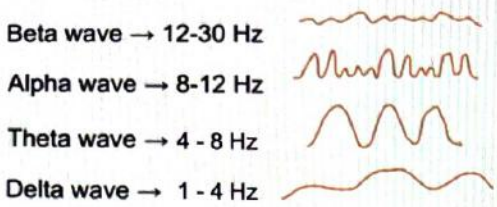
BIS MONITORING

00:16:36

- BIS monitor was developed by Aspect Company
- Monitors depth of anesthesia
- Most of the monitoring system for the depth of anesthesia is based on EEG (electroencephalogram)

PRINCIPLE OF MONITORING DEPTH

- It is based on the principle of EEG. Either spontaneous or stimulated electroencephalogram. EEG based on some stimulus
- EEG shows the response in the form of complex waveforms with frequency from 0 to 50 Hz

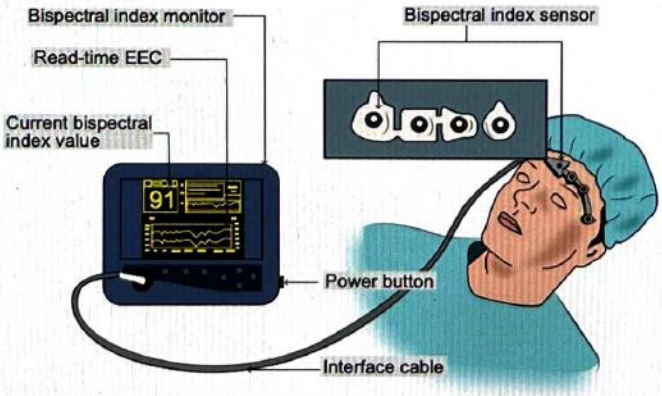


Important Information

- Beta wave: 12-30 Hz has a higher frequency and small amplitude
- Alpha wave: 8-12 Hz amplitude increase and frequency decreases
- Theta wave: 4-8 Hz amplitude further increases and frequency decreases
- Delta wave: 1-4 Hz lesser frequency and high amplitude

- This complex waveform was simplified by Aspect Company which made a monitor BIS. BIS is an EEG derived variable that is calculated and displayed on the monitor

- A band is attached on the forehead which has 3 EEG electrodes attached to it which monitors the 3 lobes of the brain
  - Frontal
  - Parietal
  - Temporal
- Stimulus is being sent and EEG response is graphically and numerically represented on the monitor



- In this fiq. The patient is lying, and a BIS band has been attached which has few electrodes
- Which correspond to the 3 lobes and module will be attached to BIS monitor and in a real-time, in numerical value that will give an idea of anesthesia

- The value of BIS varies from 0 to 100
  - Coma (no EEG activity)
  - 40-60: Target intra-operative BIS
  - 60-80: Target sedation BIS
  - 10: Fully aware

Uses of BIS

I. Prevents intraoperative awareness
II. Titration of anesthetic agents
III. Fast postoperative recovery

Important Information

Clinical parameters for monitoring depth of anesthesia

- Increase in HR
- Increase in BP
- Sweating in anesthetized patient
- If depth is not adequate, patient feel the stimulus.
- As a result, there is Sympathetic response and these parameters will be affected

Previous Year's Questions

Q. Depth of anesthesia best measured by?
(NEET Jan 2019)

A. BIS
B. MAC
C. TOF
D. Post tetanic potentiation

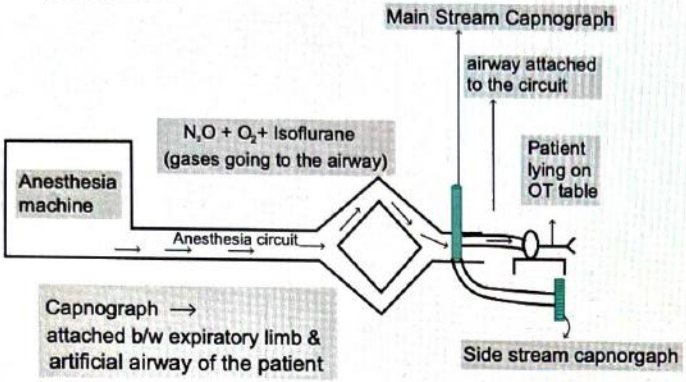
CAPNOGRAPHY

00:30:55

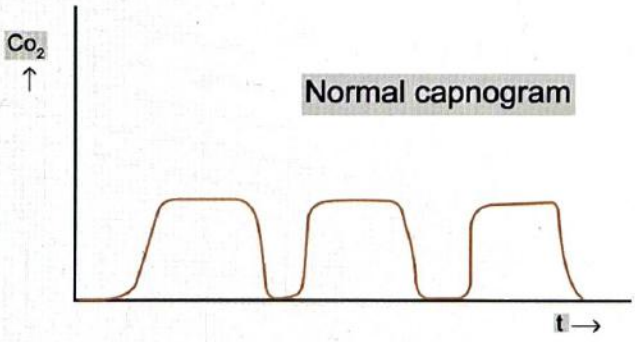
I. It is a mandatory monitor according to ASA guidelines and a desirable monitor according to ISA guidelines
II. It is a non-invasive monitor
III. It is the measurement of end-tidal carbon dioxide and waveform representation of CO_2 during inspiration and expiration
IV. It comprises of
- Capnometry - Numerical interpretation
- Capnograph - Graphical representation

V. Luft developed this monitor

VI. It monitors ventilation, circulation, and cellular metabolism



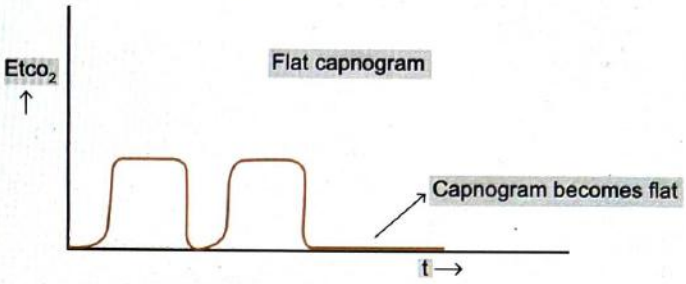
- In this fig. patient is receiving gases (nitrous oxide, oxygen, isoflurane) from machine
- All 3 goes inside the circuit
- From the inspiratory limb of the circuit, they will go to the airway of the patient and from airway, will reach to the patient
- **N_2O + Isoflurane:** used for anesthesia
- **O_2:** utilized for metabolism and because of metabolism, CO_2 is produced as a by-product
- CO_2 production occurs as a result of active metabolism in the body
  - CO_2 carried by the circulation
  - CO_2 exchanged by ventilation
- Between the artificial airway of the patient and expiratory limb, monitor attached called Capnography
- There is main stream and side stream Capnography
- The problem with the main stream is that it is heavy, so the circuit can get disconnected or bend, because of that, a side stream is preferred
- They both have the same sensitivity so, a side stream is preferred
- Expiratory gas enters capno and goes into sample line and if it has CO_2, the capno has infrared light and CO_2 has the capability of absorbing the infrared light
- By this infrared spectrometer, CO_2 is detected and once CO_2 is detected a graphical representation of CO_2 will come



- Graphical representation of detected CO_2 against time

NORMAL CAPNOGRAM

- Shows patient metabolism, ventilation, circulation
- Shows attached circuits are fine



FLAT CAPNOGRAM

- $EtCO_2$ = zero
- If ventilation stops, expiratory and inspiratory gas becomes 0^{sidc}
- If ventilation is adequate but metabolism and circulation stop, because of cardiac arrest
- In cardiac arrest
  - Flat Capnogram
  - Flat ECG
  - Low BP

Important Information

Differential diagnosis of flat Capnogram

I. **Accidental extubation**
II. **Circuit disconnection**
III. **Stoppage of mechanical ventilation**
IV. **Cardiac arrest**
V. **Esophageal intubation**

NORMAL CAPNOGRAPHY

00:50:00

Capnometry

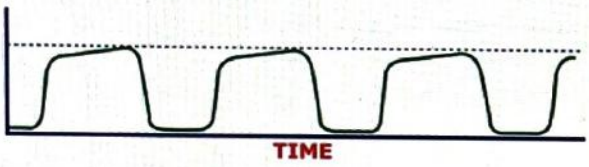
- Numerical representation
- $PaCO_2$ can be measured by ABG but in real time $PaCO_2$ is measured by capnometry
- Normal value of $PaCO_2$ is represented in expired CO_2
  - $PaCO_2$ = 40-45 mm Hg
  - $EtCO_2$ = 35-45 mm Hg
  - **$PaCO_2 - EtCO_2$ = 45 mm Hg:** Normal gradient
  - **PaCO2 – EtCO2 increase:** Alveolar diseases

$EtCO_2$ increase	$EtCO_2$ decrease
I. Hypermetabolism • Fever/ Hyperthermia • Shivering • Malignant hyperthermia • Thyroid storm • Neuroleptic malignant syndrome	I. Hypometabolism • Hypothermia • Anesthesia • Hypothyroidism

II. Hyperperfusion will not increase $EtCO_2$ because there is a fixed amount of CO_2 produced in the body	II. Hypoperfusion • Low cardiac output • Embolism • Hypovolemia
III. Hypoventilation	III. Hyperventilation

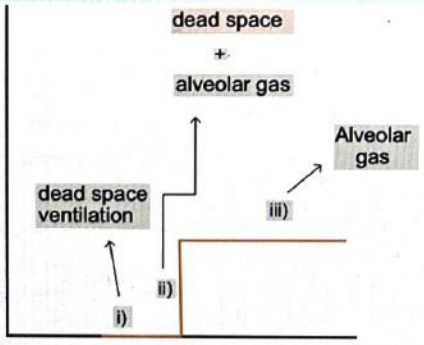
NORMAL $EtCO_2$ GRAPH

00:58:01



- Expired CO_2 against time
- Patient respiratory cycle comprises

Inspiration	Expiration
• Inspiratory gas (N_2O + O_2 + inhalational anesthetic agent) through the circuit will enter the ET tube (airway) • During inspiration o CO_2 is zero o Graph is on baseline	• Expiratory gas from the tube will enter the circuit through Capnogram to get removed • 3 phases in expiration I. Dead space ventilation ($NaCO_2$ present in dead space gas) II. Dead space + Alveolar gas CO_2 increases III. Alveolar gas fixed amount of CO_2 is coming

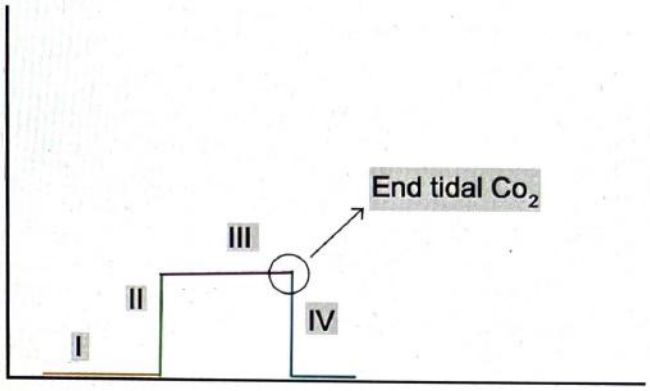


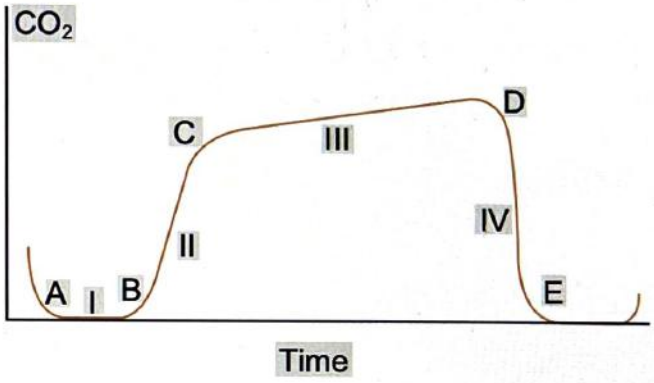
4 PHASES OF GRAPH

01:02:01

- Phase I - Dead space ventilation
- Phase II - Dead space + Alveolar ventilation
- Phase III - Alveolar ventilation
- Phase IV - Inspiration
  - **Phase I, II and III constitutes expiration**
  - **Phase IV constitute inspiration**

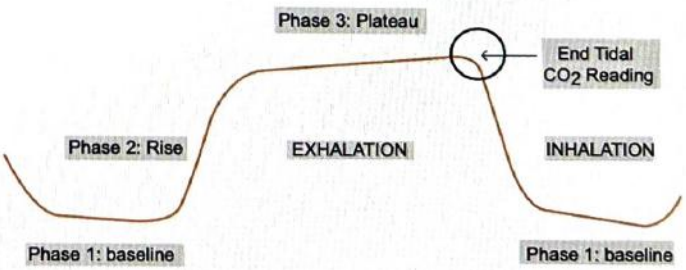
NORMAL CAPNOGRAPH





Important Information

- A-B represents dead space ventilation or inspiration
- B-C represents dead space + alveolar ventilation
- C represents alveolar ventilation
- D represents end tidal CO_2
- D-E represents inspiration



Uses of Capnogram

01:06:30

I. Confirmation of right placement of endotracheal tube
II. Capnography is the sure-shot confirmation

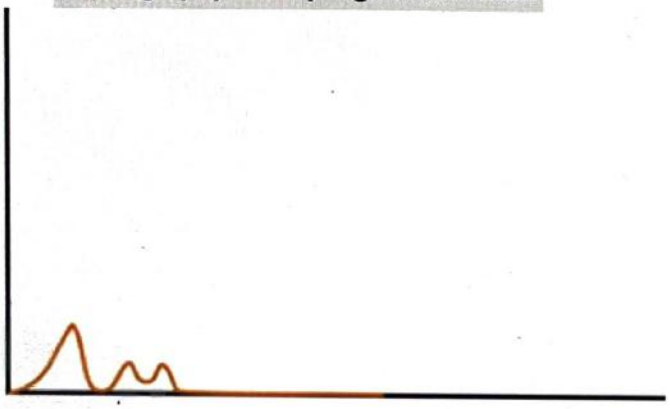
Previous Year's Questions

Q. Endotracheal intubation was done for a patient which of the following will you do to confirm the placement of ET tube? (NEET PG September 2021)

A. $EtCO_2$
B. Chest auscultation
C. Chest X-ray
D. Oxygen saturation

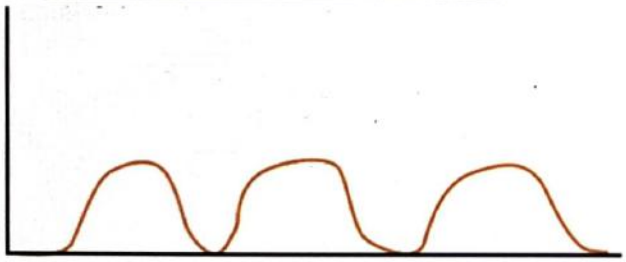
Esophageal intubation

Capnography of esophageal intubation



Tracheal intubation

Capnography of tracheal intubation

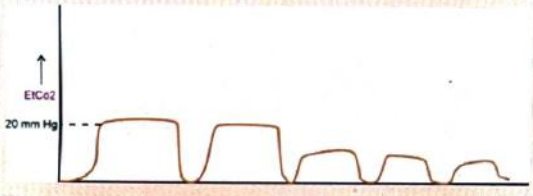


III. During Cardiopulmonary Cerebral Resuscitation

- It tells about the quality of chest compression
- By chest compression (because the heart is not pumping the blood, in order to maintain the perfusion of the organs) the heart is pumped mechanically
- If there is adequate chest compression, there will be adequate perfusion and there will be normal graph
  - **Inadequate chest compression:** if $EtCO_2 < 10$ mm Hg
  - **Adequate chest compression:** if $EtCO_2 > 20$ mm Hg

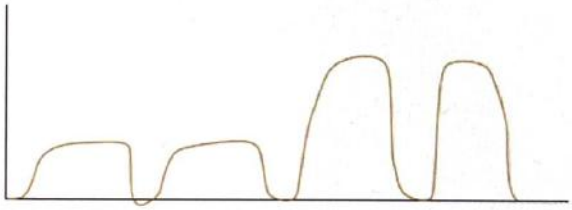
Important Information

A patient of cardiac arrest chest compression was being done. $EtCO_2$ value starts ↓sing from 20 mmHg to 7-10 mmHg. What should be done?



- Change the person doing chest compression. Because $EtCO_2$ is decreasing means inadequate chest compression i.e quality of chest compression is compromised

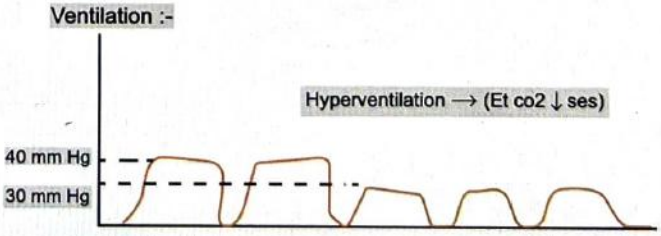
Return of spontaneous circulation (perfusion)

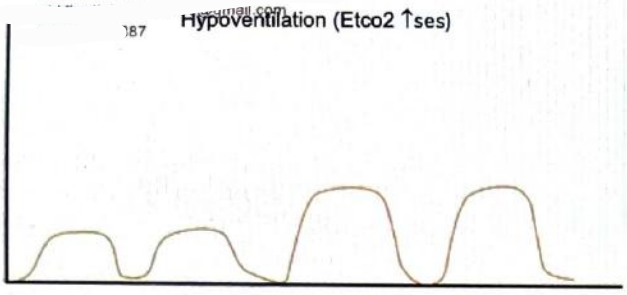


- In this figure suddenly the graph has increased, it indicates the return of spontaneous circulation
- It is a prognostic indicator
  - When doing chest compression from last 30-45 min and there is no $EtCO_2$ graph or inadequate $EtCO_2$ graph, which means unable to bring the perfusion back, then irreversible change has been taken
  - It will be difficult to revive the patient
- It is recommended to monitor during advanced cardiac life support because it provides a lot of information
  - whether the inserted tube is in the right place
  - Whether chest compression is adequate or not
  - Whether perfusion is adequate or not
  - Return of spontaneous circulation
  - Prognosis

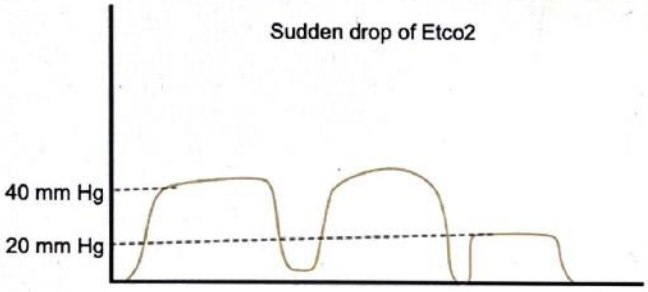
During anesthesia

- Ventilation
  - Hyperventilation: $EtCO_2$ value decreased
  - Hypoventilation: $EtCO_2$ value increased





- Circulation
  - If there is a sudden fall of $EtCO_2$ without changing the ventilating parameter, definitely perfusion is affected



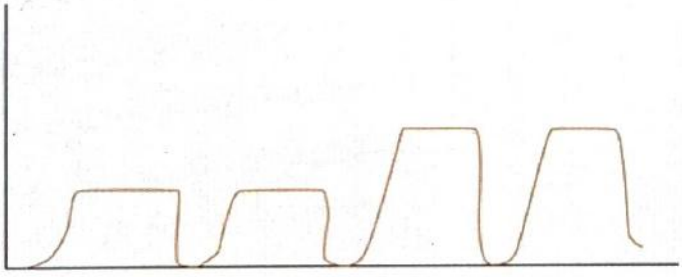
  - If a sudden drop in $EtCO_2$ from 40mm Hg to 20 mm Hg, most probably its embolism. In thromboembolism the emboli gets lost in the pulmonary segment, the cardiac output of the patient is affected, perfusion decreased

Causes of thromboembolism

- Lower limb surgery
- Neurosurgery (posterior fossa tumor surgery) in a sitting position
- Position of the head is above heart and surgeon has opened venous sinus
- Subatmospheric pressure is created, air sucked in the circulation, result in a decrease in cardiac output, decrease in perfusion and sudden drop of CO_2

MALIGNANT HYPERTHERMIA

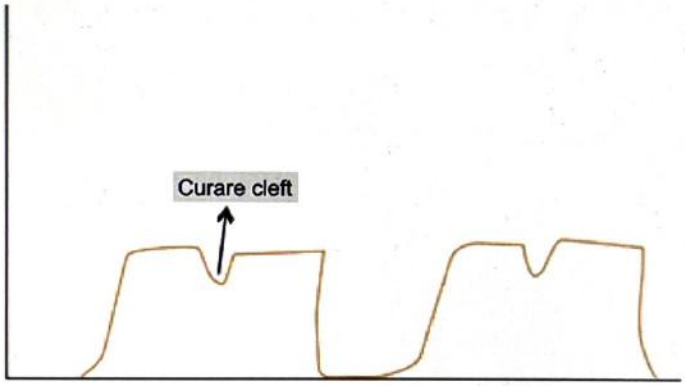
$EtCO_2$ value becomes 40 mm Hg- 90 mmHg



- Any hypermetabolic state, would increase $EtCO_2$ but in Malignant hyperthermia metabolism double/triples and $EtCO_2$ value becomes 40 mm Hg- 90 mmHg

IV Return of Spontaneous Ventilation

- Patient is on controlled ventilation and suddenly a cleft starts appearing this means return of spontaneous breathing
- Patient is out of neuromuscular blocker and has started breathing. In coordination between patient breath and ventilate appears cleft. This cleft is known as Curare cleft

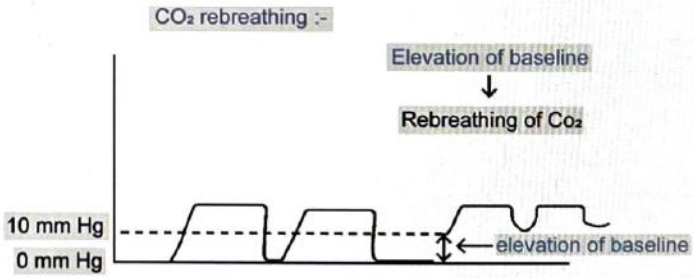


- If the surgery is ongoing and has to maintain the paralysis then repeat the dose of neuromuscular blocker

OTHER ABNORMAL CAPNOGRAMS 01:23:15

I. CO_2 rebreathing

- Elevation of baseline during anesthesia



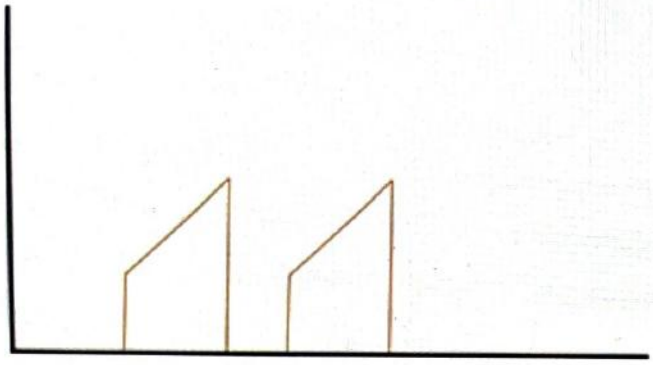
- In this figure-Phase IV is the inspiratory phase
  - It must touch the baseline as it does not contain CO_2, but in this graph, baseline is getting elevated, which means there is CO_2 in the inspiratory phase, which is due to CO_2 rebreathing

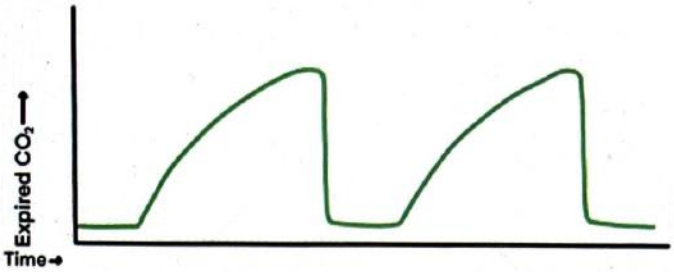
- Condition causing CO_2 rebreathing
  - Exhaustion of CO2 absorber
  - Inadequate fresh gas flow
  - Inadequate expiratory valve

II. Partial obstruction

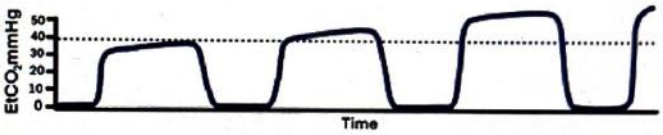
- Shark fin pattern, when there is some obstruction in the alveoli and its not getting empty

Shark fin pattern capnograpm



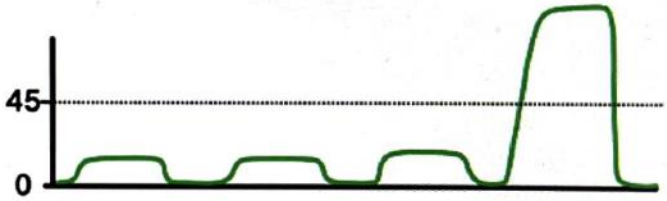


Shark fin pattern (partial obstruction)



Hypoventilation, hyperthermia, hypermetabolic state

- D/d of shark fin pattern of Capnogram
  - Bronchospasm
    - → Absolute: absolute closure, very rare, flat Capnogram
    - → Partial: shark fin pattern of Capnogram, ventilation would happen but there is slow clearing

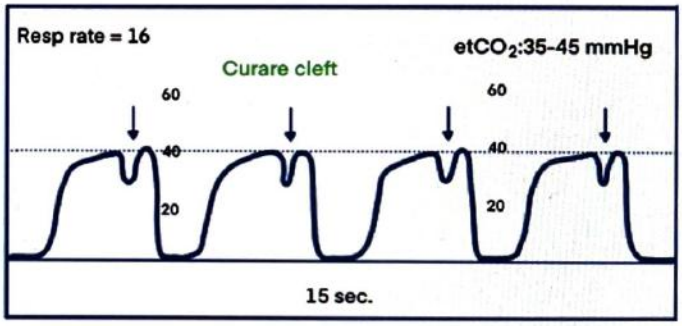


Return of spontaneous circulation

Important Information

If bronchospasm is written alone, it's always Partial

- Endotracheal tube obstruction
- COPD
- Bronchial Asthma

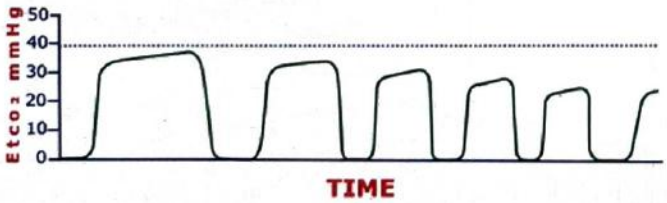


Curare Cleft

REVISION OF GRAPHS (CAPNOGRAMS)

01:32:02

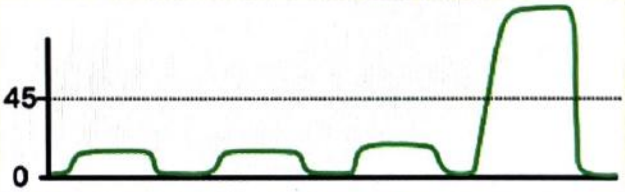
Normal $EtCO_2$ graph



Hyperventilation ($EtCO_2$ is decreasing)

Previous Year's Questions

Q. During the intraoperative period the following Capnography waveform is seen. What does it signify? (NEET PG Jan 2020)



A. Return of spontaneous ventilation
B. Airway obstruction
C. Hyperventilation
D. Esophageal intubation

PULSE OXIMETRY

01:34:15

- Pulse oximetry or Plethysmograph or SPO_2 monitor
- Pulse oximeter measures pulse rate and estimates the oxygen saturation of hemoglobin on a non-invasive continuous basis

- It is a finger probe attached with 2 light-emitting diodes and light-receiving photo diode
- We attach probe on terminal phalanges, where we have only arterious and venous capillaries, so light-emitting diode, emits light of 2 different waveform which falls on the capillary through the nail bed
- If its arterial capillary, the flow of blood would be pulsatile and only then, the light beam will get transmitted. If it's non-pulsatile then the light beam will get reflected. This is called the law of Plethysmograph

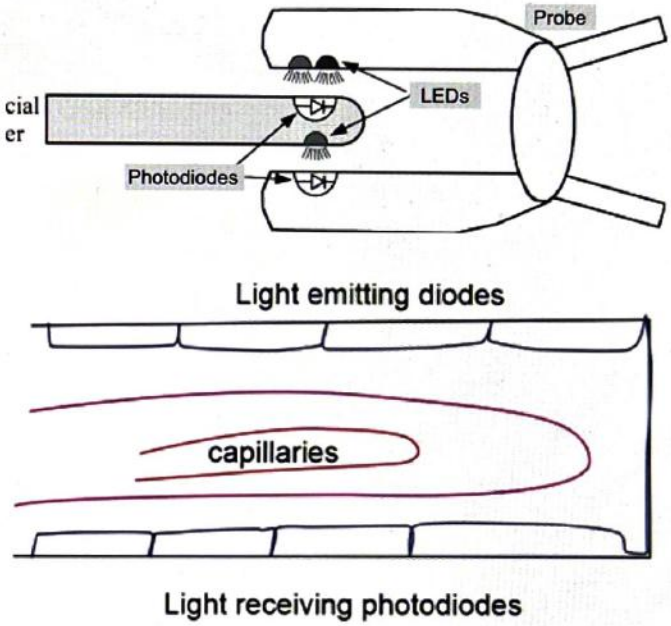
LAW OF PLETHYSMOGRAPH HAS 2 PRINCIPLES

I. To recognize, analyze and differentiate the pulsatile arterial segment from the non-pulsatile venous segment

- Once recognized arterial capillary than the light beam will get transmitted
- At a constant blood flow and a constant amount of hemoglobin, depending upon the oxy and deoxy hemoglobin, the light beam is absorbed or transmitted
- Measuring that transmitted light, we get oxygen saturation of arterial blood flow that how much oxyhemoglobin is present in the blood
- This light-emitting diode emits light of 2 different waveforms Red and Infrared
  - Oxyhemoglobin - reflects the red light and absorbs the infrared light
  - Deoxyhemoglobin- absorbs the red light and reflects the infra red light
- Depending upon, how much red and infrared light is absorbed and transmitted, we get a ratio of oxy and deoxy hemoglobin
- We get a functional saturation of arterial blood (SPO_2value). This is called the law of oximetry or / Beer Lambert's Law

II. Law of Oximetry/ Spectrophotometry/ Beer Lambert's Law

- At a constant light intensity and hemoglobin concentration, the intensity of light transmitted through tissue is a logarithmic function of oxygen saturation of hemoglobin
- Two wavelengths of light are required to distinguish HbO_2 (oxyhemoglobin) from HbH (deoxyhemoglobin)
  - Oxygen saturation $= \frac{HbO_2}{HbO_2 + HbH} \times 100$
- Pulse sensor has light emitting diode which emits
  - Red (660 nm)
  - Infra-red (940 nM)
- Light receiving photo diode



INACCURACIES IN PULSE OXIMETERY VALUE

01:48:00

I. Dyshemoglobinemia

- Carboxyhemoglobin- smokers always had carboxyhemoglobin in their blood and the absorption spectrum of oxy and carboxy is the same
  - Even if oxyhemoglobin is less in the blood, will get a higher saturation because of carboxy in the blood
- Methemoglobinemia- can happen in few local anesthetic poisoning, few solvent poisoning
  - In methemoglobinemia, methemoglobin increases, absorbs the red and infra-red wavelength of light in a 1:1 ratio. So it fixes the value of SpO_2 to 85%
  - **SpO_2> 70%:** Underestimation
  - **SpO_2< 70%:** Overestimation

CO-OXIMETER

01:50:25

- It measures fractional oxygen saturation
- $SaO_2 = \frac{HbO_2}{HbH + HbO_2 + \text{Sulph Hb} + \text{Meth Hb}} \times 100$

- HbO_2 → oxy Hb
- HbH → deoxy Hb

II. Dyes (Methylene blue)
III. Ambient light
IV. Nail polish
V. Electrocautery: Creates sound waveform in the blood, that makes, plethysmograph does not work properly
VI. Hypotension: less perfusion
VII. Hypothermia: peripheral vasoconstriction

Reflectance pulse oximeter

- Applied on the forehead
- Used in amputated patients
- Do not affect the value of pulse oximeter
- Jaundice (hyperbilirubinemia)
- Anemia

ECG

01:56:05

- ECG: Despite the increasing intra-operative use of more sophisticated monitors for cardiac function. ECG remains very helpful, so is mandatory

- ECG is used for diagnosing
  - Arrythmias: Lead II is most sensitive. Continuous monitoring of Lead II is must

- Myocardial infarction- Lead V5 is most sensitive. 75% sensitivity to diagnose MI
  - Lead V4 + V_5: 99% sensitivity to diagnose MI

NON-INVASIVE BLOOD PRESSURE MONITORING (NIBP)

01:59:05

- By oscillometric method estimates arterial blood pressure

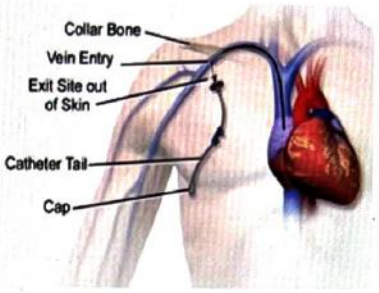
- $MAP = DP + \frac{SP-DP}{3}$
  - MAP: Mean arterial pressure
  - DP: Diastolic pressure
  - SP: Systolic pressure

- Routinely, every patient, have to attach non-invasive blood pressure monitoring but there are conditions in which there are chances of huge blood loss like tumor

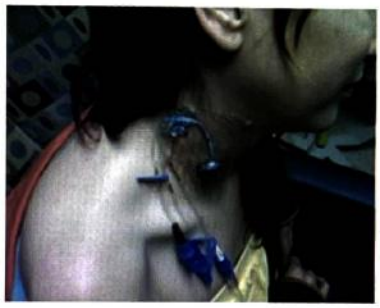
- In those circumstances NIBP is not enough than we need to do Invasive Blood Pressure Monitoring or Arterial Blood Pressure Monitoring, indicated only when
  - Surgery done with a chances of huge blood loss or a massive fluid shift
  - **M/C artery** used for arterial blood pressure monitoring is Radial Artery

CENTRAL VENOUS PRESSURE MONITORING

02:02:51



Non-Tunnelled Central Venous Access Device



Triple Lumen Central Venous Catheter

- In this figure central venous line is placed through the subclavian vein. Can have single/ double/ triple lumen
- Entry point of vein of catheter and exit point of skin is seen
- Tip of the catheter is under the junction of superior vena cava and at right atrium
- This is central venous catheter, and it measures right arterial pressure, which gives idea of other chamber and CO. This catheter is used for
  - Monitoring fluid of the patient
  - Monitoring the central venous pressure
  - To give parental nutrition to the patient
  - To give drugs with high osmolality
- Catheter is put through
  - Internal jugular vein – M/C and most preferred site
  - Subclavian vein – least infection and best tolerate by patient
  - Femoral vein- site with most infection

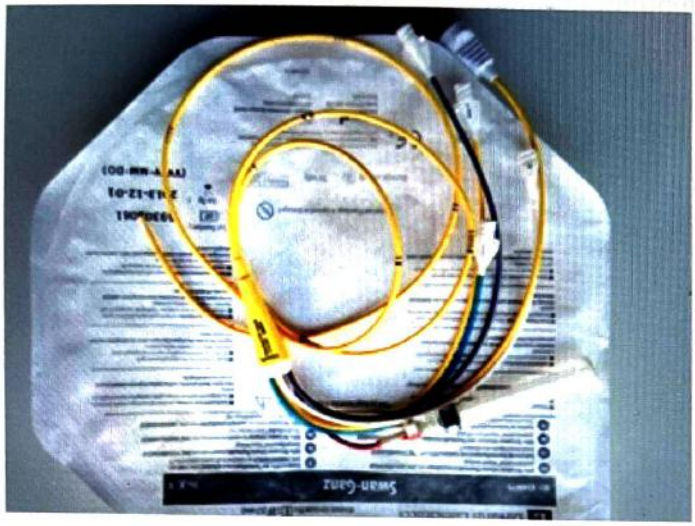
Refer Table 1.1

Uses of putting central venous line

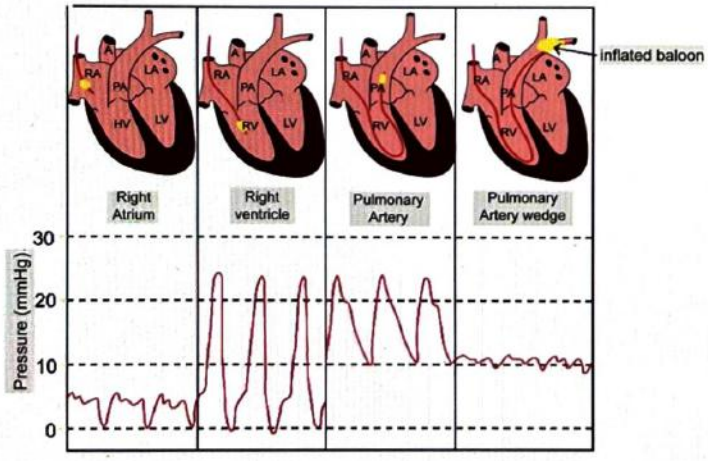
I. Central venous pressure monitoring
II. Hemodialysis
III. Intravenous pacing of heart
IV. Parenteral nutrition
V. Hyperosmolar drugs like/ inotropes / K+/ antibiotics
VI. Massive fluid transfusion

PULMONARY ARTERY CATHETER OR SWAN GANZ CATHETER

02:12:21



- It came in **1970** and this enabled clinicians to measure cardiac output bedside by the thermodilution method
- PAC can measure
  - Cardiac output
  - Right atrial pressure
  - Pulmonary artery pressure
  - Cardiac preload
  - Mixed venous oxygen saturation (Idea about global oxygen delivery
  - Monitors core temperature
- This catheter is placed in the same way as central venous catheter
- The only difference is that central venous catheter is left at the junction of superior vena cava and right atrium while pulmonary artery catheter is further progressed (introduced)
- PAC is introduced at different chambers of the heart and on the back of the catheter a pressure transducer is attached and tip of the catheter
- When it moves, the change in the pressure at the tip of the catheter will be reflected and by through pressure transducer will be seen in the monitor



In this figure, its shown that PAC goes in different chambers, it measures pulmonary artery pressure

- In right atrium the diastolic pressure is 0 and systolic pressure is 3-5 mmHg
- In right ventricle the diastolic pressure is 0 and systolic pressure is 20-25 mmHg
- In pulmonary artery the diastolic pressure will become 10-11 mmHg and systolic 20-25 mmHg
- From pulmonary artery inflate the balloon, it's get lodged in pulmonary capillary and immobile column of blood is collected which would give us idea of the pressure in left atrium

Important Information

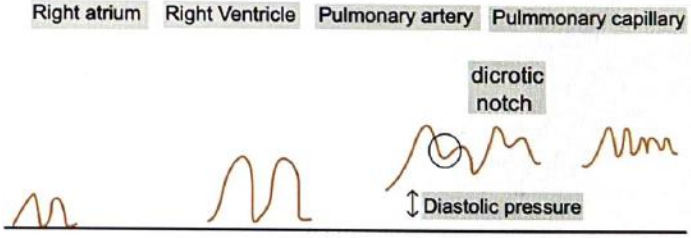
2 things will ensure that pulmonary artery catheter entered the pulmonary artery

- Appearance of the diastolic pressure in graph
- Appearance of the dicrotic notch

Important Information

- Adult pulmonary artery catheter is a multiple lumen catheter 110 cm in length and 7.0/7.5 Fr in external diameter
- It has a balloon on the tip. When it inflates, it gets lodged in the pulmonary capillary

INTRODUCTION OF PULMONARY ARTERY CATHETER



- RA - less pressure
- RV - pressure increases
- PA - diastolic pressure and dicrotic notch
- PC - wedged and pressure reduces corresponds to the LA pressure

OTHER METHODS OF CARDIAC OUTPUT MEASUREMENT

02:21:03

I. Esophageal Doppler method
II. Arterial pressure waveform analysis

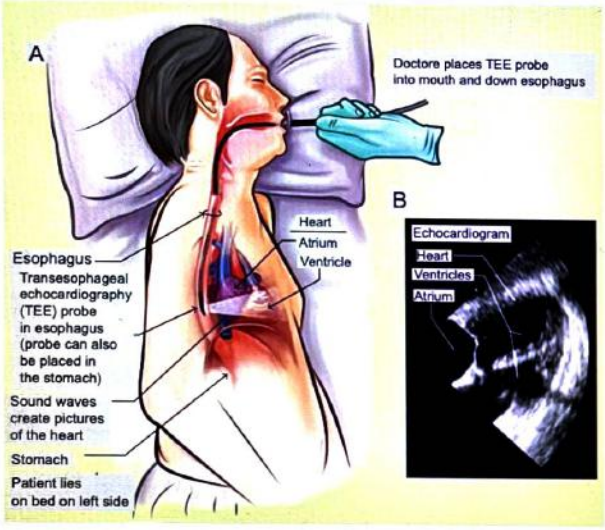
- Lithium dilution cardiac output
- Flotrac

III. Transesophageal echocardiography (TEE)

Transesophageal Echocardiography

- Minimally invasive

> **Important Information**
>
> - Most sensitive monitor for peri-operative cardiovascular monitoring
> - Most sensitive monitor to diagnose air embolism



- In this fig t probe is inserted in the esophagus through the oral cavity
- The transechocardiography probe is behind the heart and it is sending ultrasound beams to all the chambers of the heart
- So, in real time we can get full information of all the chambers of the heart and its minimally invasive

AIR EMBOLISM DIAGNOSIS

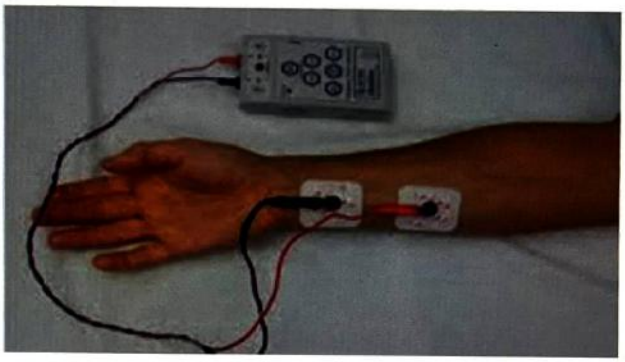
- TEE is best monitor followed by doppler ultrasonography followed by $EtCO_2$, ECG, NIBP
- Air embolism is diagnosed by TEE when CO is not affected, when CO is getting affected than only $EtCO_2$ will fall and confirms that air embolism has happened

> **Important Information**
>
> - In air embolism there is sudden drop of EtCO2 because of decrease in CO. But in TEE even before decrease in CO, very small amount of air can also be quantified and things can be reversal. SO, TEE diagnose air embolism even, when CO is not affected

NEUROMUSCULAR MONITORING

02:28:32

- It is a monitor which monitors the effect of neuromuscular blocker on neuromuscular junction
- It monitors
  - Onset of blockade
  - Intensity of blockade
  - Reversal from blockade



- In this fig it shows that on easily accessible nerve, 2 electrodes attached, and they are attached in the course of the ulnar nerve
- The ulnar nerve is stimulated and response is seen in the adductor pollicis muscle and contraction will be seen
- By visible seen the contraction or by electrically measuring the contraction ,get an idea about whether neuromuscular junction is blocked adequately or not
- Ulnar nerve is the most common site of neuromuscular monitoring

Principle

- A supramaximal electrical stimulus is given to accessible peripheral nerve (eg: ulnar nerve) and response is observed in concerned muscle group

Type of stimulus given

- Single twitch
- Train of four stimulus: M/C type of stimulus used, 4 stimulus delivered at 2 Hz
- Tetanic stimulus (Continuous stimulus)
- Double burst stimulation

Nerves used

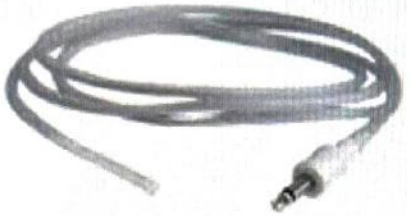
- Ulnar nerve: M/C
- Occipital nerve
- Tibial nerve
- Common peroneal nerve

> **Important Information**
>
> - Neuromuscular monitoring and BIS monitoring are advisable monitors used in general anesthesia. Both are non-invasive

TEMPERATURE MONITORING

- It is a mandatory monitor, should be attached with the patient during general or regional anesthesia

02:34:40



- In this fig, it is shown a esophageal temp probe on left side and skin temp probe on right side, which can be attached on skin surface
- They all can attached to transducer to monitor the temp. continuously

In temperature monitoring

- Core temp is monitored
- Sites for temperature monitoring
  - Pulmonary artery catheter temp. monitoring- is most sensitive, it is not routinely put in every patient
  - Lower $\frac{1}{3}$ rd of esophagus- 2nd best and best site for core temp monitoring in normal patient
  - Tympanic membrane –most correlates with brain temp
  - Rectal temperature
  - Nasopharynx

This sequence is from best to worst

EVOKED POTENTIAL MONITORING

02:37:54

- It is not a routine monitor, not done in every patient
- It is done only on those surgeries whether the surgical site is near tissue (spinal cord surgery or brain surgery etc)
- Non-invasive monitor of neural pathways
  - Sensory pathway: Sensory evoked potential
  - Motor pathway: Motor evoked potential
  - Somatosensory pathway: Somato-sensory evoked potential (Mixed nerve pathway)

Measuring sensory pathway

- When sensory nerve gets stimulate, response is measured by the electrodes
- The delay in the response and amplitude of response tells the competency of the pathway

Measuring motor pathway

- Stimulate the particular area of motor cortex and see the response in the peripheral area
- These monitoring is done under general anesthesia and patient is being given lot of anesthetic agent
- Most of the anesthetic agents, themselves affects these pathways So if the pathway is slowed or affected because of the anesthetic agent, will get a false positive result
- Most of the anesthetic agents were studied for the effect on these pathways. They are analyzed and the pathways which are least affected by anesthetic are monitored

Important Information

- **Evoked potential monitoring is affected by anesthetic agents**
  - **N_2O least affects evoked potential monitoring**
- **Brain Stem Auditory Evoked Potential Monitoring is M/C evoked potential monitoring done**
  - **Least affected by anesthetic agents**

Table 1.1

Internal jugular vein cannulation	Subclavian vein cannulation	Femoral vein cannulation
Advantages • It is in direct continuation with heart, so best estimate of central venous pressure • Ultrasound guidance is easy to follow • Valveless	**Advantages** • Least chance of infection • Best tolerated by the patient **Disadvantages** • It is not very visible through ultrasound • Less compressible if subclavian artery is punctured • Chances of hematoma will be huge • So in coagulation disorder, it is not preferred site	• Least preferred site

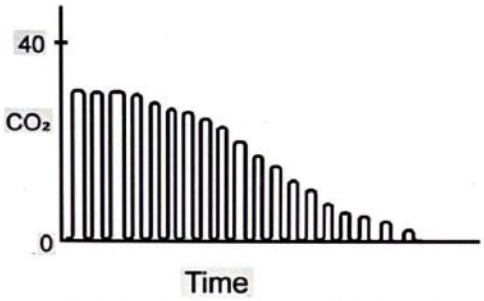
CLINICAL QUESTIONS

Q. A 48 year old male posted for resection of cerebellopontine angle tumor under general anesthesia. Patient was induced with Inj. Thiopentone sodium and intubation facilitated with the aid of Inj. Rocuronium. The patient placed in the sitting position for the better operator orientation and to reduce the blood loss. Intraoperatively the monitor showed sudden decrease in $EtCO_2$.The most probable diagnosis is?

A. Air embolism
B. Obstructive Airway disease
C. Malignant hyperthermia
D. Oesophageal intubation

Answer: A

Solution



Events that cause an exponential in end tidal CO_2 include sudden hypertension, circulatory arrest and pulmonary embolism

Sudden drop of End tidal CO_2 to zero is usually caused by the following

- Extubation
- Esophageal intubation
- Complete breathing system disconnection
- Ventilator malfunction
- Totally obstructed tracheal tube
- Plugged gas sampling tube

Sudden drop of End tidal CO_2 to low not zero is usually caused by the following

- Poorly fitting tracheal tube or mask
- Leak or partial disconnection in the breathing
- Partial obstruction of tracheal tube

Exponential decrease in End tidal CO_2 is usually caused by the following

- Sudden hypotension (Massive blood loss or obstruction to a major blood vessel)
- Circulatory arrest with continued pulmonary ventilation
- Pulmonary embolism (air, clot, thrombus or marrow)

Reference: Dorsch and Dorsch Anaesthetic Equipments, 5th edition, p.g. 1023 ,1024

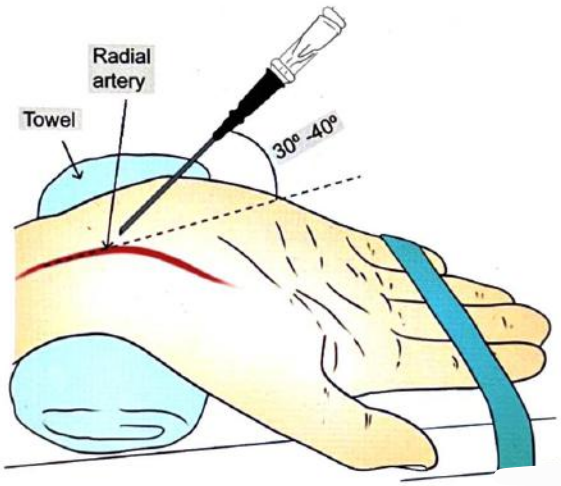
Q. A 50 year old male who is a known case of systemic hypertension, diabetes mellitus and triple vessel coronary artery disease posted for coronary artery bypass graft surgery. Right internal jugular vein was cannulated under ultrasound guidance for central venous pressure monitoring. The most preferred artery to be cannulated in this case for invasive blood pressure monitoring is?

A. Radial artery
B. Ulnar artery
C. Femoral artery
D. Axillary artery

Answer: A

Solution

- The radial artery is the most common site for invasive blood pressure monitoring because it is easy to cannulate and complications are rare
- The radial artery is chosen for cannulation primarily because of the superficial nature of the vessel, substantial collateral flow and ease of maintenance of the site. The radial artery lies between the brachioradialis tendon and flexor carpi radialis tendon, approximately 1-2 cm from the wrist, medial to the bony head of the distal radius.



- Before cannulation of radial artery, Modified Allen's Test is the most frequently used method to clinically assess adequacy of ulnar artery collateral flow despite poor predictive values. Doppler ultrasound can be used to evaluate collateral hand perfusion in an effort to stratify the risk of potential ischemic injury from cannulation.
- Ulnar artery: more deeper and has tortuous course. so it is difficult to catheterise
- Axillary artery: surrounded by axillary plexus and nerve damage can result from hematoma or traumatic cannulation, air or thrombi can access to cerebral circulation quickly during vigorous retrograde flushing of axillary artery catheters
- Femoral artery: prone to atheroma formation, infections, thrombosis, aseptic necrosis of femoral head

Reference: Morgan and Mikhail's Clinical Anaesthesiology 5th edition, Page no. 93
Miller's Textbook of Anaesthesia 9th edition, Page no. 1159

Q. A 27 year old female patient admitted in intensive care unit with the complaints of headache, nausea and shortness of breath. History revealed that she had no other comorbid conditions and history of unknown drug poisoning was noted. Clinical examination showed cyanosis, no pallor, blood pressure-100/60 mmHg, pulse rate-125/minute, SpO_2-99%, and respiratory rate-30/minute. The probable diagnosis in this case is?

A. Methemoglobinemia
B. Carboxyhemoglobin

C. Hemoglobin S, Hemoglobin F
D. Sulphemoglobin

Answer: B

Solution

Pulse oximetry

- Measure oxygen saturation of arterial blood (SpO2)
- 2 principle:
  Law of plethysmography – Measures the pulsatile flow of blood in capillary
  Law of oximetry / BEER LAMBERT'S Law

Inaccuracies in pulse oximetry reading

Most of the pulse: oximeters are designed to detect only 2 types of hemoglobin - reduced and oxygenated. Whole blood contains carboxyhemoglobin, sulphemoglobin and methemoglobin. This disturbs the absorbants ratio of the wavelengths used to determine oxygen saturation

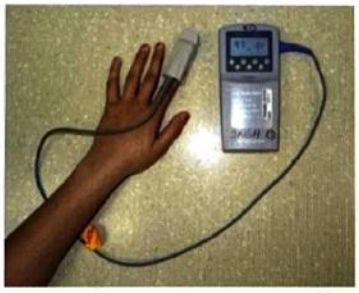
- **Methemoglobin**: absorbs light equally at the red and infrared wavelengths that are used by most of the pulse oximeters. When compared with functional saturation, most of the pulse oximeters give falsely low readings for saturations above 85% and falsely high values for saturation below 85%

- **Carboxyhemoglobin**: It has an absorption spectrum similar to oxyhemoglobin. So pulse oximeters will over read SpO_2 by the percentage of carboxyhemoglobin present
- **Fetal hemoglobin**: It doesn't affect the accuracy to clinically important degree. Very high levels may cause slightly low reading

- **Hemoglobin S**: The use of pulse oximetry in sickle cell disease is controversial. It is inaccurate and unreliable for detecting serious hypoxemia

- **Sulphemoglobin**: cause pulse oximeter to display artifactally low oxygen saturation

- **Other hemoglobinopathies**
  - Hemoglobin koln - artificially low oxygen saturation
  - Hemoglobin H disease - higher saturation than actual
  - Alpha thalassemia 2 and Hemoglobin constant springs - consistently low reading
  - Heinz body hemolytic anemia - low reading
  - Hemoglobin M Hemoglobin Hammersmith - It affects the reading so much .So it is not useful



Portable pulse oximeter with finger probe.

- Pulse oximetry = $HbO_2/(HbO_2 + HbH)$
- CO oximetry = $HbO_2/(HbO_2 + HbH + Sulph\ Hb + Meth\ Hb)$
- Reflectance oximeter - for forehead attachment E.g. Used in amputated patients

$HbO_2 \rightarrow$ Oxyhemoglobin, $HbH \rightarrow$ Deoxyhemoglobin

Reference: Dorsch and Dorsch Understanding Anesthetic Equipments 5th Edition, Page no-1138, 1139

Q. A 45 year old obese female patient posted for laparoscopic cholecystectomy under general anesthesia. Patient had one 20 G IV cannula on the right hand and not able to secure peripheral venous cannula anywhere because of morbid obesity. Central venous cannulation was planned under ultrasound guidance. The most preferred site for central venous cannulation to prevent catheter related infections in this patient is?

A. Subclavian vein
B. Femoral vein
C. Internal jugular vein
D. External jugular vein

Answer: A

Solution

Subclavian vein

- Is the site with least infection and better patient tolerance.
- But; the demerit is torturous course and high risk for pneumothorax, neurovascular injuries

Right internal jugularvein is the most preferred for,

- Transvenous pacemaker wires
- Hemodialysis catheters
- Pulmonary artery catheters
- Reasons for this preference are
  - Absence of valves.
  - Consistent anatomic location of the internal jugular vein.
  - Easily identifiable surface landmarks.
  - Direct communication with the right atrium.
- Awake patients complain of discomfort and limited neck mobility, so other sites to be preferred
  - **Left internal jugular vein**: greater risk of pleural effusion & chylothorax.

Other sites

- **Femoral vein**
- least desirable site, increased risk of thromboembolic complications, infection and vascular injury.
- favored site during cardiopulmonary resuscitation and for temporary hemodialysis catheters
- avoid in deep vein thrombosis and penetrating abdominal injuries

Reference: Marino's The ICU book 4th edition

Q. A 45 year old patient admitted with the history of road traffic accident in the casuality. His glasgow coma scale was 6/15. While doing laryngoscopy, the oral cavity was filled with blood and vomitus. After thorough oropharyngeal suctioning the anesthesiology resident intubated the patient but chest rise could not be seen and immediately the cuff deflated and the endotracheal tube removed then reintubated and connected to mechanical ventilator. The monitor which is most reliable to identify esophageal intubation in this case is?

A. Pulse oximeter
B. Measurement of CO_2 in exhaled air ($EtCO_2$)
C. Direct visualization of passing tube between the vocal cords
D. Auscultation over chest

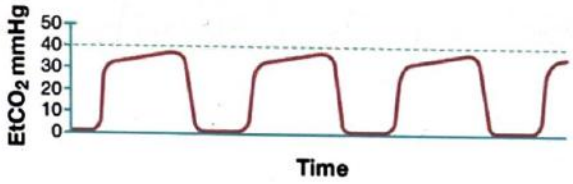
Answer: B

Solution

Endotracheal tube placement can be confirmed by

1. If chest rise
2. Visible condensation on the endotracheal tube
3. Bilaterally equal breath sounds over the chest wall
4. Over the epigastrium, lack of breath sounds
5. Tidal volume large exhaled
6. Appropriate compliance of reservoir bag during mechanical ventilation
7. Most important and objective indicator is presence of normal capnogram in atleast 3 breaths

Capnography



Others method for confirmation of placement of Endotracheal tube

- If clinical picture is unclear, flexible bronchoscopy, chest radiography can be used

Reference: Miller's textbook of Anesthesia 9th edition, Page no. 1397, 1398

Q. A 60 year old female patient underwent modified radical mastectomy under general anesthesia. She is very anxious preoperatively. Which of the following monitors, the anesthesiologist might have used during surgery so that she does not remember any intraoperative events?

A. Color doppler
B. End tidal CO_2
C. Bispectral index
D. Neuromuscular monitoring

Answer: C

Solution

Monitors used to assess depth of anesthesia

1. **Clinical signs**: blood pressure, heart rate, respiratory rate, pupillary response, perspiration, tearing, eyelash reflex, movement, response to commands

2. **Clinical techniques**
   - Skin conductance
   - Isolated forearm technique
   - Surface and facial electromyogram
   - Lower esophageal contractility
   - Heart rate variability

3. **Brain electrical activity monitoring**
   - Electroencephalography (EEG)

- Compressed spectral analysis
- Bispectral index (BIS)
- Entropy
- Evoked responses (EP) - Motor EP somatosensory EP, Auditory, visual, brain stem evoked potentials
- Patient safety index
- Narcotrend
- Patient state analyser
- SNAP index
- Cerebral function monitor

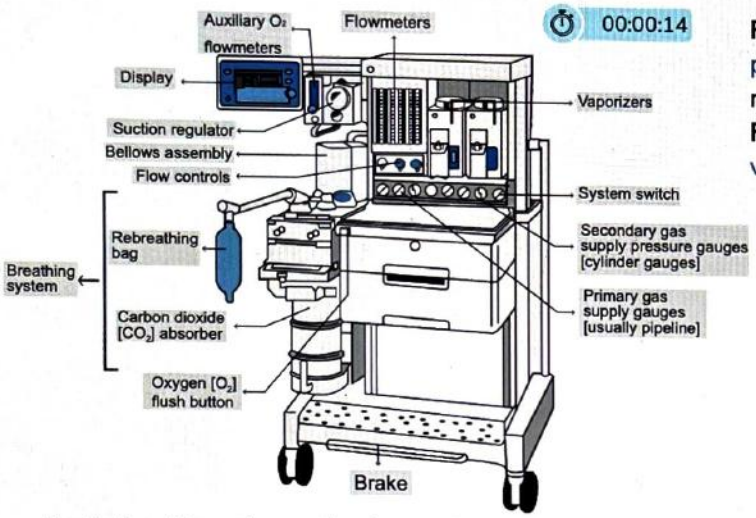
4. **Evoked potentials (EP)**: Motor EP somatosensory EP, Auditory, visual, brain stem evoked potentials
   - The bispectral index (BIS) is an empirically derived scale which helps to monitor the depth of anesthesia and intraoperative awareness.
   - It processes the EEG and provides an index value between **0 and 100** that indicates the patient's level of consciousness.

BIS index values range

- 100 - Awake (Responds to normal voice)
- 0 - Flatline EEG (Deep coma)
- Recommended range of BIS index values for anesthesia-40-60. Values of <60 associated with low probability of recall and high probability of unresponsiveness during surgery.

Reference: Stoelting's pharmacology and physiology in Anesthetic practice, 5th Edition, Page no. 67-69

5 ANESTHESIA MACHINE



00:00:14

- Basic function of anesthesia machine is to prepare a precisely known but variable mixture of gases and deliver it to the breathing circuit

HISTORY OF MACHINE

- **1917:** Dr. Edmund Gaskin Boyle designed Boyle's apparatus, the only system available for the continuous flow of gases. He was not the first person who developed this Boyle
- **1914:** Gwathmey made Gwathmey's box. He was using it for some time for the flow of gases but it was not marked as essential
- Dr Boyle improvised the Gwathmey's box

THE ADVANCED MACHINE/ ANESTHESIA WORK STATION

00:03:51

1. It accurately mixes anesthetic gas and vapours
2. It gives oxygen to the patient
3. It has a ventilator attached to it
4. It has monitors attached to it
5. It minimizes anaesthesia-related risks to patients as well as staff

Figure A

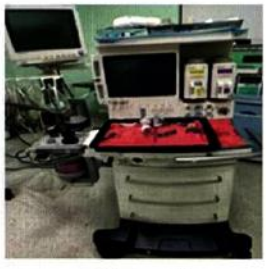


Figure B

Figure A is a basic anesthesia machine. It has only a pneumatic component. It has no electrical components, not run by electricity

Figure B is a modern anesthesia workstation, has ventilators and monitors attached

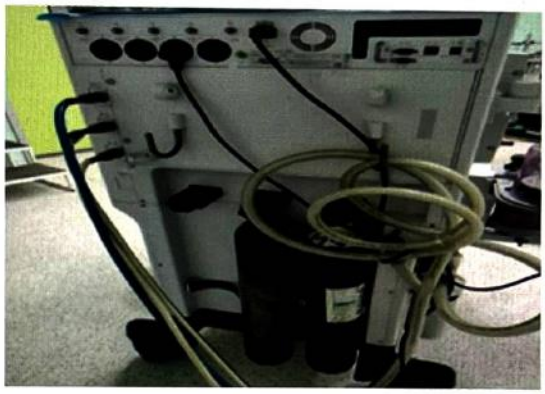


Figure C

Figure C back of the machine has electrical sockets (black), cylinders attached, pipeline attached

ANESTHESIA WORK STATION IS DIVIDED INTO 2 PARTS

00:08:04

1. Electrical components

- Master switch: When turn ON the master switch, only then the machine will turn ON
- Power back up: In case of power failure, the machine has its own power backup
- Power failure indicator
- Electric sockets: It is not advisable to attach any outside devices to the electrical socket of this machine
  - It may not have that much power to sustain those devices
  - If attach outside devices there are power circuit breaker in the machine, which would break the circuit and save the machine from damage
- Circuit breaker: To save the machine from any damage

2. Pneumatic components

00:10:52

I. High-pressure system
II. Intermediate pressure system
III. Low-pressure system

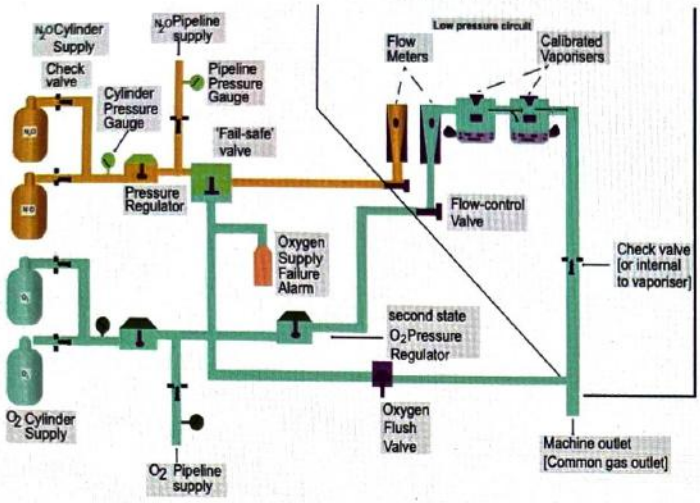


Fig A: Line diagram of machine

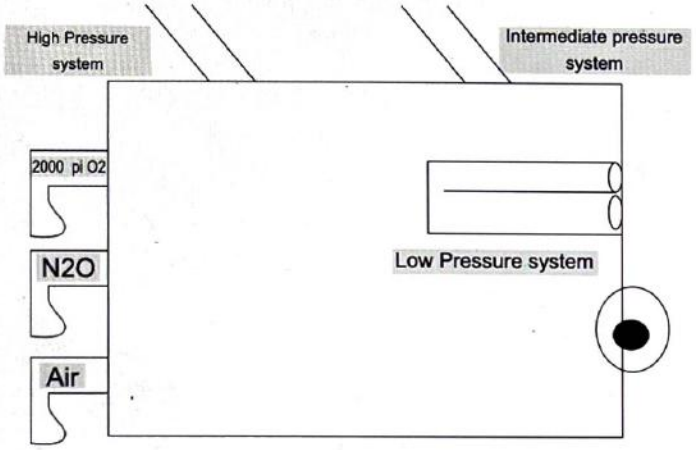


Fig A: From cylinders, gases are received by the machine and it flows through the machine

- Oxygen cylinder has gases of 2000 psi, so the machine receives 2000 psi, which passes through the machine and reaches a point called pressure regulator, where the pressure of the gas is reduced
- This point is the first pressure regulator, till here it is called a high-pressure system. Beyond this, it enters the intermediate pressure system and reaches the second pressure regulator, where the pressure of the gas is reduced more and then reach a low-pressure system
- As the gases flow through the machine, the pressure gets reduced and ultimately the gases are received at 8-10 psi which our lungs can tolerate

I. High Pressure System: till first pressure regulator 00:18:10

- Hanger yoke Assembly: the point of the machine where the cylinder is attached
- Cylinder Pressure Gauge or Bourdon's Pressure Gauge
- First Pressure Regulator

II. Intermediate Pressure System 00:19:00

- Pipeline inlet connection
- Pipeline pressure indicator 55 to 60 Psi pressure
- Piping (pipeline supply)
- Gas power outlet
- Oxygen failure safe valve
- Oxygen failure safety alarm
- Emergency oxygen flush
- Second stage pressure regulator
- Flow control valve which controls the flow of gases from the machine

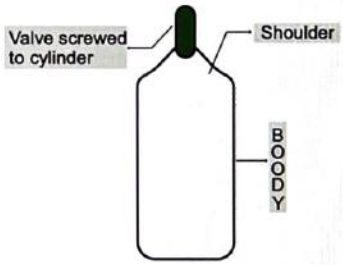
III. Low Pressure System

- Pressure 14-20 psi and then it reduced to 8-10psi
- Flowmeters 00:21:01
- Vaporizer
- Pressure check valve
- Hypoxia guard
- Common gas outlet

I. HIGH PRESSURE SYSTEM

Gas Cylinders 00:22:13

- Gas cylinders are not the part of anesthesia machine
- They are mounted on high pressure system of anesthesia machine
- Gas cylinders are made up of steel and molybdenum because it gives high tensile strength & it is lightweight
- MRI compatible cylinders are made up of Aluminum or Titanium
- **Size**: A to HH (in increasing order)
- Most commonly type E cylinder is attached to the anesthesia machine



- **2 parts of the cylinder**

I. Body (Lower part): which can stand straight on the ground

II. Shoulder/neck (upper tapering end): fitted with a screwed valve

Oxygen cylinder

Oxygen cylinder

- Back of the cylinder has a conical machine which is fitted with a handle
- Part which attaches to the machine has a central port, which would go into conical depression coming out the machine and through which the gas will flow in the machine and below the port
- There are 2 small holes that will correspond to the pin index on the machine where the cylinder is attached

Pin Index System

- It is a system that prevents incorrect attachment of cylinder to the machine. Around the port in the semicircular form 9/16 dm, the holes are arranged which correspond to pin
  - **Pins**: coming out of the machine
  - **Pinholes**: present on the cylinder
- Every gas cylinder has unique pair of pinholes in which pins (coming from the machine) attach
- Various safety mechanisms present in the cylinder in order to prevent wrong attachment

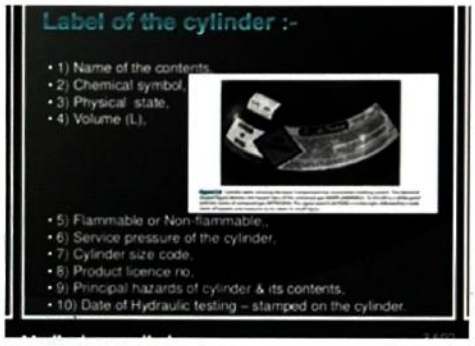
1. Color coding

- Every gas cylinder has its own unique colour. Oxygen has a black body white shoulder, N_2o is blue

Oxygen cylinder N_2o cylinder

2. Label of cylinder

- It is the most accurate to identify the content of the cylinder



- Name of the contents
- Chemical symbol
- Physical state
- Volume of gas
- Flammable or non-flammable
- Service pressure of the cylinder
- Cylinder size code
- Product license no
- Principal hazards of the cylinder and its contents
- Data of hydraulic testing (stamped on the cylinder)

Important Information

Contents of cylinder is best identified by:

- **Color coding**
- **Pin index**
- **Label of the cylinder**

Color coding is also helpful but no. of times there can be a mistake inspite of color, due to lack of maintenance or due to different shades of the color as well

Previous Year's Questions

Q. Color of the nitrous oxide cylinder is?
(FMGE June 2019 and INI CET Nov 2020)

A. Blue
B. Blue body white shoulder
C. White
D. Black

3. Pin-index system

- It is a safeguard introduced to eliminate any possibility of wrong attachment of cylinder to the machine

O_2 Cylinder

- Color coding: Black body & white shoulder
- Pin index: 2,5
- Pressure: 2200 psi, if its fully loaded
- If the pressure of the O_2 cylinder is < 1000 psi. It is mandatory to change the cylinder
- Calculation: How much gas is present in the cylinder and for how long it will last at a particular flow rate. Below is formula
  - Calculate the total volume and divide with pressure
  - An E type of oxygen cylinder contains 22 cubic feet of oxygen
  - One cubic feet = 28.3 L
  - Tank factor of type E cylinder = $\frac{28.3 \times 22\ L}{2200\ psi} = \frac{0.28\ L}{psi}$
  - Time till cylinder will last = tank factor $\frac{(guage\ pressure\ -500)}{Flow\ per\ min}$

$$= \frac{0.28\ (200-500)}{8\ L} = 52.5\ min$$

- Formula: To calculate for how long the cylinder will last, once open the cylinder the pressure comes, subtract 500 and divide with flow rate we want to give
- Thus, a cylinder with a pressure of 2000 psi at a flow of 8 L per minute will last for 52.5 min
- At a pressure of 1000 psi, it will last for 45 min

N_2O cylinder
- Color coding: Blue
- Pin index: 3,5
- Pressure: 760 psi

Air cylinder
- Color coding: Grey body + Black & White shoulder
- Pin index: 1,5

Co_2 cylinder
- Color coding: grey
- Pin index
  - 1,6 When > 7% CO_2 conc^n
  - 2,6 When < 7% CO_2 conc^n

Cyclopropane
- Potent agent
- Color coding: Orange
- Pin index: 3,6

Important Information

- Potent inhalational agents are not stored in cylinder
- They are liquid at room temperature. Therefore, are stored in vaporizers
- Cyclopropane is the only potent inhalational agent which is not liquefied at room temperature.
- It is gas at room temperature. Therefore, stored in cylinder

SUMMARY

	Color	Pin index
O_2 cylinder	Black body + white shoulder	2,5
N_2O cylinder	Blue	3,5
Air cylinder	Grey body + Black + Black white shoulder	1,5
CO_2 cylinder	Grey	2,6
Cyclopropane	Orange	3,6

HELIUM CYLINDER
- It is Heliox ($He + O_2$)
- Helium is added to O_2 because it decreases
  1. The viscosity of oxygen
  2. The decreases the turbulence of oxygen
  3. Resistance and work of breathing
- Color – Brown
- He: oxygen
  - 70 : 30
  - 60 : 40
- Pin index
  - 2,4
  - 4,6

I. HIGH PRESSURE SYSTEM

Hanger Yoke Assembly 00:47:45
- It orients and supports the cylinder for a tight seal and unidirectional flow of gas from the cylinder to the machine
- A Nipple projects out from yoke Assembly system which will fit into the cylinder port
- 2 index pins project out which will fit into its corresponding holes
- Nipple has a washer which creates a seal named as Bodok seal which prevents any leakage of gas
- **Cylinder pressure gauge or Bourdon's pressure gauge** 00:50:00
  - It has a calibration 33% more than the total pressure of the cylinder
- First Pressure regulator
  - High pressure is reduced to 45 psi for oxygen and 30 psi for N_2O

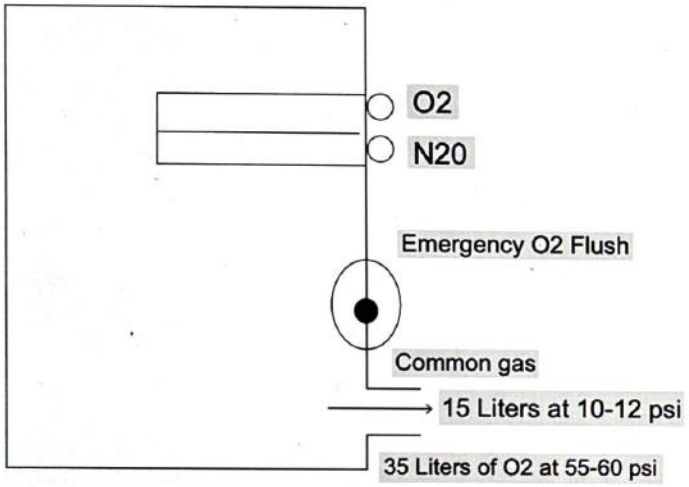
II. INTERMEDIATE PRESSURE SYSTEM

00:52:46
- Pipeline supply: when pipeline supply is intact, the cylinder should be closed

Color Coding	
• Blue N_2O • White O_2 • Black Air } Vaccum • Yellow pipeline	These gases supplied at 55 to 60 psi

This figure is showing different pipelines. The end shown will attach to the machine and all pipelines have a different diameter (threading), to prevent any interchange of the pipeline

- DISS (Diameter Index Safety System)
  - It is a safely system which prevents incorrect attachment of pipeline to anesthesia machine
  - The pipeline inlet connection is incorporated with DISS
- Gas power outlet
  - Supplies gases to ventilator
  - Jet ventilation
- Oxygen failure safe valve
  - It is a valve which closes if O_2 pressure falls below a required limit
- Oxygen failure safety alarm or **Ritchie's whistle**
  - If O_2 pressure falls below 30 psi, → alarm gets activated

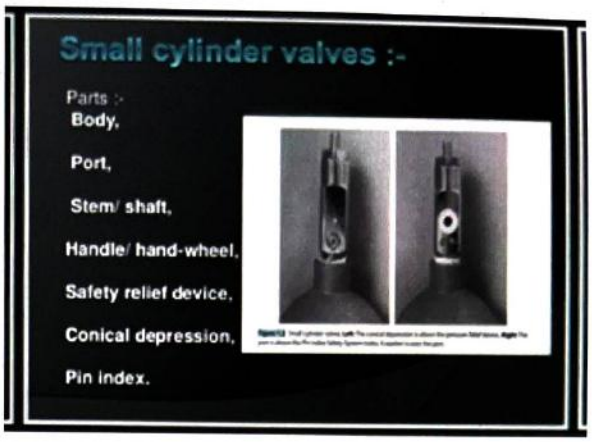


- **Emergency O_2 flush**
  - When it is pressed inwards, 35 Liters of O_2 comes out at pressure of 55 to 60 psi
  - It is not used routinely. It is used only in emergency situations

Important Information

- **The oxygen which comes out can be 35-75 L (it varies from machine to machine)**

- Second Stage Pressure Regulator
  - This reduces the pressure of O_2 to 14 psi and N_2O to 28 psi
- Flow Control Valve
  - The second pressure regulator is attached on flow control valve



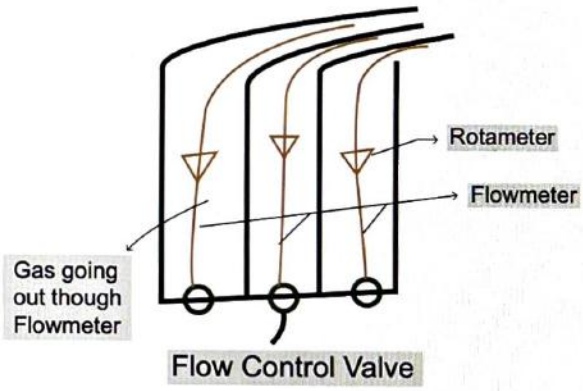
- Flow control valves are colour-coded and fluted.
- **O_2:** White has wider, thickened striations
- **N_2O:** Blue
- **Air:** Black

III. LOW PRESSURE SYSTEM

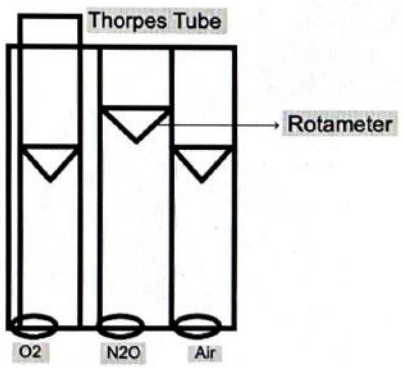
01:07:43

- **Flowmeters**
  - Flowmeters are of 2 types
  1. Mechanical flowmeters (glass flowmeters) made up of glass tube with single/ dual taper. Upper end of rotameter indicates true flow of gas
  2. Electronic flowmeters

Mechanical flowmeters



Flowmeter



Rotameter

In this figure: when flow control valve is turned ON, the flow indicator ascends, is held in the center, rotates on its axis and indicates the flow of gas

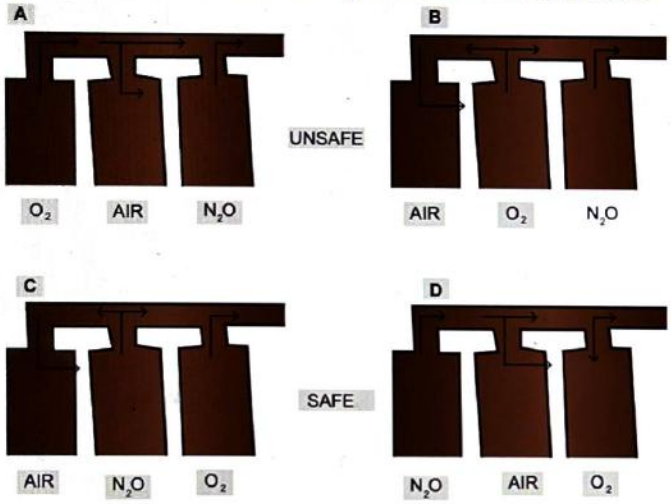
- Individual indicators which rotates on its axis is called rotameter

Thorpe's tube

- Special tube designed by Thorpe for flowmeter
- Mechanical tube of the flowmeter which has rotameter in it which rotates and indicate the flow

Arrangement of flowmeter

- Direction of one part of the machine to other is described as downstream/ upstream
- **Downstream**: from cylinder towards common gas outlet
- **Upstream**: from common gas outlet towards cylinder



- **Figure A**: N_2O and air is downstream to O_2 towards the flow meter. So any leak in air than O_2 will also leak
- **Figure B**: O_2 in between. If there is any leak in any part than O_2 will also leak
- O_2 should always be kept downstream. If there is any problem in N_2O atleast O_2 will be delivered

Important Information

- **O_2 flowmeter should always be downstream to N_2O and air flowmeter**

VAPORISERS

01:14:30

- It is a device which stores potent agent in liquid form and vaporises it and add to O_2 and N_2O/ air
- **Color coding** for vaporiser
  - **Halothane** - Red
  - **Isoflurane** - Purple
  - **Sevoflurane** - Yellow
  - **Desflurane** - Blue
  - **Enflurane** - Orange

HYPOXIA GUARD

01:15:39

- Safeguards that prevent O_2 conc^n to fall below the required limit
- There are 3 hypoxia guards:

1. Link 25 system: N_2O flow control valve is mechanically linked to O_2 flow control valve.
   - A chain is attached between N_2O and O_2 control valves. When N_2O flow control valve is turned ON, O_2 flow control valve also moves in a certain direction and until and unless, a certain amount of O_2 open, N_2O will not stop.
   - If O_2 flow turns ON, N_2O will not start. There is a required amount of O_2 which has to start, only then N_2O will stop
2. Basal O_2 flow of machine: master switch starts a minimum O_2 flow from machine, when it is turned on, varies from 25 – 250 ml/min
3. O_2 safety alarms: If O_2 Conc^n falls below certain limit, alarm gets activated

PRESSURE CHECK/ RELIEF VALVE

01:20:00

- It protects by decreasing the pressure

COMMON GAS OUTLET

01:20:32

- Breathing system is attached to common gas outlet for final flow of gas out of anesthesia machine

CLINICAL QUESTIONS

Q. A 35 year old obese male who is a case of gynaecomastia planned for webster's procedure under general anesthesia. After the induction of anesthesia with Inj. Thiopentone sodium, the reservoir bag was collapsed. Guedel's airway was inserted and the oxygen flush valve was activated and then the patient was ventilated and intubated. No other leaks were found in anaesthesia machine. This oxygen flush valve does nothave?

A. Delivery of a flow between 25 and 50 L/minute
B. Barotrauma and awareness during anaesthesia if accidentally activated
C. Activation regardless of master switch on off
D. Delivery of oxygen at 55 to 60 psi pressure

Answer: A

Solution

- Oxygen flush valve can deliver flow between 35 to 75 L /minute depending on the machine and operating pressure(minimum flow is 35 L/minute)directly to the patient's breathing circuit to overcome the circuit leaks or to rapidly increase inhaled oxygen concentration and it bypasses the anesthetic vaporizers.
- It can be activated regardless of whether the master switch is turned on or off.
- There is a direct tubing connecting the O_2 pressure regulator to the O_2 flush directs high unmetered flow directly to the common gas outlet
- It comes under the components of **intermediate pressure system**

Hazards of oxygen flush valve

- Accidental activation results in delivery of high tidal volumes cause barotrauma and awareness during anaesthesia due to delivery of diluted inspired anesthetic gases
- Internal leakage
- Sticking of the valve

Reference: Miller's textbook of Anaesthesia, 9th edition, page 579

Q. A 40 year old morbidly obese female patient who was posted for bariatric surgery under general anesthesia. She underwent laparascopic cholecystectomy under general anesthesia few months back. Inj. Propofol 200 mg was used for induction of anesthesia, endotracheal intubation facilitated with Inj. Succinylcholine and anesthesia was maintained with oxygen/nitrous oxide, desflurane and cisatracurium. Minimal mandatory percentage of oxygen used in this patient during the intraoperative period would be?

A. 33%
B. 30%
C. 21%
D. 66%

Answer: B

Solution

Nitrous oxide oxygen delivery is limited to a maximum of 70 percent and 30 percent oxygen delivery, during the administration of general anaesthesia, The delivery of nitrous oxide stops, If oxygen flow stops

Reference: British journal of Anaesthesia

Q. A 24 year old female posted for elective lower segment caesarean section under spinal anesthesia. Supplemental oxygen of 4 litres/minute kept through type E auxilary oxygen cylinder fitted on the anesthesia machine. This cylinder does not have?

A. Pin index safety system
B. Diameter index safety system
C. Contains high pressure
D. Air is stored in cylinder with black body with black and white shoulder

Answer: B

Solution

DISS

- It is a safely system which prevents incorrect attachment of pipeline to anesthesia machine
- Pipeline inlet connection is incorporated with DISS
- It is used in conjunction with individual gas lines of medical gas administering equipment at pressures of 200 psig or less.
- This includes outlets from medical gas regulators and connectors for anesthesia, resuscitation and therapy apparatus.
- They have a unique diameter for each type of gas, to prevent erroneous connection
- The system contains a valve at the outlet wall supply side, which shuts off gas supply upon disconnection.

Colour coding of cylinders

Gas	State in cylinder	International	USA
Air	Gas	Black body and shoulders with black and white quarters	Yellow
Oxygen	Gas	Black body and white shoulders	Green
Nitrous oxide	Gas + liquid (below 98 degree F)	Blue	Blue
Carbon dioxide	Gas + liquid (below 88 degree F)	Grey	Grey
Helium	Gas	Brown	Brown
Entonox		Blue body and shoulders with blue and white quarters	
Cyclopropane		Orange	Orange
Nitrogen	Gas	Black	Black

- In carbon dioxide-oxygen mixtures with CO_2>7%-cylinder is predominately grey and balance is green
- If CO_2<7%-cylinder is predominately green
- In He-O_2 mixture (He>80%)-predominant colour is brown and balance is green Air, including oxygen-nitrogen mixtures containing 19.5-23.5% oxygen-yellow and other than those containing 19.5-23.5% oxygen-black and green

Pin index-safety system

- It is a system which prevents incorrect attachment of cylinder to machine. Around the port in the semicircular form 9/16 dm, the holes are arranged which correspond to pin
  - Pins: coming out of machine
  - Pin holes: present on cylinder

- Every gas cylinder has unique pair of pin holes in which pins (coming from machine) attach
- Various safety mechanisms present in cylinder in order to prevent wrong attachment

Reference: Dorsch and Dorsch Understanding Anaesthesia equipment, 5th edition, page-12,118
Miller's textbook of Anaesthesia-9th edition, page-580

Q. A 54 year old male posted for hernioplasty under spinal anesthesia. Supplemental oxygen of 8 litres/minute kept through central gas supply as the patient was a known case of COPD. Suddenly the oxygen failure alarm was activated and no pressure was noted in the anesthesia machine. Type E auxilary oxygen cylinder already fitted on the anesthesia machine was opened and the surgery was completed. Oxygen content in this cylinder is?

A. 500 L
B. 1200 L
C. 900 L
D. 680 L

Answer: D

Solution
Medical gas cylinder dimensions and gas capacities

Cylinder size	C	D	E	F	G	J
Dimensions (mm) Capacities (L)	356x89	457x102	788x102	865x140	1248x40	1450x29
Oxygen	170	340	680	1360	3400	6800
Nitrous Oxide	450	900	1800	3600	9000	-
Entonox	-	500	-	2000	5000	-
Air	-	-	-	-	3200	6400
Carbon Dioxide	450	1800	1800	-	-	-

Maximum pressure in the E-cylinders
- 750 psig for nitrous oxide(liquid)
- 2000 psig for air(gaseous)
- 2000 psig for oxygen(gaseous)

Reference: Dorsch and Dorsch Understanding Anaesthesia equipment, 5th edition, page-13-14,118
Miller's textbook of Anaesthesia-9th edition, page-580

6 ANESTHESIA CIRCUIT

ANESTHESIA CIRCUIT OR ANESTHESIA BREATHING SYSTEM

00:00:16

- It is a link between anesthesia machine and the patient which brings inspiratory gas towards patient and takes expiratory gas away from the patient

Classification 00:01:30

I. Open circuit: Draw-over circuits or Open drop method.
- It is obsolete now. Not in clinical use anymore

II. Semi-closed circuit or Mapleson system of circuit: Used clinically

III. Closed Circuit or circle system: Most common and best circuit, used clinically

SEMI CLOSED CIRCUIT OR MAPLESON CIRCUIT/ SYSTEM

00:04:19

- Mapleson classified Mapleson system in 1954 from A to E.
- Later in 1975, Willis added F and so Mapleson circuit is from A to F

Components of Mapleson Circuit 00:08:29

- All 6 types of Mapleson circuit (Mapleson A to E) have same components. Only the orientation of components is different in each circuit.
  - Breathing tubes: Inspiratory limb & Expiratory limb
  - Fresh gas inlet: The end which is receiving gas from machine (entry point of gases into the circuit).
  - Expiratory valve/ adjustable pressure limiting valve
  - Reservoir bag/ breathing bag

Important Information

Breathing tubes
- **Corrugated and made up of plastic or rubber**

  - **Adjustable pressure limiting valve (APL valve)**
    → As anesthetic gases enter the circuit, expiratory gases enter the circuit, pressure will rise, if gas flow is greater than combined uptake of patient and circuit, Gases will exit out from the APL valve into atmosphere (OT) or scavenging system
  - **Reservoir bag**
    → Functions as reservoir for fresh gas and also act as a method for generating positive pressure ventilation.

MAPLESON A CIRCUIT OR MAGILL CIRCUIT

00:13:11

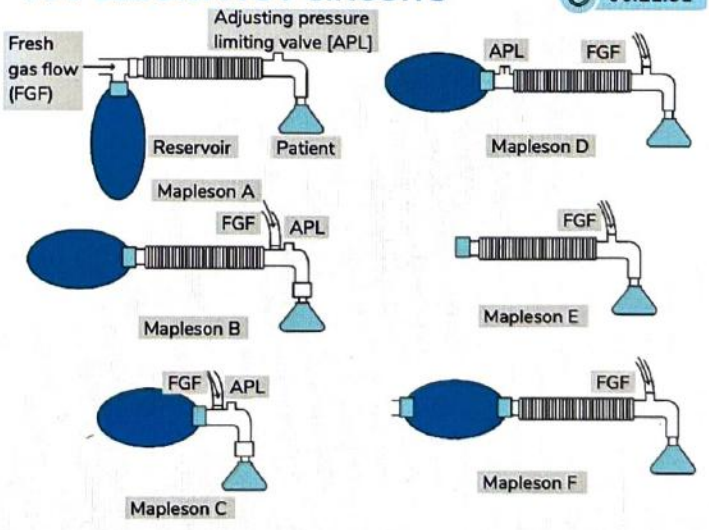
- It is designed by Dr. Ivan Magill
- Patient under anesthesia can be on spontaneous ventilation or controlled ventilation
- If patient is paralyzed, will be on controlled ventilation. So, the gas which is entering into the system, enters in the reservoir bag and which expands when the gas fills
- When the bag is squeezed, it acts as a positive pressure mechanism of sending the gas to the alveoli of patient. So, the inspiration is up
- After squeezing the bag, wait for expiration to happen. Expiratory gas will enter into the circuit
- Expiratory gas will be inspiratory gases + CO_2 too. After removing CO_2, we let patient to rebreathe other gases again, because when we squeeze back again these gases will reenter

Semi – closed circuit
- For inspiration: Fresh gas is given
- During expiration: Expiratory gas has to exit out, cannot separate CO_2 from rest of the gases

Important Information
- **Semi-closed circuit is less economical. On the other hand, closed circuit is more economical**

MAPLESON A TO F CIRCUITS

00:21:51



- When expiratory valve is near the patient end: It is good circuit for spontaneous ventilation
- When fresh gas inlet is near the patient end: It is good circuit for controlled ventilation

Mapleson A

- Inspiratory limb is longer and expiratory limb is shorter
- When connected in spontaneously ventilating patient, have to keep the fresh gas flow from the machine to towards the patient, which is equal to minute ventilation of the patient
- Expiratory gas will able to vent out
- Good circuit for spontaneous ventilation
- Has modified circuit also known as Lack circuit
- Fresh gas flow = Minute ventilation (spontaneous)
- Mapleson A for controlled ventilation is very uneconomical

Mapleson D

- Inspiratory limb is shorter and expiratory limb is longer
- If connect Mapleson D to spontaneously ventilating patient. Have to keep the fresh gas equals to 3 times of the fresh ventilation, then only the expiratory gases will exit out
- Best circuit of choice for controlled ventilation
- Has modified version also known as Bains circuit
- Fresh gas flow = 1.8- 2 times minute ventilation
- Mapleson D for spontaneous ventilation is very uneconomical
- Also called universal circuit, because it is best for controlled ventilation and 2nd best for spontaneous ventilation
- Mapleson B & Mapleson C: not much in clinical use

Mapleson Circuits

For Adults	For Pediatrics
A B C D	E F

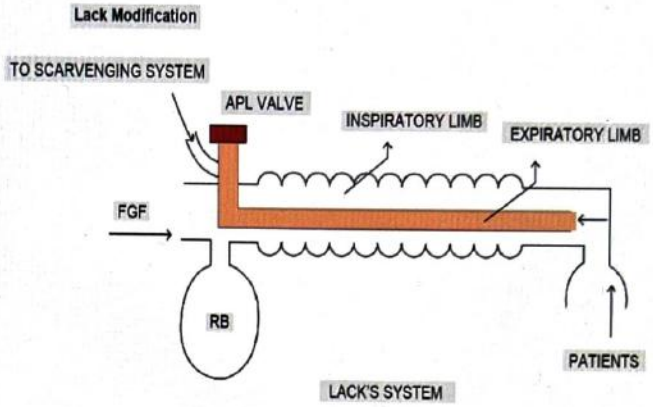
For Adults

	Spontaneous ventilation	Controlled ventilation
Best circuit	A	D
Worst circuit	B, C	A
Order	A > D > B = C	D > B = C > A

LACKS CIRCUIT

00:39:21

- It is a modified Mapleson A
- Also known as co-axial Mapleson A

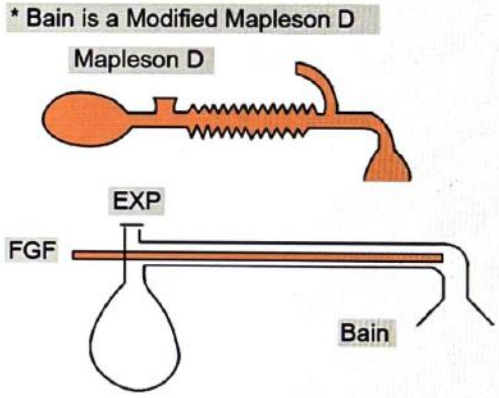


- Inspiratory limb: Outer
- Expiratory limb: Inner

BAIN'S CIRCUIT

00:42:22

- Modified Mapleson D
- Also, k/a Coaxial Mapleson D
- Inspiratory limb: Inner
- Expiratory limb: Outer



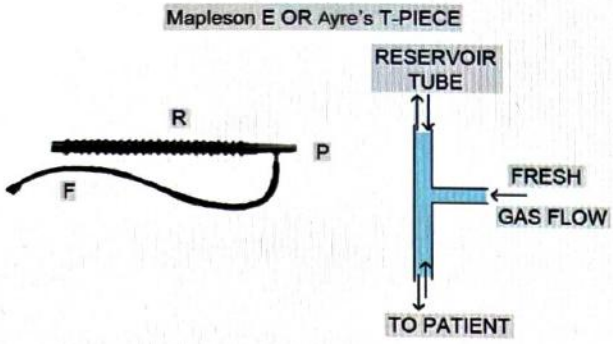
PEDIATRIC CIRCUIT

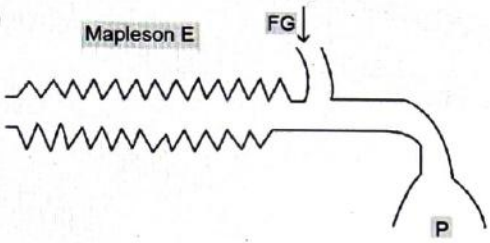
00:43:40

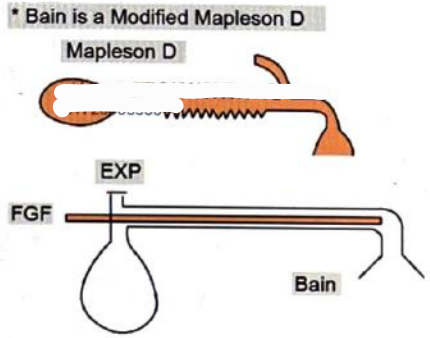
- Mapleson E & F
- < 6 years and < 20 kg
- Adult circuit has high pressure and high resistance, so not acceptable for pediatric patient

Mapleson E circuit/Ayre's T – piece (inverted T – shaped circuit)

- This circuit is used in pediatric patients
- Bagless and valveless circuit
- It is not a useful system because this system has not interpretation for the tidal volume used
- It can be used for spontaneous ventilation but cannot be used for controlled ventilation

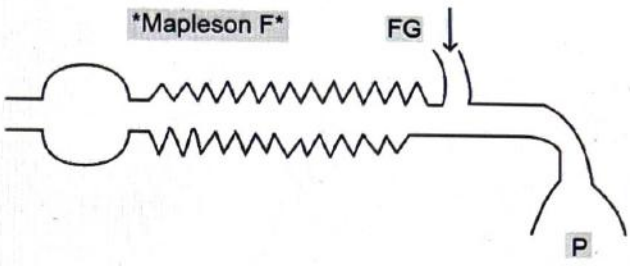






Mapleson F circuit

- Also, k/a Jackson Rees modification of Ayre's T-piece circuit
- Also, k/a Jackson = Rees circuit
- In this system, a bag is attached toward the expiratory end, thus movement of bag give us the visible perception about the tidal volume generated by child patient in spontaneous ventilation
- Controlled ventilation: The anesthetic holds the bag, close the opening of the bag with thumb, gently squeeze the bag, depending upon the age of the child, the opening is closed and generate pressure for ventilate. So, the ventilating pressure is under anesthetic control. When the child is in expiratory phase, gases will enter the circuit, so anesthetic will remove the thumb and gases will go out in atmosphere
- Can be used both for spontaneous ventilation and controlled ventilation
- It is semi-closed circuit of choice in Pediatric patient
- Disadvantage of semi-closed circuit-wastage of gas

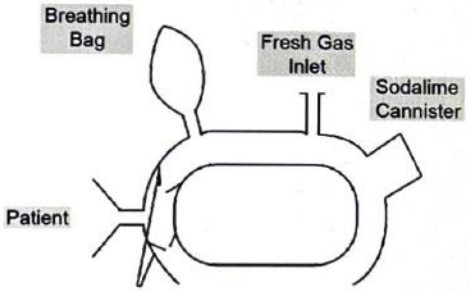


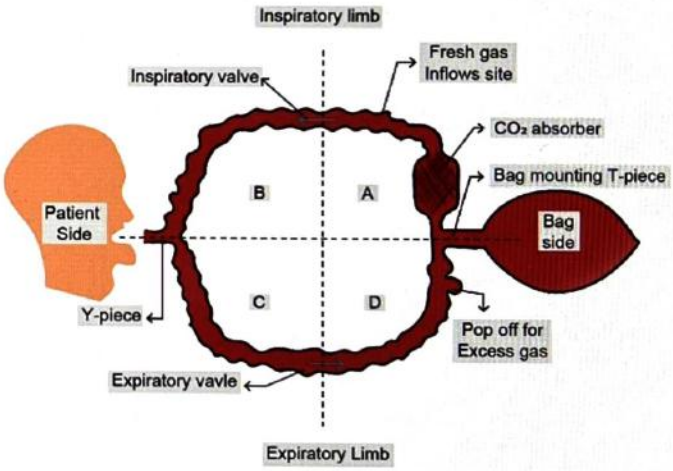
Mapleson system

Refer Table 6.1

CIRCLE SYSTEM (CLOSED CIRCUIT) 00:56:40

- Inspiratory limb and expiratory limb are separated
- Unidirectional valve is attached
- CO_2 absorber is attached





01:03:00

Semi – closed circuit	Closed circuit
• Less economical	• Very economical
• More atmospheric and operating room pollution	• Minimal pollution
• Heat & humidification is also lost	• Recycling of heat & humidification

• Light weight, simple portable	• Heavy (CO_2 absorber is attached), complex (lot of attachments), fixed, bulky
• Advanced monitoring is not mandatory	• Advanced monitoring is mandatory, because when expiratory gases get recycled, the potent agents can also get recycled and it would reach the patient alveoli
• Has common expiratory & inspiratory limb. • Therefore, every time fresh inspiratory gas is given and expired leading to wastage of gases	• Has separate inspiratory limb and expiratory limb with unidirectional valves

CIRCLE SYSTEM (CLOSED CIRCUIT) 01:06:56

- Circle system is unidirectional flow system with carbon dioxide absorption

Components of circle system

- A soda lime canister
- Two unidirectional valves
- Fresh gas entry
- Y - piece to connect to the patient
- A reservoir bag (for Positive pressure ventilation)
- Adjustable pressure limiting valve (to control pressure of the circuit)
- Circuit tubings

CO_2 absorber

- Soda lime
- Baralyme etc.

Soda lime

- M/C CO_2 absorber used in India: Soda lime
- Small granule of size 4 – 8 mesh in a transparent container
- Granular form has 2 advantages
  - The surface area of CO_2 will Increase
  - Free passage of gas

Composition of granules	
	% Age composition
NaOH	4%
KOH	1%
$Ca(OH)_2$	Rest
Water	14-17%
Silica	
Dye	

- Powder form: when expiratory gas pass, it will blow the dust and these particles can reach the alveoli through inspiratory limb, it can cause chemical pneumonitis. So, silica was added to prevent dust formation

Silica

- Gives hardness to soda lime
- Added to prevent dust formation

Dye

- Added to see the change in color
- Change in color indicates the exhaustion of CO_2 absorber.
- Pink: At basic of PH, Colorless – At acidic PH

Important Information

- NaOH, KOH, $Ca(OH)_2$, Water: Required for CO_2 absorption

CO_2 absorption 01:17:19

$$CO_2 + H_2O \longleftarrow H_2CO_{3(\text{carbonic acid})}$$

$$NaOH + H_2CO_3 \xrightarrow[KoH]{\text{Catalyst}} Na_2CO_{3(\text{sodium carbonate})} + H_2O$$

(last reaction)

$$Ca(OH)_2 + Na_2CO_3 \longrightarrow CaCo_3 + NaOH \text{ (freshly made and it recycled again)}$$

- NaOH formed is recycled and again used for CO_2 absorption
- As NaOH is highly caustic, thus to decreased its side effects, it is kept at low concentration & instead $Ca(OH)_2$ is used in higher concentration since $Ca(OH)_2$ is least caustic
- 100 gm of soda lime can absorb 21-26 litres of CO_2
- All above reaction are exothermic

Important Information

- Major constituent of soda lime which is present in higher amount is $Ca(OH)_2$
- NaOH main constituent of Soda lime which is responsible for CO_2 absorption

Baralyme 01:21:17

- Baralyme → $Ba(OH)_2$ + $Ca(OH)_2$
  (20%) (80%)
- Baralyme is not so popular because of
  - More chances of CO production
  - More heat liberated with baralyme
  - Chances of fire hazards

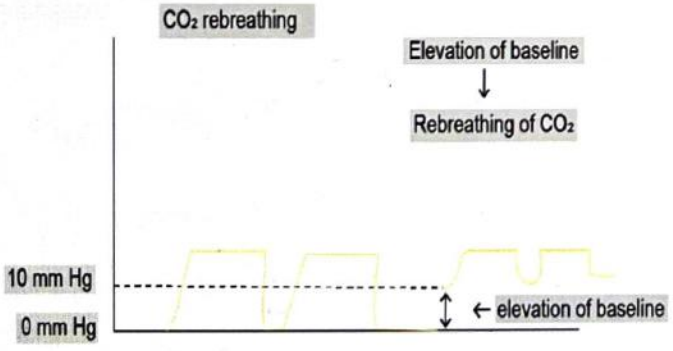
CLINICAL SIGNS OF CO_2 ABSORBER EXHAUSTION 01:22:50

- Hypertension (increased BP)

Important Information

- Hypocarbia it leads to
  - Sympathetic systemic is stimulated
  - Increased heart rate

- Sweating in anesthetized patient
- Increased oozing of blood from the surgical site.
- Change in the colour of CO_2 absorber
- Change in the graph of Capnography



PRE-DISPOSING FACTORS FOR CARBON MONOXIDE PRODUCTION IN CLOSED CIRCUIT 01:25:55

- Caused by
  - **D** - Desflurane
  - **I** - Isoflurane
  - **E** - Enflurane
- Very high concentration of
  - **D** - Desflurane
  - **I** - Isoflurane
  - **E** - Enflurane

How to remember

- DIE

- Dry CO_2 absorber
- Use of Baralyme ($Ba(OH)_2$) + $Ca(OH)_2$) instead of soda lime

Previous Year's Questions

Q. Maximum airway irritation caused by?
(NEET Jan 2019)

A. Desflurane
B. Enflurane
C. Sevoflurane
D. Halothane

LOW FLOW ANAESTHESIA 01:28:08

- Low flow anaesthesia is possible only with circle system (closed circuit)
- Any technique utilizing fresh gas flow to be kept less than alveolar ventilation of the patient is Low flow anaesthesia.
- It is a technique in which 50% of expired gas is recycled after CO_2 absorption

Table 6.1 Mapleson System

A	B C	D	E	F
Adult circuits			**Pediatric circuits (<20 kg, <6 years)**	

• Also, Ak/a Magill circuit
• Circuit of choice for spontaneous ventilation in adults
• It requires less fresh gas flow (FGF) for CO_2 elimination
• Lesser the FGF required for expiratory CO_2 elimination → more efficient is the circuit.
• In Mapleson A, we keep:
  ○ Fresh Gas flow (FGF) = Minute ventilation (MV) for spontaneous ventilation
  ○ For controlled ventilation FGF = 3 x MV (Very high FGF)
	• Not of any use	• Circuit of choice for controlled ventilation in adults
		• For controlled ventilation, we keep:
		  ○ Fresh Gas Flow = 1.8-2 x M V.
		  ○ In spontaneous ventilation, FGF = 3-4 x MV (Very high FGF)
			• Aka Ayer's T - piece circuit
			• Bagless, and valveless
			• Useless circuit
				• Aka Jackson Rees modification of Ayre's T – piece
				• Circuit of choice of pediatric patient for both controlled ventilation on & spontaneous ventilation
				  ○ For Spontaneous Ventilation, FGF = 3-4 x MV
				  ○ For Controlled Ventilation, FGF = 2-3 x MV

Modified Mapleson A • Aka Lack's circuit • Aka Co axial Mapleson A		**Modified Mapleson D** • Aka Bain's circuit • Aka coaxial Mapleson D		

FGF: Fresh Gas Flow
MV: Minute Ventilation

CLINICAL QUESTIONS

Q. A 50 year old female who is case of carcinoma cervix posted for brachytherapy, planned under total intravenous anesthesia with spontaneous ventilation assessed through magill circuit. The fresh gas flow used in this patient is?

A. Equal to minute ventilation
B. Twice the minute ventilation
C. 2.5 times the minute ventilation
D. Half the minute ventilation

Answer: A

Solution

- **Mapleson A** or the Magill circuit is the circuit of choice for spontaneous ventilation.
- In all mapleson circuits, rebreathing of carbon dioxide is prevented by an adequate fresh gas flow and by the presence of adjustable pressure release valve. The exhaled carbon dioxide flows through the outer corrugated tube and out via this valve from where it can be scavenged.
- Out of these, Mapleson A circuit is considered the best for spontaneous ventilation because it requires a fresh gas inflow rate of only 1 times minute ventilation to prevent rebreathing of carbon dioxide.
- In mapleson circuits D, E, and F, the amount of fresh gas flow required is 2.5 times a minute ventilation and in mapleson circuits B and C, it is much higher.
- But the disadvantage of mapleson circuit A is that it is not very useful in controlled ventilation because a minute ventilation as high as 20 L/minute (fresh gas flow rate should be greater than 3 times a minute ventilation) is needed to prevent rebreathing.

Reference: Miller's Textbook of Anaesthesia, 9th edition, Page no 611

7 AIRWAY

Natural airway: The path from which air reaches the lungs 00:00:39

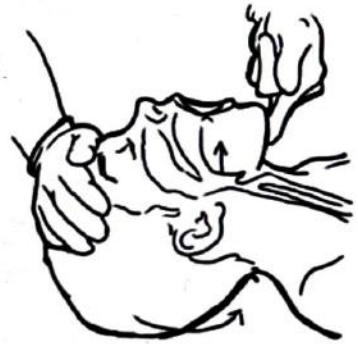
- Eg: Nose, Oral cavity, Trachea, Bronchus leading to alveoli

ADVANCED/ ARTIFICIAL AIRWAY 00:01:32

- Any device when put in this natural airway to create an unobstructed passage for air to reach the lung in a spontaneously ventilating person or in a patient on mechanical/artificial ventilation

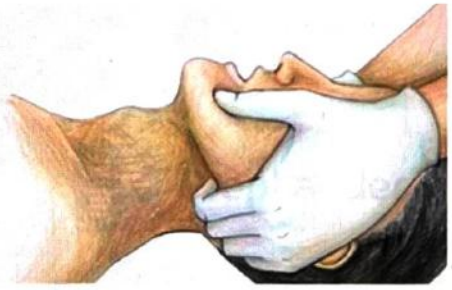
SIMPLE MANEUVERS TO OPEN AIRWAY 00:03:10

I. Head tilt and chin lift



- Can be done in any patient except trauma patient
- Backward pressure on the head (head is extended) and chin is lifted forward, pulls the tongue away from the posterior pharyngeal wall
- Neck movement is present

II. Jaw lift or Jaw thrust (forward protrusion of jaw) 00:05:27



- For trauma patients, suspecting cervical-spinal injury, head tilt and chin lift maneuver involves neck movement. Therefore, we perform jaw lift maneuver in order to open airway
- Keep the head in neutral position and with the thumb, forward protrusion of the jaw while the head kept stabilized in both hands

Previous Year's Questions

Q. What is this maneuver shown below? (NEET PG Sep 2021)

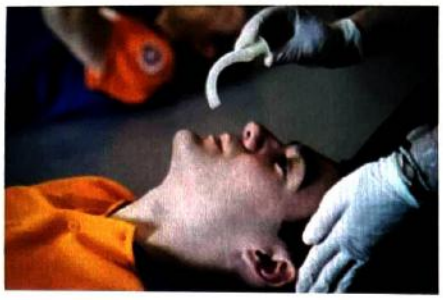
A. Head extension
B. Head tilt – chin lift
C. Jaw thrust
D. Manual inline stabilisation

SIMPLE AIRWAY ADJUNCT 00:07:17

I. Oral airway

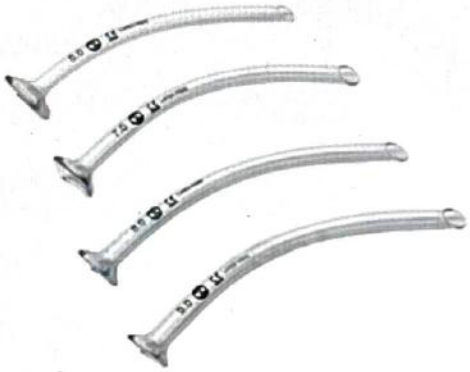
- M/C is Guedel's airway

- **Guedel's airway** has phalange, integrated wide block, body, tip and open channel present in the body for suctioning. It is made up of rigid plastic
- **Size** is determined: from the angle of mouth to angle of mandible
- **Insertion**: It is inserted in an upside-down position with the tip facing the roof of the mouth. Once it is half inserted, it is rotated to 180°. The tongue is lifted away from the posterior pharyngeal wall
- Since it is made up of rigid plastic, it is not very well accepted in conscious oriented patient



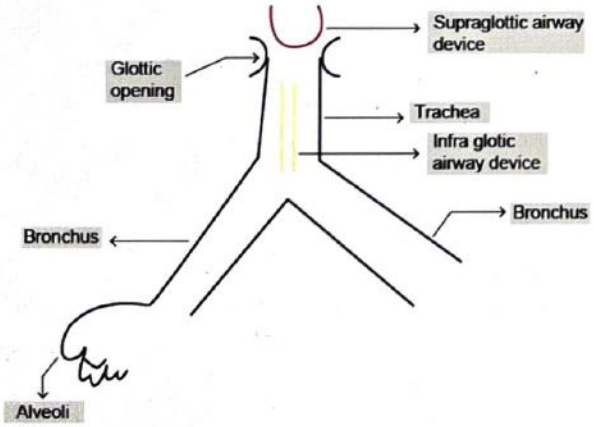
II. Nasopharyngeal airway

- In a conscious patient with compromised airway, we use nasopharyngeal airway



- It is made up of soft silicon
- **Size** is determined – from the tip of the nose or nostril to the ear lobe
- Insertion- lubricate with water-based jelly, insert it through nasal cavity level facing the septum
- It is a comfortable device. It can be inserted in a conscious oriented patient

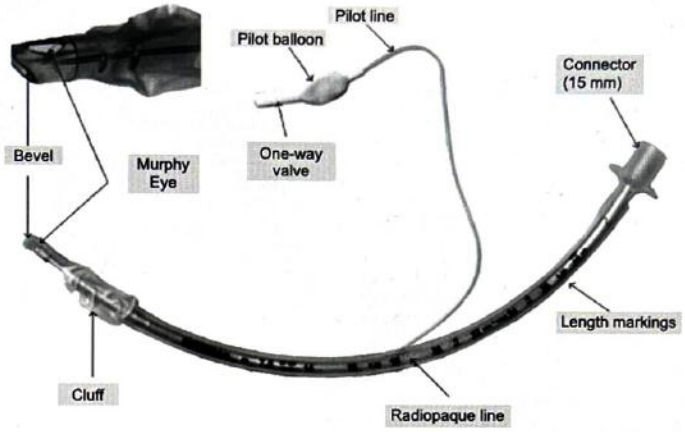
ADVANCED AIRWAYS



- **Supraglottic airway device:** Device ventilating above the glottic opening
  - E.g: Laryngeal mask airway
- **Infraglottic airway device:** Device ventilating below the glottic opening
  - E.g.: Endotracheal tube

ENDOTRACHEAL TUBE

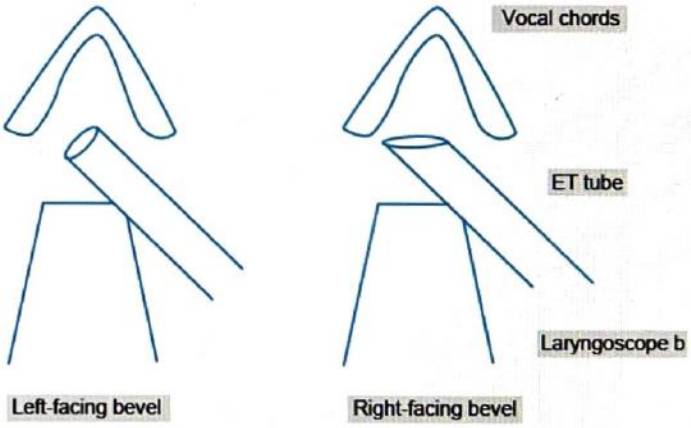
00:18:43



Parts of ET Tube

I. Bevelled end

- Proximal end of the tube is bevelled. Bevel faces the left, to have proper visualization of the tube crossing the glottis opening, while introducing the tube



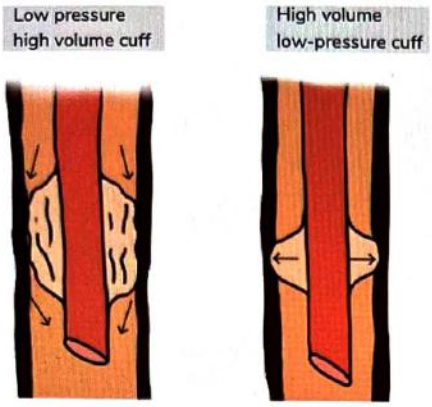
II. Murphy's eye: It is the alternate opening present in the tube for ventilation

Important Information

- **A special tube named as Magill's tube do not contain murphy's eye**

III. Cuff

- 2 types of cuff



1. High volume low-pressure cuff
   - It is more common than the other one
   - It creates a seal with a wider area, so less pressure is exerted at a single point
2. Low volume high-pressure cuff
   - Laser tube (a tube used in laser surgery) contains this cuff

Important Information

- Cuff is inflated to create a seal in trachea for positive pressure ventilation and to prevent aspiration

IV. Black mark
- 2 black marks are present to guide proper positioning of the tube
- Black mark should be left on glottis opening (should not cross carina) while inserting the tube. If no black mark, then insert the tube until 2-2.5 cm

V. Tube size is decided by its internal diameter in mm

VI. Tube is made up of Polyvinyl Chloride

VII. Marked on the tube, tested for safe human use

VIII. Markings are present on tube indicating the distance from glottic opening in cm

IX. Circuit end- Universal connector is attached on circuit end. 15 mm size of the universal connector, goes into the circuit with 22 mm connector

Previous Year's Questions

Q. Airway resistance to flow of gases through endotracheal tube is due to? (FMGE June 2021)

A. Diameter
B. Curvature
C. Length
D. Material

INTUBATION

00:36:11

I. Orotracheal intubation: Most preferrable

II. Nasotracheal intubation: Vascular area and not very clean area

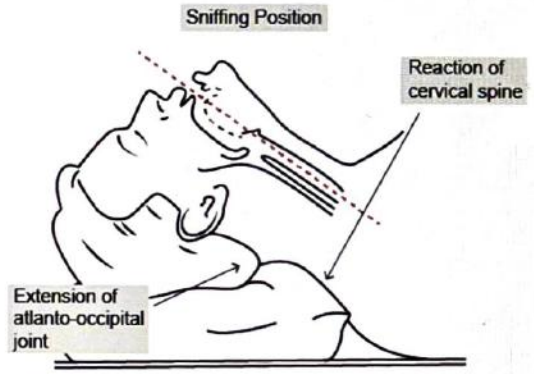
- Unless indicated, we do not go for it

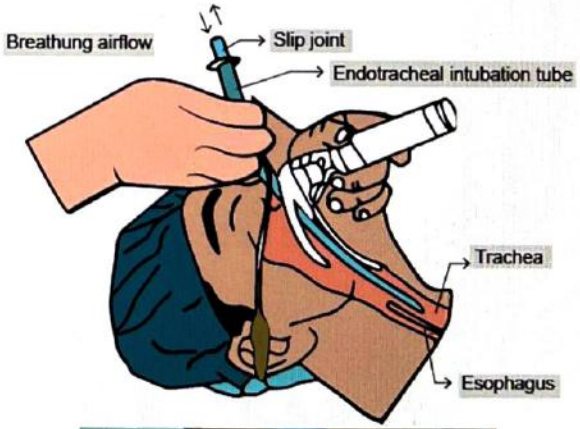
Orotracheal intubation

- To do orotracheal intubation, we use a laryngoscope, called Macintosh Laryngoscope, which has a curved blade, electric connect handle, with the light source and tip. Macintosh Laryngoscope is still preferred

LARYNGOSCOPY

00:43:40



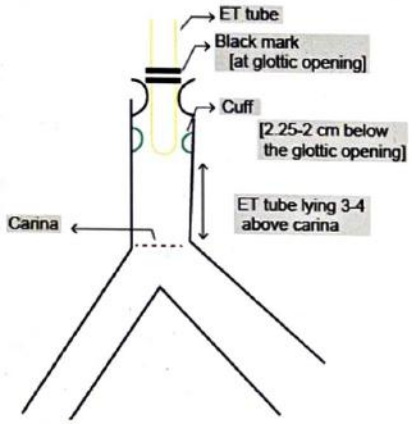


Steps of Laryngoscopy

I. Positioning
- Morning sniffing position or barking dog position
- There is the movement of 2 joints
  - Atlanto-occipital joint: Extended
  - Neck-joint: Flexed

II. Laryngoscopy
- Hold the laryngoscope in the left hand
- Introduce the laryngoscope from the right angle of the mouth
- Sweep the tongue from middle to left side
- Introduce the laryngoscope deep and try to locate epiglottis
- Reach fold between the epiglottis and Arytenoid/ Vallecula
- Hinge the tip of Laryngoscope in Vallecula
- Lift the laryngoscope towards the roof: Glottic opening is visualized

III. Intubation 00:47:28



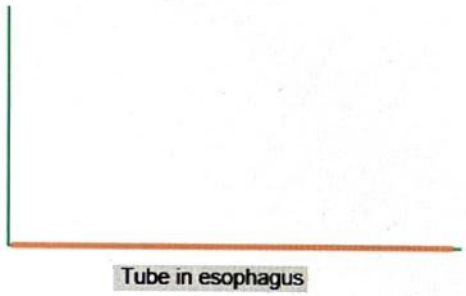
- Best position of ET tube: 3-4 cm about carina
- Hold ET tube in the dominant hand
- Introduce the ET tube in the glottic opening
- Inflate the cuff
  - Optimum cuff pressure
    - → 25–30 cm of H_2O
    - → 18–22 mm of Hg
  - Role of cuff
    - → It prevents aspiration
    - → Creates a seal for ventilation
    - → Cuff does not prevent the dislodgement of tube
- Check for the right position of the tube by attaching a monitor called Capnograph

Important Information

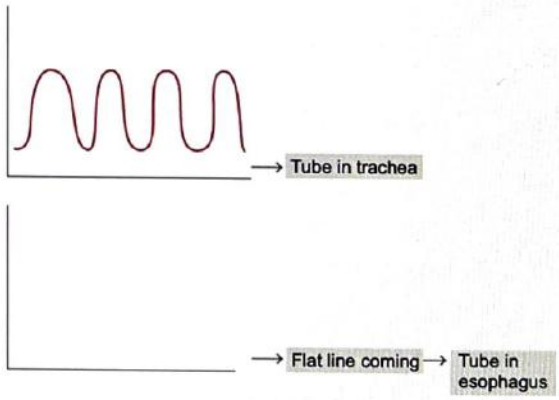
- **After inflating the cuff, do not fix the tube. Check for the right placement of the tube**

TO CHECK FOR THE RIGHT POSITION OF THE TUBE 00:50:09

I. Capnography: If the graph appears, it is the sure shot confirmation of correct placement of the tube



(Correct position)

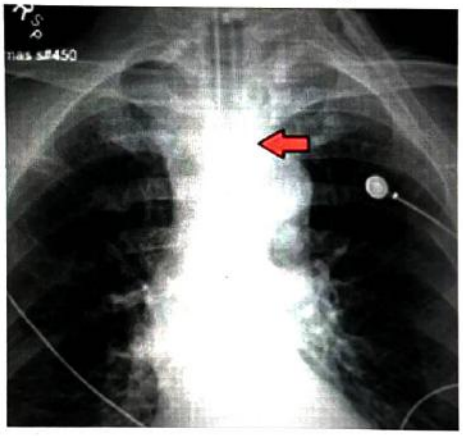


(Incorrect position)

II. Auscultation: 5 point auscultation
- Epigastric
- Gastric
- Right and left side of upper thorax
- Right and left axilla

III. B/L movement of chest on ventilation
IV. Vapor condensation on the tube
V. Chest X-ray
VI. Fiberoptic

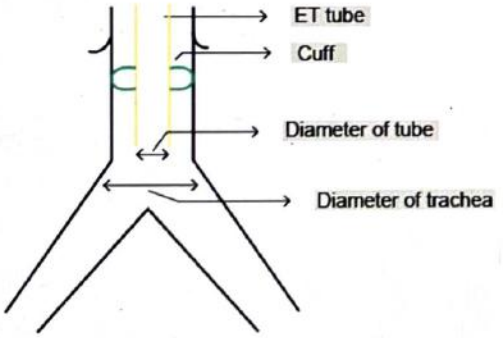
In this fig. cuff is below the glottic opening, the tip of the tube is above the carina, cuff inflated, creating a seal

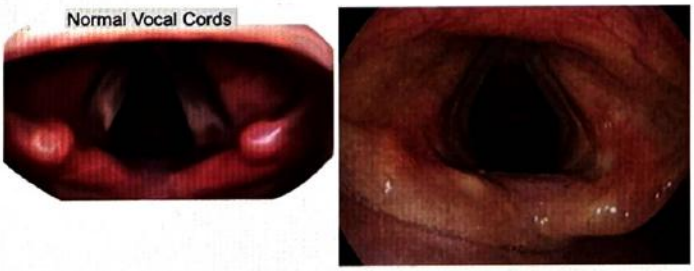


In this fig. red arrow is showing the tip of the tube

VII. Fix the tube on the margin of the lip with adhesive to prevent dislodgement of the tube

- Anatomical dead space decreases
- Resistance for the passage of air increases always, because the diameter of the tube decreases, work of breathing increases $R \frac{1}{r^4}$ 00:59:14

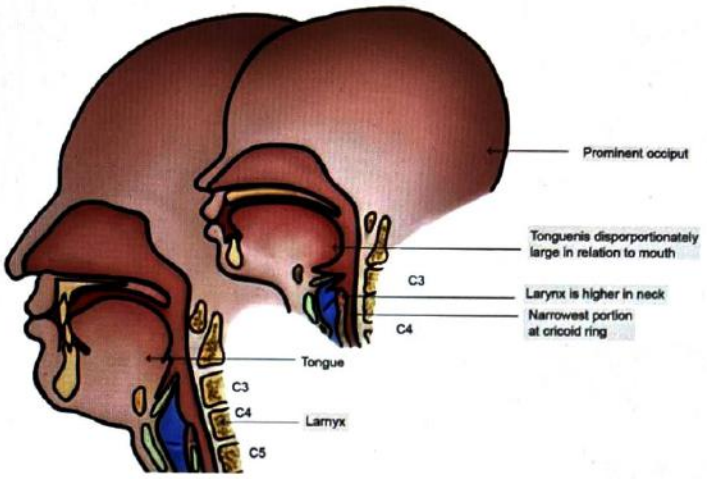




(Fig A Green arrow is epiglottis) (Fig B shows glottic opening)

PEDIATRIC INTUBATION

00:58:22



Difference between Adult and Pediatric Airway

Adult	Pediatric
• Larynx in Adults C_4-C_5 • Narrowest portion of the airway is glottic opening • Shorter epiglottis	• Larynx is higher in neck C_2-C_3 • Narrowest portion of the airway is cricoid • Longer and leaf-like epiglottis • Prominent occiput • Tongue is disproportionately larger in relation to the mouth

Pediatric intubation

1. Use of straight blade laryngoscope (Miller's Laryngoscope) to lift up the whole epiglottis
2. Use of uncuffed tube in the pediatric population (< 6-7 years) to prevent subglottic edema

Indications of Intubation

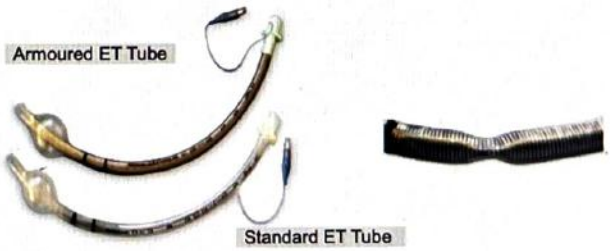
01:06:57

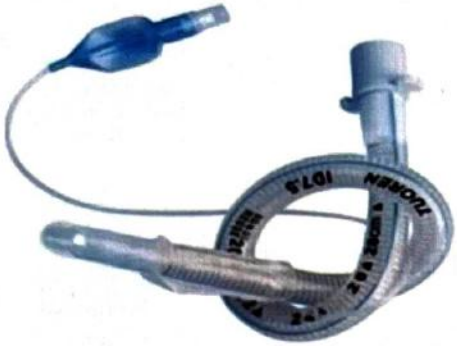
- During general anesthesia
- For positive pressure ventilation
- To protect the airway from aspiration
- For pulmonary toileting: patient unable to cough

SOME SPECIAL TUBES

01:10:21

I. Flexometallic / Armoured tube/ Reinforced tube





- Inner diameter reinforced by metallic wire to make it kink resistant
- Differences between Flexometalic tube and standard ET tube

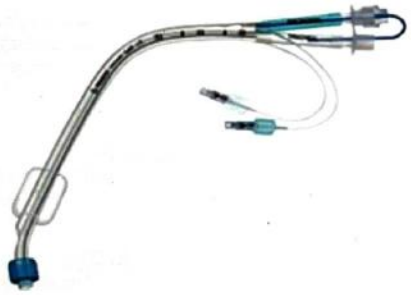
Flexometallic tube

- Universal connector is fixed
- Highly malleable (rigid) so always needs a stylet during insertion
- No radio opaque line required
- Kink resistant

Indications

- Neurosurgery
- Head and neck surgery
- Prone position surgery
- Dental surgery

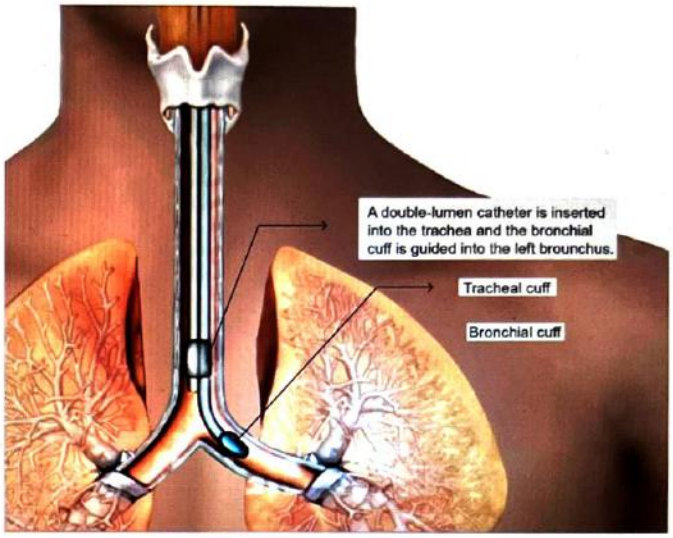
II. Double lumen tube: Is used for one lung ventilation

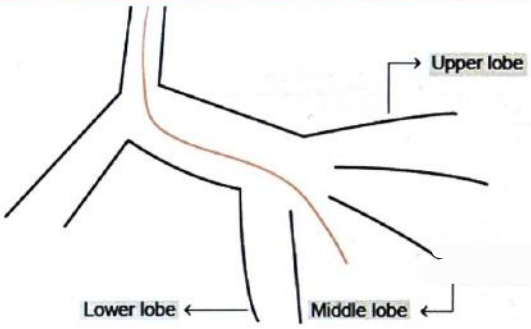


- It has 2 lumens
  1. Bronchus lumen: Going into either bronchus
  2. Tracheal lumen: Going into the trachea
- It is used if needed to ventilate one lung and collapse other or when we need to separate one lung from the other

Indications

- Lung separation
- Thoracic surgery
- Pneumonectomy
- Lobectomy
- Thoracic aorta aneurysm repair



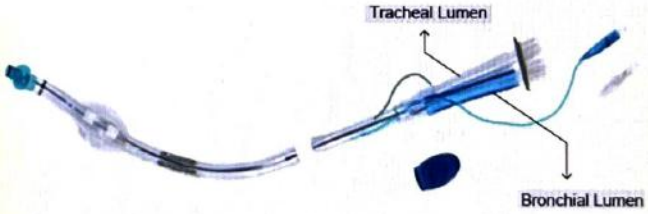


Important Information

- The best placement of double lumen tube is confirmed by fiber optic bronchoscopy especially right side, because right division is more crowded compared to left one
- Normal tube confirmation: Capnography
- Double lumen tube confirmation: Fiber optic bronchoscopy

Previous Year's Questions

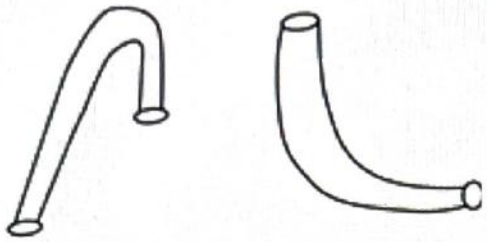
Q. Identify the device? (FMGE August 2020)



A. Endotracheal tube
B. Double lumen endotracheal tube
C. Laryngeal mask airway
D. Flexometallic tube

III. Ring-Aladain Elwin tube (RAE tube)

- Specially designed for cleft-lip palate surgery
- Bent in one direction either upward or lower direction
- Not popular these days

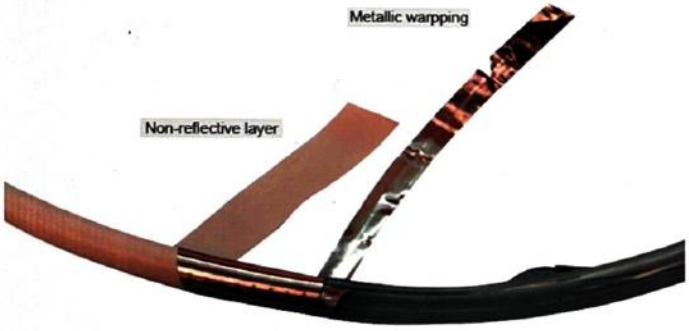


IV. Uncuffed tube

- Used in pediatric < 6-7 years to prevent subglottic edema/ injury

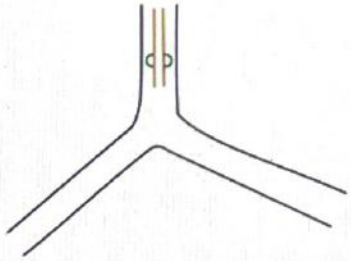
V. Laser tube

- Tube used in laser surgery. It is made up of polyvinyl chloride (PVC). PVC is inflammable material, can easily catch fire
- Laser, Oxygen and PVC is a huge risk of airway fire
- Tube is covered by 2 layers. The inner layer is covered by metallic wrapping to prevent the contact of the tube and the outer layer non-reflective layer to protect the tube from fire



- Cuff of tube
  Is low volume and high pressure- makes very tight seal has dye in it is inflated with water- act as a fire extinguisher

ENDOTRACHEAL TUBE WITH SUBGLOTTIC DRAINAGE



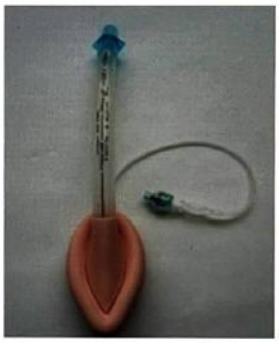
- Patient on long-term ventilation. VAP (Ventilator Associated Pneumonia) can occur due to the collection of secretions in the cuff
- Therefore, this tube was designed for the proper drainage of these secretions to prevent VAP

- Size of the tube 01:28:22

Adult	[illegible]
• **Adult male** = 8mm ID to 9mm ID (8.5 mm ID) • **Adult female** = 7mm ID to 8mm ID (7.5 mm ID)	• **< 6 yrs** $\frac{Age}{4}$ + 4.5 mm ID • **6 yrs** $\frac{Age}{3}$ + 3.5 mm ID

SUPRAGLOTTIC AIRWAY DEVICES 01:30:07

- **Credit** for **origin** goes to Dr. Archie Brain
- He came up with Laryngeal Mask Airway (LMA) or Classical LMA Or Brain's LMA
- LMA holds a very good place in algorithm of managing very difficult airway



Classical LMA

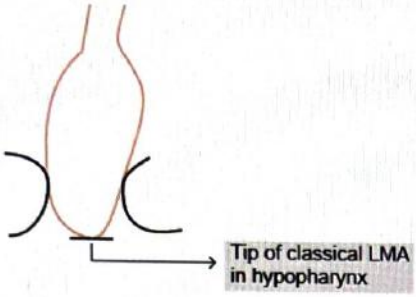
Pro-seal LMA

- 2nd generation

First generation	Second generation
• Classical LMA • Cobra peri laryngeal airway • There is single tube present, which can be used for ventilation only • Demerit: cannot prevent aspiration	• Proseal LMA • Fast track LMA or intubating LMA • I gel airway • LMA supreme • They have an airway tube and a gastric tube • They create a better seal than first generation supraglottic device (more protective against aspiration)

CLASSICAL LMA 01:37:49

- **Designed** by Dr Archie Brain
- Tip of classical LMA goes into hypopharynx (not glottic opening)



Classical LMA	Endotracheal tube
• Easy to insert	• Needs more expertise
• Fast to insert	
• Less invasive & less complications	• More invasive & more complications associated with laryngoscopy & intubation (spasm of bronchus, sympathetic stimulation etc)
• Aspiration cannot be prevented (major demerit of classical LMA)	• Still, it is the best device to prevent aspiration
• Not a definitive airway device (risk of aspiration is present)	• Definitive airway device

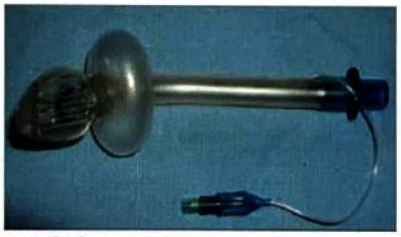
Important Information

Definitive airway device
An airway device which
1. **Can ventilate**
2. **Can prevent aspiration**

Indications of LMA 01:45:00

1. To secure airway in difficult airway conditions
2. To be used in selected cases (during general anesthesia) which do not involve any risk of aspiration (i.e full elective surgery in which patient is NPO so no risk of aspiration)
3. As an aid in intubation

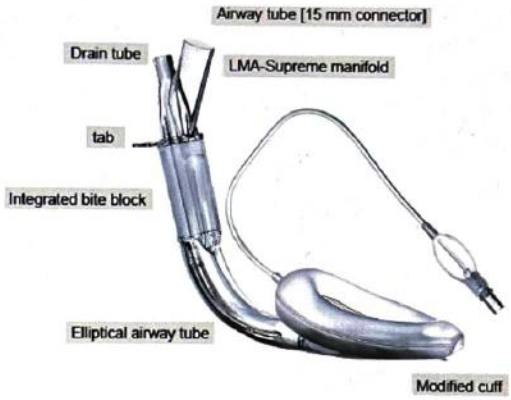
- Fast track LMA & sometimes the pro seal LMA serve as a track to insert the tube. Therefore, fast track LMA is known as Intubating LMA



Cobra peri laryngeal airway

- 1st generation supraglottic airway device

I-gel airway



LMA

Important Information

First generation supraglottic airway devices
- LMA classic
- Cobra peri laryngeal airway

} Both have single tube

Second generation supraglottic airway devices
- Proseal LMA
- LMA supreme

} Both have 2 tubes & inflatable cuffs

- Proseal LMA : Silicon cuff
- LMA supreme : single use, curved to go easily in oral cavity
- I-gel airway : 2 tubes & non inflatable cuff

Previous Year's Questions

Q. Identify following device? (FMGE August 2020)

A. Classical laryngeal mask airway
B. Proseal LMA
C. I-gel
D. LMA supreme

SIZE OF LMA

01:52:26

- For classic LMA & Proseal LMA

Weight in Kg	Size of LMA
< 5 kg	1
5-10 kg	1.5
10-20 kg	2
20-30 kg	2.5
30-50 kg	3
50-70 kg	4
> 70 kg	5
> 100 kg	6

01:54:22

Important Information

Cervical spine injury
- Emergency: Manual in-line stabilization of head and oro-tracheal intubation
- Elective: Fiber optic nasal intubation

Maxillofacial injury
- Emergency: Orotracheal intubation
- Elective: Tracheostomy

MANAGEMENT OF DIFFICULT AIRWAY

01:57:06

According to, All India Difficult Airway Society Guidelines

Step 1

Call for help

- Laryngoscopy + intubation
- Continue O_2 through nasal canula at 12-15 L/minute
- Maximum two more attempts can be taken
- Mask ventilation in between
- Maximum optimization

Succeed
- Go for capnography

Fails: step 2

Step 2
- Continue O_2 through nasal cannula
- Use supraglottic airway devices (preferably 2nd generation)
- Maximum two attempts

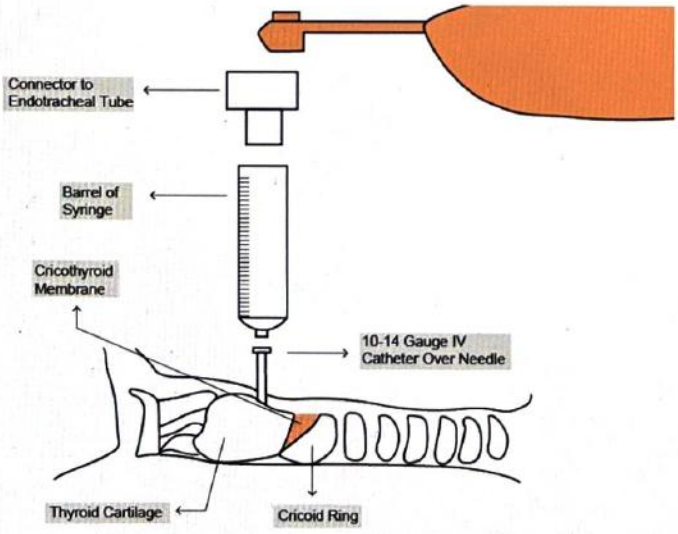
Succeed
- Intubation again Tracheostomy
- Continue on LMA
- Postpone the surgery

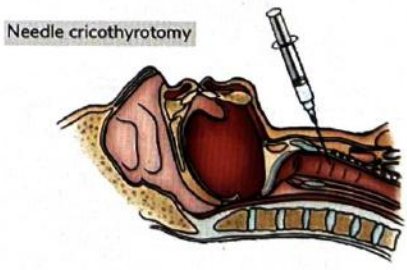
Fails: Step 3

Step 3
- Continue nasal oxygen
- Mask ventilation

Succeed
- Plan for definitive airway

Fails
- Emergency cricothyrotomy
- Surgical cricothyrotomy
- Needle cricothyrotomy (jet ventilation can be done through it): Tracheostomy





CLINICAL QUESTIONS

Q. A 24-year-old primi, full term admitted with fetal distress and meconium stained liquor. The patient was immediately prepared for Emergency lower segment caesarean section (LSCS) and done under spinal anesthesia. After delivery, the child developed severe respiratory distress warranting endotracheal intubation. Appropriate size of endotracheal tube in this case would be?

A. 2.5 mm
B. 3.5 mm
C. 4.5 mm
D. 5.5 mm

Answer: B

Solution

Appropriate size of endotracheal tube in a normal term newborn is **3.0-3.5mm**

GUIDELINES FOR SELECTION OF ENDOTRACHEAL TUBE IN TERMS OF APPROPRIATE INTERNAL DIAMETER (ID)		
Age	Internal Diameter (mm)	
1.	Premature or small for gestational age	2.5-3.0 mm
2.	Normal term newborn	3.0-3.5 mm
3.	Six months to 2 years	4.0-4.5 mm
4.	Greater than 2 years	= mm ID
5.	Penlington's formula	+ 3.5 = mm + 4.5 = mm
	<6.5 years	$\frac{\text{Age}}{3}$ + 3.5 = mm
	>6.5 years	$\frac{\text{Age}}{4}$ + 4.5 = mm
6.	(Anteroposterior diameter of distal joint of the fifth finger) - (2.2mm) = outside diameter of endotracheal tube	

Based on data from Fukuoka et al. [39]

GUIDELINES FOR PROPER DEPTH OF INSERTION OF ENDOTRACHEAL TUBES IN PEDIATRIC PATIENTS, FROM THE LEVEL OF THE ANTERIOR GUM LINE

	Weight/Age	Oral	Nasal
1.	1, 2 and 3 kg	7,8,9 cm	1. Crown-heel length x 0.21 cm
2.	Newborn	9,5 cm	2. Crown-heel length x 0.16+2.5 cm
3.	6 months	10.5-11 cm	
4.	Greater than 1 year	$\frac{Age}{2}$ + 12 cm OR $\frac{Height\ (cm)}{2}$ + 5	4. $\frac{Age}{2}$ + 15 cm

Reference: Page no. 321 Morgan and Mikhail's anaesthesiology, 5th edition

Q. A 45 year old male admitted in casuality with the history of sustained head injury from road traffic accident. His Glascow coma scale was 7/15. The senior resident of anesthesia advised the resident to secure definitive airway device. The airway device could not be used in this patient is?

A. Orotracheal Intubation
B. Nasotracheal intubation
C. LMA
D. Tracheostomy

Answer: C

Solution

- Tracheal intubation is a definitive airway, provides maximal protection against aspiration of gastric contents and allows positive pressure ventilation with a high airway pressures than via a face mask or supraglottic airway. LMA is temporary airway device since it cannot prevent aspiration. Invasive airways (Tracheostomy) are indicated as rescue technique when attempts of non-invasive techniques failed
- The Laryngeal Mask Airway is a **supraglottic airway device** which sits in the hypopharynx and forms a seal around the periglottic tissues. The seal around the laryngeal inlet allows for delivery of oxygen and volatile agents during spontaneous ventilation and permits positive pressure ventilation at pressures upto 20 cm H_2O.
- Once positioned, the cuff should be inflated with the minimum volume of air, with a target cuff pressure of 60 cm H_2O. It can be used for ventilation as a primary airway management device, rescue airway device, and a conduit for tracheal intubation

Advantages

- Easy and rapid
- Less invasive
- Better hemodynamic stability

- Very useful in difficult intubations
- Lack of need for muscle relaxation
- requires lesser plane of Anaesthesia
- Avoidance of risk of some risks of tracheal intubation (trauma to teeth and airway, sore throat, coughing on emergence, bronchospasm)

Disadvantages

- Supraglottic airway devices have comparatively lesser seal pressures than tracheal tubes which leads to ineffective ventilation when higher airway pressures required
- Increased risk of gastrointestinal aspiration when first generation supraglottic airway devices used
- No protection from laryngospasm
- Less safe in prone or jackknife positions
- Less secure airway
- Greater risk of gas leak and pollution
- Can cause gastric distention.

Reference: Miller's textbook of Anesthesia 9th edition, Page no. 1373, 1389, 1390.

Q. A 50 year old female, known case of systemic hypertension and multinodular goitre with euthyroid status posted for total thyroidectomy under general anesthesia. To confirm the correct placement of the endotracheal tube the gold standard technique to be used in this patient After intubation?

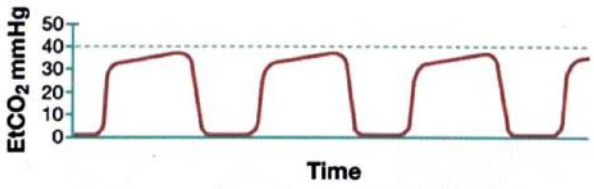
A. Capnography
B. Visualization of the chest excursion
C. Auscultation
D. Ultrasonogram

Answer: A

Solution

1. Endotracheal tube placement can be confirmed by,
2. If chest rise
3. Visible condensation on the endotracheal tube
4. Bilaterally equal breath sounds over the chest wall
5. Over the epigastrium, lack of breath sounds
6. Tidal volume large exhaled
7. Appropriate compliance of reservoir bag during mechanical ventilation
8. Most important and objective indicator is presence of normal capnogram in atleast 3 breaths

Capnography



Others method for confirmation of placement of Endotracheal tube

- Flexible bronchoscopy, Chest radiography can be used if clinical picture is unclear.

Reference: Miller's textbook of Anesthesia 9th edition, Page no. 1397, 1398

Q. A 30 year old female who is a case of fibroadenoma of left breast posted for excision biopsy under LMA with spontaneous ventilation. Inj. Glycopyrollate, Propofol, fentanyl and succinylcholine was used to facilitate the LMA insertion. Oxygen/nitrous oxide and sevoflurane was used for maintanance of anesthesia. This patient would not have the benefit of?

A. Less invasive
B. Less haemodynamic alteration
C. Prevention of pulmonary aspiration
D. Lesser time for insertion

Answer: C

Solution

- Endotracheal tube is the best device and definitive airway to prevent aspiration.
- There is an increased incidence of aspiration of gastric contents with laryngeal mask airway.
- The Laryngeal Mask Airway is a **supraglottic airway device inserted** in the hypopharynx and forms a seal around the periglottic tissues, which allows for delivery of oxygen and volatile agents during spontaneous ventilation and permits positive pressure ventilation upto 20 cm H_2O.
- Once positioned ,the cuff should be inflated with the minimum volume of air, with a target cuff pressure of 60 cm H_2O

Advantages	Disadvantages
• Easy and rapid • Less invasive • Better hemodynamic stability • Very useful in difficult intubations • Lack of need for muscle relaxation • Requires lesser plane of Anaesthesia • Avoidance of risk of some risks of tracheal intubation (trauma to teeth and airway, sore throat, coughing on emergence, broncho spasm) • It can be used for ventilation as a primary airway management device, rescue airway device, and a conduit for tracheal intubation.	• Supraglottic airway devices have comparatively lesser seal pressures than tracheal tubes which leads to ineffective ventilation when higher airway pressures required • Increased risk of gastrointestinal aspiration when first generation Supraglottic airway devices used • No protection from laryngospasm • Less safe in prone or jackknife positions • Less secure airway • Greater risk of gas leak and pollution • Can cause gastric distention

Reference: Miller's textbook of Anesthesia 9th edition, Page no. 1373, 1389, 1390.

Q. A 40 year old female patient who is posted for total thyroidectomy under general anesthesia. The patient was induced with Inj. Thiopentone sodium 250 mg and intubation facilitated with Inj. Succinylcholine. The cuff of endotracheal tube used in this patient to prevent tracheal mucosal injury is?

A. Low pressure – high volume
B. High pressure – low volume
C. Variable pressure – low volume
D. Low pressure – low volume

Answer: A

Solution

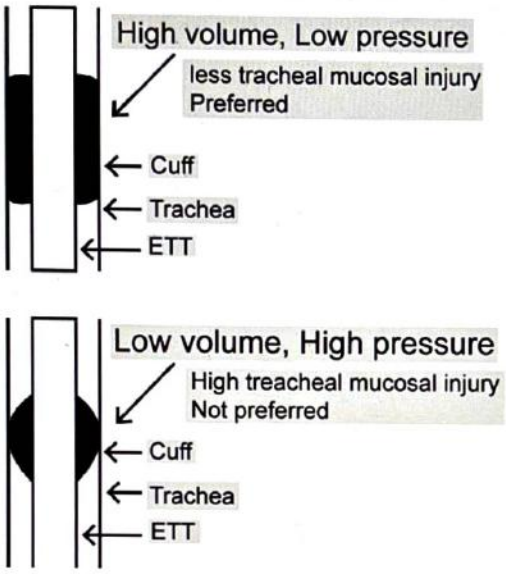
- Low pressure: High volume type cuffs have a comparatively large volumes and consequently large contact areas between cuff and trachea

Advantage of high volume, low pressure cuff

- lesser incidence of tracheal mucosal damage as the intracuff pressure closely approximates pressure on the tracheal wall, provided the cuff wall is not stretched. With proper use, cuff induced complications of prolonged intubation is reduced

Disadvantages of high volume, low pressure cuff include

- Sore throat (due to larger mucosal contact area)
- Aspiration (it may not prevent fluid leakage into lower airway even at cuff pressures as high as 60 cm H_2O)
- Spontaneous extubation
- Difficulty in insertion (because of the floppy cuff may obscure the view of tube tip and larynx)



Low volume High pressure cuff

Advantages

- Better protection against aspiration
- Better visibility during intubation

Disadvantages

- Damage to the tracheal mucosal wall on prolonged intubation(as pressure exerted on tracheal wall is above the mucosal perfusion pressure).It is controversial for use in short duration procedures and if the surgery expected to last for few hours or it must be in place following surgery, low pressure cuffed tubes should be used

Reference: Dorsch and Dorsch understanding Anaestheticequipments, 5th edition, page 771-774

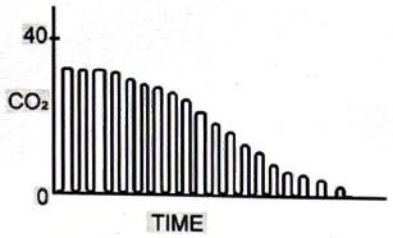
Q. A 20 year old male who is a case of subacute appendicitis posted for laparascopic appendicectomy under general anesthesia. Patient was intubated and connected to volume control mode of ventilation. Pneumoperitoneum was created and the patient positioned in trendelenberg position. During intraoperative period, the capnogram showed flat line suddenly and the patient started desaturating. This patient would not have the diagnosis of?

A. Disconnection of endotracheal tube
B. Accidental extubation
C. Ventilation failure
D. Endobronchial intubation

Answer: D

Solution

A sudden drop of ET CO_2 to near Zero followed by absence of a CO_2 waveform heralds a potentially life threatening problem.



Events that cause an exponential in end tidal CO_2 include sudden hypertension, circulatory arrest and pulmonary embolism

Sudden drop of End tidal CO_2 to zero is usually caused by the following

- Extubation
- Esophageal intubation
- Complete breathing system disconnection
- Ventilator malfunction
- Tracheal tube totally obstructed
- Plugged gas sampling tube

Sudden drop of End tidal CO_2 to low not zero is usually caused by the following

- Tracheal tube or mask poorly fitting
- Partial disconnection or leak in the breathing
- Partial obstruction of tracheal tube

Exponential decrease in End tidal CO_2 is usually caused by the following

- Sudden hypotension (blood loss or obstruction to a major blood vessel)
- With continued pulmonary ventilation, circulatory arrest
- Pulmonary embolism (air, clot, thrombus or marrow)

In endobronchial intubation, A dual waveform capnogram also seen

Reference: Dorsch and Dorsch Anaesthetic Equipments, 5th edition, pg 1023, 1024

8 MECHANICAL VENTILATION

MECHANICAL VENTILATION

00:01:38

- It is a respiratory therapy to beat serious respiratory failure or respiratory insufficiency happening due to a wide variety of clinical causes
- This therapy is properly applied on temporarily and artificially support or replace seriously damaged lung function
- Trying to maintain near normal ventilation and oxygenation

History

- **1555**: The concept of MV was given by Vesalius
- **1955**: After 400 years, during the polio epidemic, the first prototype of the mechanical ventilator was designed by a company called Emerson

Fundamental: Operation of Mechanical ventilation

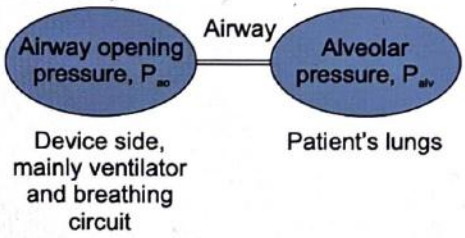
- To create a pressure difference to move a volume of gas into the lung
- **2 principals**
  I. Intermittent positive pressure ventilation (IPPV)
  II. Intermittent negative pressure ventilation (INPV)

I. IPPV

00:07:45

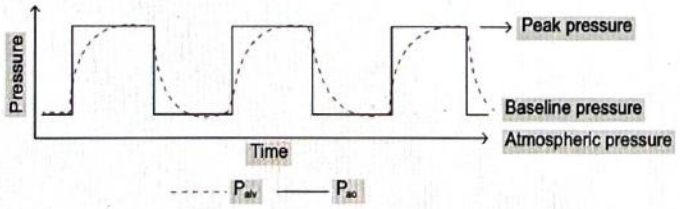
Principal of MV

- The patient's respiratory system is integrated to the ventilator system
- A positive pressure is applied intermittently to the patient's airway



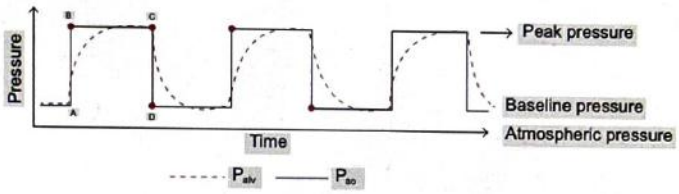
  - **PaO > PaW** → gas moves into alveoli → Inspiration
  - **PaW > PaO** → gas moves out of lung → Expiration

IPPV



- **X-axis:** Atmospheric pressure, **Y-axis:** Changes in the pressure above atmospheric pressure
  - **Dotted line**: is the pressure changed in the alveoli
  - **Solid line**: is the pressure changed in the airway

IPPV



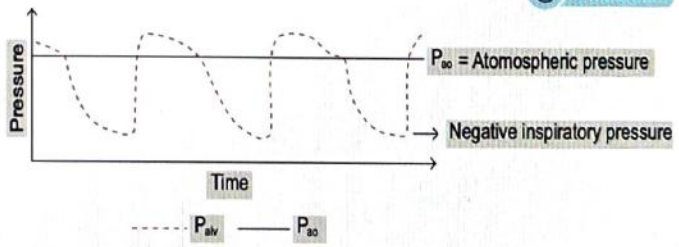
- **B point**: When positive airway pressure is applied, the airway pressure is high & alveolar pressure is low → inspiration starts
- **As the inspiration goes on the alveolar pressure increases**
- **C point**: Positive pressure is removed
- **D point**: Airway opening pressure falls & alveolar pressure is high, gas will move out from the alveoli into the air

Airway opening pressure

- A: Fixed
- A–B: High
- B–C: Fixed
- C–D: Low
- Alveolar pressure changes according to the gas fills it and according to the gas empties it

INPV

00:12:25



- The ventilated patient's mouth and nose are open to the atmosphere
- The gas moves in and out when alveolar pressure changes to atmospheric pressure
- When alveolar pressure is below atmospheric pressure, the atmospheric air sucked in inspiration

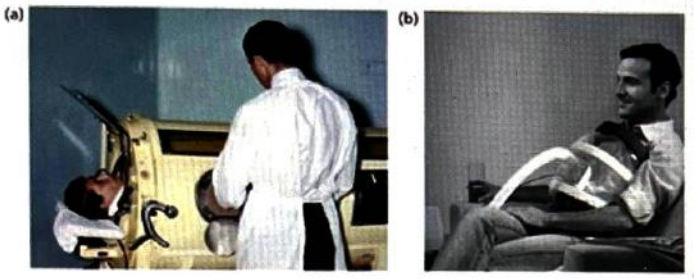
- When alveolar pressure is above atmospheric pressure, the atmospheric air emptied in expiration

a. Iron lung

- Whole body in the iron container and negative pressure is applied in the chest, in accordance air moves in and out

b Chest cuirass

- Only chest is in cuirass and negative pressure is applied



Iron Lung Chest Cuirass

INTERMITTENT POSITIVE PRESSURE VENTILATION (IPPV)

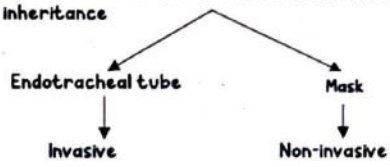
00:15:37

- Ventilator mode: Operation principle set by the operator according to which ventilator will deliver a mechanical breath

Important Information

Modes of ventilation

- Invasive/ non-invasive: Divided on the basis of patient's inheritance



- IPPV/ INPV -operating principle
- Supine/ prone – depends on patient's position

MECHANICAL BREATH

00:20:28

I. Triggering → Inspiration starts

- Time triggering
- Patients triggering
  - **Totally controlled mode**: All the breaths taken by ventilator
  - **Totally spontaneous mode**: All the breaths taken by the patients
  - **Semi control mode**: Both patient & ventilator can trigger

II. Cycling → end of inspiration

- Time cycling - **I** (Inspiration): **E** (Expiration)
- Flow cycling - Pressure support ventilation

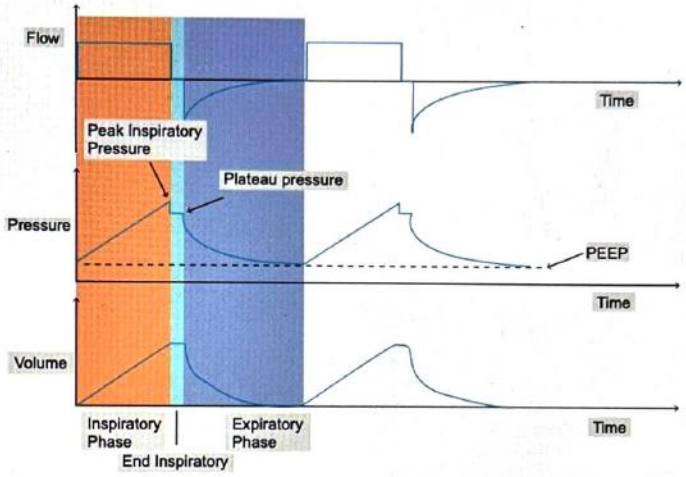
III. Controlling

- Volume control
- Pressure control

VOLUME CONTROL

00:23:31

- Preselected tidal volume is fixed
- A fixed, inspiratory flow is initiated till the selected tidal volume is achieved



Volume control flow

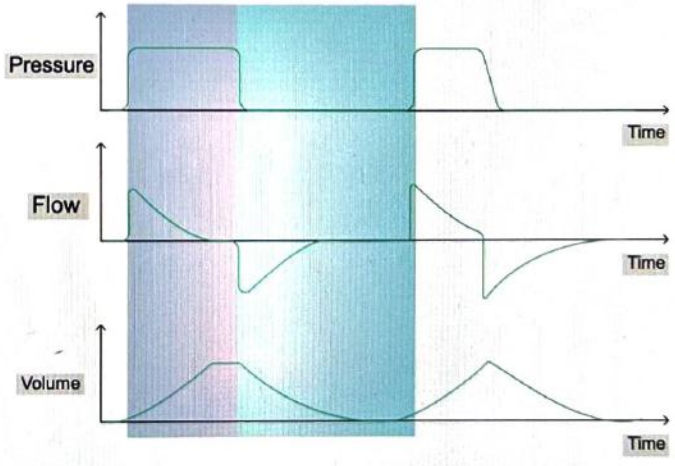
- In volume control at end inspiration, inspiratory flow is there
- This creates a difference in Peak Airway Pressure and Peak Alveolar Pressure

Advantages	Disadvantages
• Fixed volume	• Peak pressure cannot be controlled • Uneven alveolar filling • Patient's discomfort because of inflexible inspiratory flow

PRESSURE CONTROL VENTILATION

00:29:35

- Preselected pressure is fixed. To achieve that a peak inspiratory flow is started at the beginning of preselected pressure inspiration

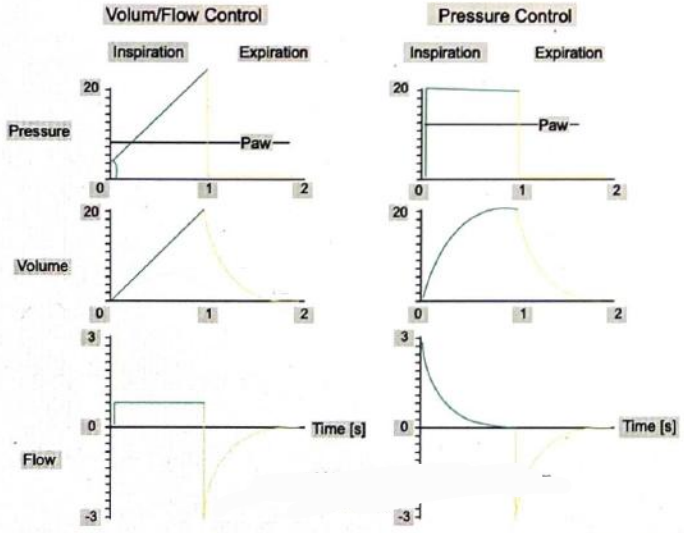


- Fix inspiratory time according to the required volume needed to be achieved

Advantages	Disadvantages
1. Fixed peak pressure: Less risk of lung injury 2. More comfortable flow pattern 3. More even alveolar filling 4. Rate, tidal volume and flow can be controlled by the patient	1. Not fixed tidal volume

00:34:17

Volume control	Pressure control
1. Preselected tidal volume	1. Preselected pressure decelerating flow
2. Fixed or constant inspiratory flow	2. Peak airway pressure = Peak alveolar pressure
3. Peak airway pressure > peak alveolar pressure	3. Tidal volume varies according to fixed pressure and lung compliance
4. Fixed tidal volume pressure vary according to lung compliance	



Baseline pressure 00:37:28

- Pressure above inspiration and expiration is happening

POSITIVE END EXPIRATORY PRESSURE (PEEP) 00:38:23

- The risk of alveolar collapse at end expiration
- To eliminate this we prevent airway pressure to fall below closing pressure
- **PEEP**: Valve is put in expiratory limb of the ventilator circuit. This allows exhalation until preselected pressure falls to end expiratory pressure of alveoli

Benefit

- Prevent atelect trauma
- Increase the surface area of gas exchange
- Alveolar recruitment
- Improves oxygenation

Side effects

- Increase intrathoracic pressure: barotrauma
- Decrease venous return: ↑ ICP
- Decrease cardiac output: ↓ BP
- Decrease perfusion of organs: ↓ urine output

CLASSIFICATION OF MODES 00:45:10

I. Conventional mode

- Most common, simplest
- Ventilator works completely according to operator setting

II. Adaptive mode

- Intelligent ventilation
- One or two parameters can be changed according to monitoring input and software
- Ex. **PRVC**: Pressure regulated volume control

III. Biphasic mode

- Inspiration and expiration happen at two levels of positive pressure
  - **BIPAP**: Bi-level Positive Airway Pressure
  - **APRV**: Airway Pressure Release Ventilation

CONVENTIONAL MODES 00:48:31

I. Assist Control Mode (A/C)

- Volume A/c
- Pressure A/c

II. Synchronized Intermittent Minute Ventilation (SIMV)

- Volume SIMV
- Pressure SIMV

III. Pressure support ventilation

ASSIST CONTROL MODE 00:49:35

- This allows the patient to initiate a ventilator breath (Assist breath/ patient triggered breath)

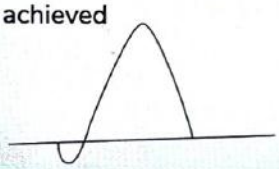
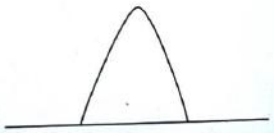
- If the patient does not initiate the breath a ventilator breath is given at a preselected rate (control breath/ time triggered breath)

I. Triggering
- Patient triggered
- Time triggered

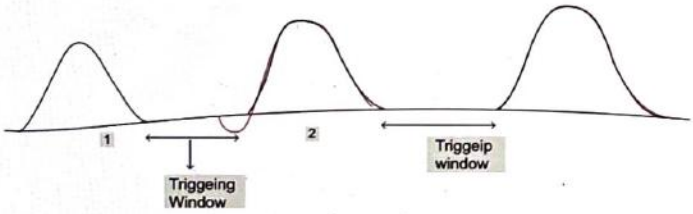
II. Cycling
- Time cycle

III. Controlling
- Volume control
- Pressure control

IV. Baseline pressure

Baseline pressure patient triggered breath	Ventilator triggered breath
• -ve deflection and fixed tidal volume will be achieved 	• No -ve deflection 

Fix the parameters
- R.R -12 bpm, 60 sec -12 b, 5 sec-1 breath, I:E - 1:2



Triggering window: Time between 1^{stand} 2nd breath

00:55:58

Volume A/C FIX	Pressure A/C FIX

• TV - 500ml
• RR-12bpm
• I:E- 1:2
• Pt trigger
  ○ Flow- 2L/min
  ○ Pressure – (-2cm H2O)
• PEEP-5 mmHg
• FiO_2-1 (100% O_2) Initially increase and than gradually decrease
	• PC-23 mmHg
	• RR-12
	• I:E-1:2
	• Pt trigger- 2 L/min
	• PEEP-5 mmHg
	• FiO_2-1 (100%)

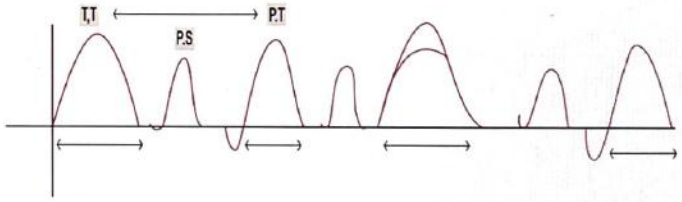
SIMV (SYNCHRONIZED INTERMITTENT MANDATORY VENTILATION)

00:58:31

- In this mode three types of breath is delivered
- Time triggered
  - Patient triggered
  - Patient triggered spontaneous breath

SIMV – Volume	SIMV – Pressure
I. Volume control breath	I. Pressure control breath
II. Volume assist breath	II. Pressure assist breath
III. Pressure support breath	III. Pressure support breath

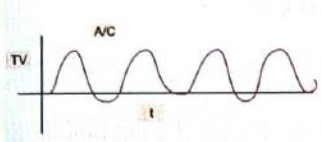
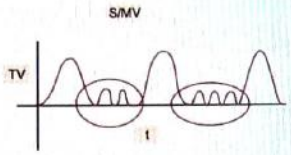
Fix the parameters	
• TV- 500ml • RR -12 • I:E -1:2 • BCT(breath cycle time) - 3sec	• PC - 23mmHg • RR -12 • I:E - 1:2 • BCT - 3sec



- 12 times fixed breath has to be given
- It can be either time triggered or patient triggered

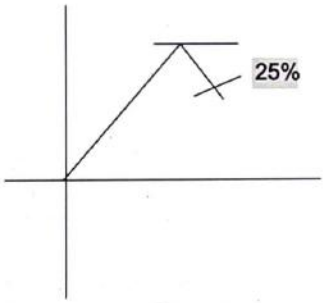
Fix the parameters
- Trigger flow: 2L/min
- PS (pressure support): 10 mmHg
  - For spontaneous breath
  - Nothing to do with the time triggered or patient triggered breath
  - Spontaneous breath between two fixed breaths and fixed breath either can be time triggered or patient triggered
- PEEP
- FiO_2

Important Information

A/C	SIMV
	
• Controlled breath	• In between 2 breath there is spontaneous breath not very controlled

PRESSURE SUPPORT VENTILATION 01:05:40

- Pure spontaneous mode
- Only one time of breath is delivered → Pressure support breath
- **Fix the parameters**
  - PS: 10 mmHg
  - Trigger: Flow 2L/min
  - Cycling: Flow cycling



- **When peak inspiratory flow falls 25% of peak, the breath is cycled from inspiration to expiration**
  - FiO_2: 1
  - PEEP: 5
- Whatever fixed, it will augment the tidal volume

Important Information

- In this mode all breath is patient triggered
- This is used for weaving and to decrease work of breathing

NON-INVASIVE VENTILATION 01:10:28

- When a tight-fitting mask is used as patient's interface, we call it non-invasive mechanical ventilation

Important Information

- Major benefit over Invasive ventilation is less incidence of ventilator associated pneumonia

Indication

- Obstructive sleep apnea syndrome
- Chronic obstructive pulmonary disease with exacerbation
- Bilateral pneumonia
- Acute congestive heart failure with pulmonary edema
- Neuromuscular disorders
- Acute lung injury
- Weaning from ventilator

Contraindications

- Respiratory arrest or unstable cardiorespiratory status
- Uncooperative patients
- Inability to protect airway (impaired swallowing and cough)
- Facial, esophageal or gastric surgery
- Apnea (poor respiratory drive)
- Reduced consciousness

PRIMARILY 3 IMPORTANT MODES 01:15:06

I. CPAP
II. BiPAP
III. PSV

I. **CPAP**: Continuous Positive Airway Pressure

- Spontaneous breathing at a positive end expiratory pressure
- ↑se functional residual capacity does not augment tidal volume
- Has a limited role

II. **BiPAP**: Bilevel Positive Airway Pressure 01:17:15

- Is CPAP which alternates between two pressure level
- The high pressure: Inspiratory Positive Airway Pressure (IPAP)
- The low pressure: Expiratory Positive Airway Pressure (EPAP)

Important Information

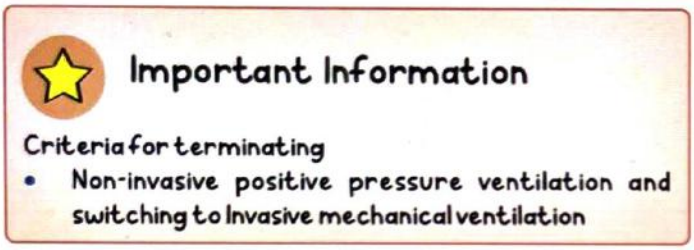
PS = IPAP – EPAP
Mean airway pressure = IPAP + EPAP
EPAP = ↑se Oxygenation
IPAP = Augment tidal volume and ↓ se work of breathing

PRESSURE SUPPORT VENTILATION (PSV)

01:19:57

- Falls both in Invasive and Non-invasive ventilation
- Provides patient triggered and pressure augmented tidal volume
- Inspiratory flow is decelerating
- Pressure augmented Tidal Volume is terminated when Inspiratory flow < 25% peak

01:22:58



- Worsening pH and arterial partial pressure of carbon dioxide ($PaCO_2$)
- Tachypnea (over 30 breaths/min)
- Hemodynamic instability
- Oxygen saturation by pulse oximeter (SPO_2) < then 90%
- Decreased level of consciousness
- Inability to clear secretions
- Inability to tolerate interface

Prone ventilation 01:23:40

- Ventilation in prone position

Benefits 01:24:13

- More homogenous distribution of tidal volume
- Improves resting lung volume by reducing super imposed pressure of heart and abdomen
- Improves ventilation and perfusion ratio
- Homogenous distribution of pleural pressure decreases stress & strain causing lung injury

PROSEVA Trail 01:26:29

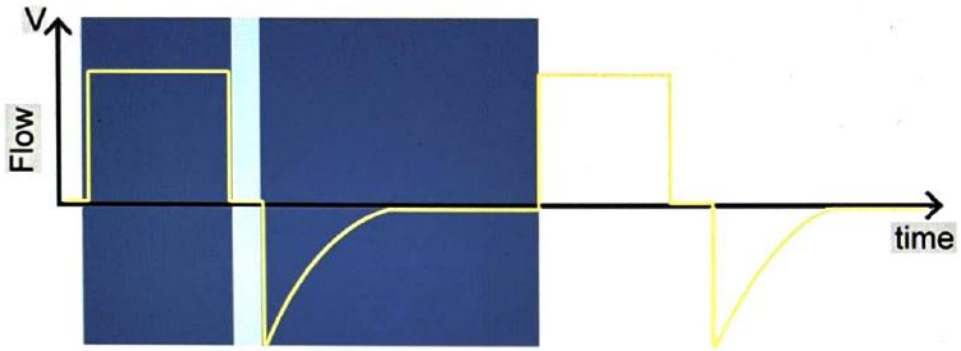
- Moderate to severe ARDS

Duration

- 6 – 8 hrs/day
- Prolonged for 17 – 20 hrs

CLINICAL QUESTIONS

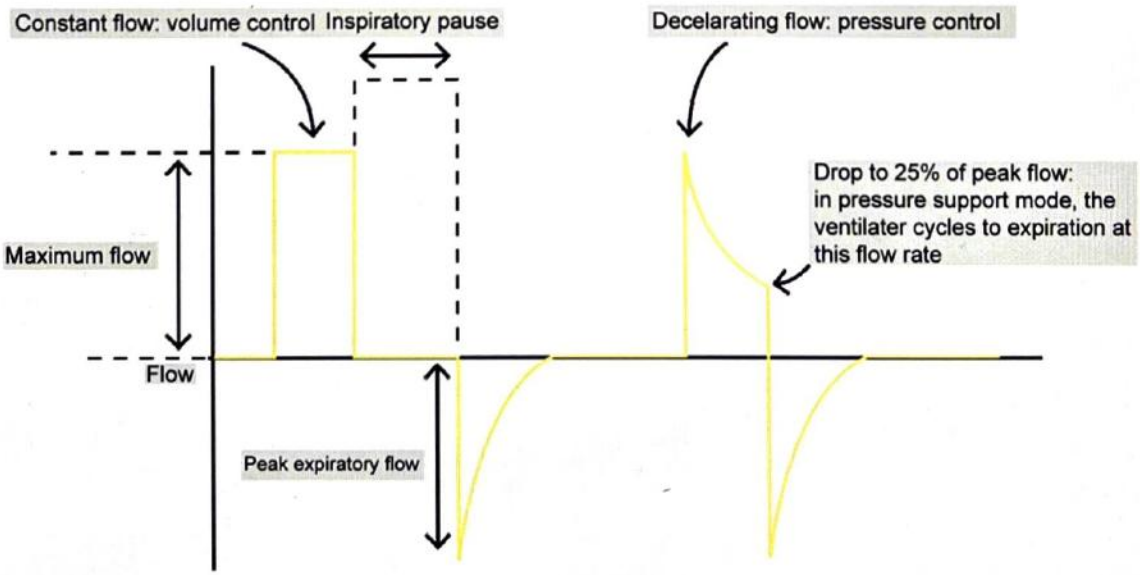
Q. A 52 year old male patient who is a known case of systemic hypertension, admitted with the history of road traffic accident with subdural hematoma and his glasgow coma scale-6/15, on mechanical ventilation posted for emergency decompressive craniotomy under general anesthesia. The patient was induced with Inj. Thiopentone sodium 250 mg IV and endotracheal intubation was facilitated with Inj. Cisatracurium. Intraoperatively 3 units of fresh whole blood was transfused. After surgery, the patient was shifted to intensive care unit and connected to mechanical ventilation. The ventilator waveform analysis shown below in this patient indicates?



A. VCV
B. PCV
C. PSV
D. CPAP

Answer: A

Solution



- In Volume Control Ventilation (VCV) there is fixed volume
- The disadvantage is that peak pressure cannot be controlled, uneven alveolar filling, Patient's discomfort because of inflexible inspiratory flow
- Preselected tidal volume is fixed
- A fixed, inspiratory flow is initiated till the selected tidal volume is achieved
- In volume control at end inspiration, inspiratory flow is there
- This creates a difference in Peak Airway Pressure and Peak Alveolar Pressure

Reference: W. Chang's clinical application of mechanical ventilation, page-307, 4th edition

Q. A 50 year old male who is a chronic smoker and a known case of chronic obstructive pulmonary disease admitted in intensive care unit with the complains of respiratory distress. His blood pressure-145/70 mmHg; Pulse rate-110/min; SpO_2-88%; respiratory rate-30/min; bilateral wheeze and crepitations heard on auscultation. Non-invasive ventilation with PEEP-7 cm H_2O; pressure support-18 cm H_2O started and brochodilaltors and steroids were given. The patient's SpO_2 and respiration improved gradually and he became comfortable at rest. The complication of PEEP that is not expected in this case is?

A. Decreased urine ouput
B. Increased blood pressure
C. Increased intracranial pressure
D. Inc`reased intrathoracic pressure

Answer: B

Solution

- PEEP (Positive End Expiratory Pressure) is an airway pressure strategy that increases end expiratory pressure or baseline airway pressure more than that of atmospheric pressure
- This is used to treat refractory hypoxemia from intrapulmonary shunting

Indications

- Intrapulmonary shunt and refractory hypoxemia
- Decreased functional residual capacity (FRC) and lung compliance
- Auto- PEEP which is not responding to adjustment of ventilator settings

Complications of PEEP

1. Decreased venous return resulting in decreased cardiac output and hypotension-During PEEP. pleural pressure becomes less negative and pressure gradient between central venous pressure and right atrium will decrease resulting in decreased venous return
2. Barotrauma-due to hyperinflation of the alveoli
3. Increased intracranial pressure: Due to the impedence of venous return from cerebral perfusion
4. Alteration of renal function and water metabolism-decreased cardiac output causes hypoperfusion of the glomeruli resulting in less effective filtration which in turn results in decreased urine output.

Reference: Chang's clinical application of mechanical ventilation, page. 89, 4th edition

Q. A 32 year old male patient admitted with the history of road traffic accident in the causality. His glasgow coma scale was 6/15. A definitive airway with endotracheal tube secured to prevent aspiration of gastric contents. The pure control mode of mechanical ventilation selected for this patient is?

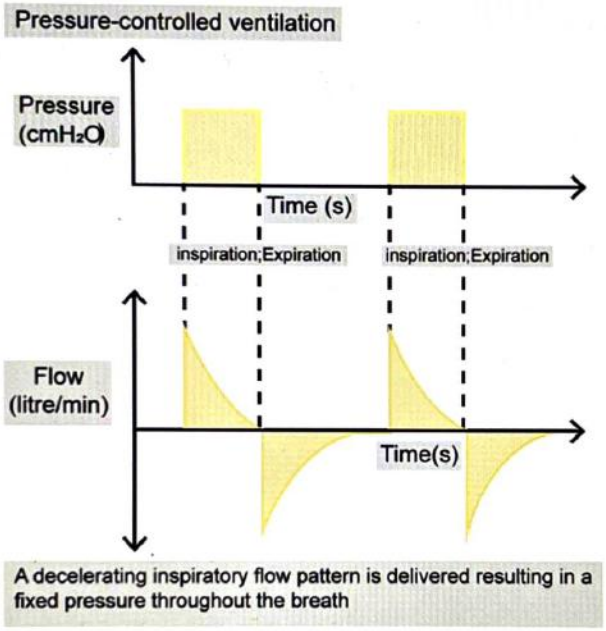
A. Pressure support ventilation
B. Synchronised intermittent minute ventilation
C. Pressure control ventilation
D. Continuous positive airway pressure

Answer: C

Solution
Modes of ventilation

Control mode ventilation (CMV) Pressure control ventilation (PCV)	Pure control modes (all breath is supplied by ventilator, breath is not taken by the patient)
Synchronized intermittent minute ventilation (SIMV)	Breath can be supplied by the ventilator and can be taken by the patient
Pressure support ventilation (PSV) Continuous positive airway pressure (CPAP)	Pure spontaneous mode (in which all the breath has to be taken by the patient)

In this graph constant Pressure is achieved which is seen in Pressure Control Ventilation. The major benefit of PCV is ability to control peak alveolar pressure which is a pressure most closely related to alveolar distention and injury. Thus PCV is protecting alveoli from overdistension.



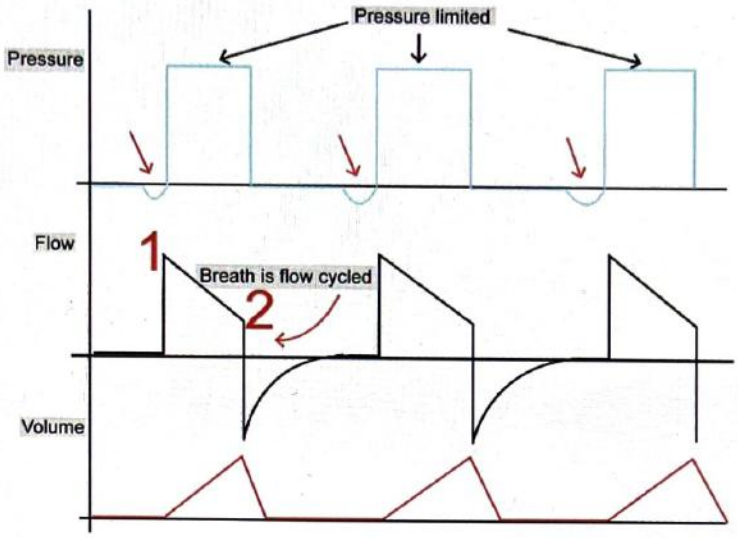
- In pressure controlled mode of ventilation, preselected pressure is fixed to achieve that preselected pressure a peak inspiratory flow is started at the beginning of inspiration As a result of this, the pressure waveform is "square". This increases the mean airway pressure (i.e. the area under the pressure/time graph is greater).

Pressure control ventilation

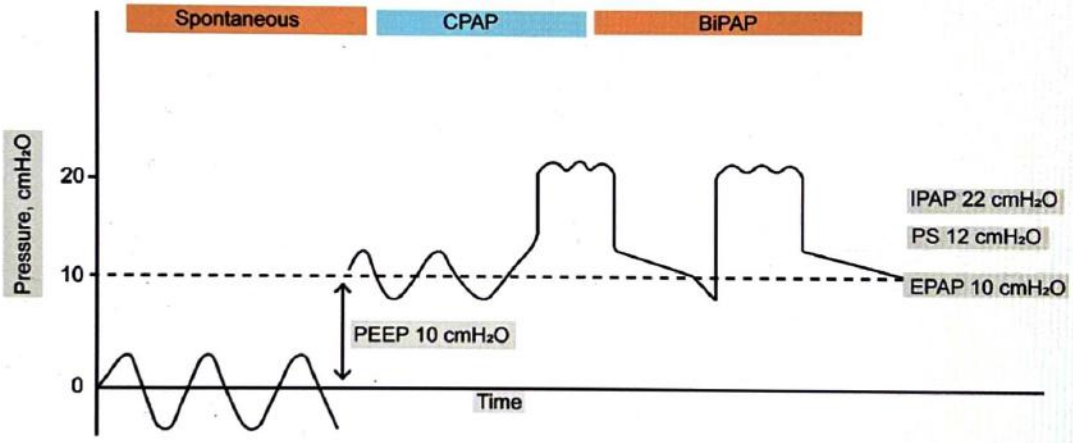
- Lung protective mode of ventilation
- Mode of choice in ARDS and pediatric patients
- Limit the upper limit of intra alveolar pressure
- Titrate the limit of intra alveolar pressure at which just adequate tidal volume is achieved

Volume controlled ventilation: where the inflation volume is preselected, and the ventilator automatically adjusts the inflation pressure to deliver the desired volume, the rate of lung inflation can be constant or decelerating

Pressure support ventilation: lowers the work of spontaneous breathing and augment patient's spontaneous tidal volume. If it is used with SIMV mode, it significantly lowers oxygen consumption by reducing the work of breathing



CPAP (continuous positive airway pressure) is PEEP applied to the airway of the patient who is spontaneously breathing



Reference: W. Chang clinical application of mechanical ventilation, 4th edition, page. 109

9 INHALATIONAL ANESTHETIC AGENT PART- I

00:00:15

- Induction and Maintenance agent of general anesthesia
- Acts on CNS

INHALATIONAL ANESTHETIC AGENT 00:01:14

- Starts in machine → Circuit → Airway → Alveoli → Along with pressure gradient moves in blood → CNS and other organs
- Target
  - Achieve the required and constant partial pressure in the brain for making the patient unconsciousness
  - For maintaining the state of unconsciousness

O_2 00:05:14

- Mandatory gas
- Required (O_2) 30% + carrier gas 70% (N_2O) to carry inhalational agent to CNS to produce general anesthesia

N_2O 00:07:16

- Inhalational anesthetic agent
- Not potent enough to use as single anesthetic agent
- Not complete anaesthetic agent, the patient would not achieve surgical anesthesia plane
- Carrier gas

Air 00:08:02

- Can be used as carrier gas
- Not anesthetic agent
- Will not contribute in anesthesia

FUNCTIONAL INHALATION ANESTHETIC AGENT

2 groups

I. Potent Inhalational Anesthetics
II. Carrier gas
  - N_2O
  - Xenon: latest inhalational agent
  - Not used because of high cost

Potent Inhalational agent 00:10:31

New		Old
In clinical use		Not in clinical use
1. Halothane 2. Methoxyflurane 3. Enflurane 4. Isoflurane 5. Sevoflurane 6. Desflurane	} Not in clinical use	Ether Chloroform Cyclopropane Trilene

MINIMUM ALVEOLAR CONCENTRATION (MAC) 00:15:08

- Concentration of inhalational anesthetic agent required at one atmospheric pressure to produce no movement on standardized surgical stimulus in 60% of the test population
- MAC = MAC_{50}

HALOTHANE	0.75
ISOFLURANE	1.13
SEVOFLURANE	2
DESFLURANE	6

MAC ↑ Potency ↓

Important Information

- High MAC = Less Potency
- Low MAC = High Potency

Important Information

- Most potent → Least potent
- Halothane → Isoflurane → Sevoflurane → Desflurane

Important Information

- Most potent Inhalational agent: Methoxyflurane
- Least potent Inhalational agent : N_2O (MAC 104)
  ↓
  Not complete anesthetic agent

- MAC_{95} = 1.3 – 1.5 times MAC_{50}
- 1 MAC = 1.5 MAC

Important Information

What is effect of 1 – 1.5 MAC on EEG waveform

- Shift from higher frequency to lower frequency
- Beta (Higher frequency) (Lower amplitude) → Alpha → Theta → Delta (Least frequency high amplitude)

Submaximal MAC 00:26:54

- Sympathetic stimulation
  - EEG would not shift to lower frequency
  - β – α – β

Important Information

- What was the effect of submaximal MAC on EEG waveform

β – α – β

Supramaximal MAC 00:28:17

- β – – δ

MAC Bar 00:29:03

- $2MAC_{50}$

Important Information

- Cerebral obtundation → ↓se MAC
- Cerebral stimulation → ↑se MAC

00:31:00

↓se MAC	↑se MAC
• Hypoxia • Hypercapnia • Hypovolemia • Hypothermia • Hyperthermia • Hyponatraemia • Hypercalcemia	↑ 42° C Hypernatremia
• Acute alcohol intoxication	Chronic alcoholic
• Age: ↑se MAC ↓se by 6% per decade of life	Infant > Neonate > Adult > old age
• Pregnancy	Amphetamine

Important Information

How with age the valve of MAC varies

Infant > neonate > Adult > Old age

Highest MAC ⟶ Lowest MAC

Important Information

In pregnancy the dose of General Anaesthesia or Regional Anaesthesia must reduce because of progesterone which has

- Sedative effect on the brain
- Increases sensitivity of nerve fiber

Important Information

- Any drug contributing in any component of GA would reduce the requirement

BLOOD: GAS PARTITION COEFFICIENT

00:42:13

Solubility of inhalational anesthetic in blood and tissues is denoted by its Partition Coefficient

Partition Coefficient (PC)

- Ratio which tells us the distribution of inhaled anesthetic in two medium at equilibrium

Important Information

- The agent with high solubility in blood achieve a equilibrium pressure slower. have slow speed of induction

	B:G Partition Coefficient	
Halothane	2.25	
Isoflurane	1.3	B:G
Sevoflurane	0.63	Solubility ↓se
Desflurane	0.42	speed faster

Important Information

- Fastest speed of Induction → Slowest speed
- Desflurane – sevoflurane – Isoflurane – Halothane

Important Information

Analgesic agent of choice for induction of GA

- Desflurane: Not used for induction
  - Respiratory irritant: cough, laryngospasm
  - Bad smell
- Sevoflurane: Inhalational agent of choice
  - Sweet smelling gas
  - Good speed

Important Information

Most appropriate inhalational agent of choice in Paediatrics

- Sevoflurane

Maintenance 00:57:50

- Agent with low blood gas solubility not only give fast induction but also fast reversal
- Appropriate with day care surgery
- Since with Sevoflurane and Desflurane quick reversal is seen, there is an incidence of postoperative delirium and hallucination seen with these agents
- If Pa (Alveolar Partial Pressure) is maintained, then brain partial pressure is achieved faster
- Induction speed will be faster

Conditions causing 01:06:05

Fast speed of induction	Slow speed of induction
• Low Blood : Gas solubility	High Blood : Gas solubility
• High rate of ventilation	Low rate of ventilation
• Low cardiac output	High cardiac output
• Second gas effect	

PHARMACOKINETICS 01:11:56

Refer Table 9.1

Important Information

- All are ether derivative except Halothane

Important Information

- Isoflurane is Isomer of Enflurane same chemical formula but different structure and properties
- Desflurane is fluorinated Isoflurane. Structural analogue of Isoflurane

Refer Table 9.2

Important Information

- Halothane causes Autoimmune Hepatitis

HALOTHANE HEPATITIS (HH) 01:34:40

Type I HH	Type II HH
• Mild self-limiting hepatitis seen post exposure to halothane	• Severe, acute necrotic hepatitis
• LFT's deranged	• Incidence 1 in 30,000/ 40,000 patients
	• Most probable cause autoimmune reaction due to metabolic by product

Predisposing factors

I. Female
II. Obese
III. Middle Age (less in children)
IV. Recurrent exposure of halothane
V. Pre-existing liver dysfunction

Refer Table 9.3

Important Information

- Sevoflurane is best for induction
- Halothane is the 2nd choice of induction after Sevoflurane in Paediatric
- Halothane has good smell
- Halothane is less notorious in causing necrotizing hepatitis
- Compare to adults Halothane is safer in Paediatrics

Previous Year's Questions

Q. Maximum airway irritation caused by? (NEET Jan 2019)

A. Desflurane
B. Enflurane
C. Sevoflurane
D. Halothane

Previous Year's Questions

Q. On repeated use, which of the following inhalational anaesthetic agents can cause hepatitis? (FMGE June 2019)

A. Isoflurane
B. Halothane
C. Sevoflurane
D. Ether

Table 9.1

Halothane	Isoflurane	Sevoflurane	Desflurane
Halogenated Ethane		Halogenated ether	
	c – o - c – c (ethyl methyl ether) • Isomer of enflurane	F I c - c – o - c – c I c (Ethyl propyl ether)	c – o - c – c (ethyl methyl ether) • Fluorinated Isoflurane • Structural analogue of Isoflurane

Table 9.2

Halothane	Isoflurane	Sevoflurane	Desflurane
I. Highest fluoride release ↓ Methoxyflurane ↓ Most Nephrotoxic			• Highest fluoride content
II. Boiling point 50 ± 2° C	Boiling point 50 ± 2° C	Boiling point 50 ± 2° C	• Boil at room temp 23° C ↓ Required special vapour technology ↓ TEC 6
III. Color code: Red	Purple	Yellow	Blue

IV. MAC: 0.75 (MAC ↑ ed Potency ↓ed)	1.12 (MAC ↑ ed Potency ↓ed)	2 (MAC ↑ ed Potency ↓ed)	6 (MAC ↑ ed Potency ↓ed)
V. Blood : Gas partition coefficient 2.25	1.3	0.63	0.42

B:G soluble ↓ ed. Speed of induction faster so fast recovery and very suitable for day care surgery

VI. Stability: Most unstable I. Oxidative decomposition on light exposure (requires to be stored in Amber color bottle) II. Require a preservative: Thymol (0.01%)	Stable	Stable	Most stable, good for maintenance agent
VII. Metabolism > 30% Metabolized ↓ Acyl halide ↓ Autoimmune hepatitis	0.1% - 0.2%`	1-2% ↓ By product Vinyl halide ↓ Nephrotoxicity	Not Metabolized ↓ Maintenance agent of choice

Table 9.3

Halothane	Isoflurane	Sevoflurane	Desflurane
Smell & pungency			
• Non-pungent good smell • Used both for Induction and Maintenance	• Ethereal pungent smell • Only used for Maintenance	• Sweet non-pungent smell • Used both for Induction and Maintenance • Inhalational induction agent of choice	• Respiratory irritant • Pungent smell • Maintenance agent of choice o Best stability o Not metabolized

CLINICAL QUESTIONS

Q. A 25 year old male patient underwent surgery under general anesthesia with 1-2 MAC dose of sevoflurane. EEG waveform pattern was recorded intraoperatively showed?

A. β-α-θ-S
B. S-θ-α-β
C. β-θ-S-α
D. α-θ-S-β

Answer: A

Solution

- EEGs recorded on the scalp can be processed to quantify the amount of activity in each of four frequency bands:
- Delta (o to 3hz), Theta (4 to 7 Hz)
- Alpha (8 to 13 Hz), Beta (> 13 Hz)
- Volatile agents with less than 1 MAC and Nitrous oxide at 30-70% can produce shift to increasing frequencies
- Between 1-2 MAC shift is towards decreased frequency β-α-θ-S and increased amplitude
- At more than 2 MAC, all of the potent agents can produce burst suppression or electrical silence

Reference: Barash Clinical Anaesthesia 6th edition pg. 651

Q. A 40 year old morbidly obese female patient who was posted for bariatric surgery under general anesthesia. She underwent laparascopic cholecystectomy under general anesthesia few months back. Inj. Propofol 200 mg was used for induction of anesthesia, endotracheal intubation facilitated with Inj. Succinylcholine and anesthesia maintained with oxygen/nitrous oxide, volatile anesthetic and cisatracurium. Postoperatively, the patient complained severe abdominal pain and vomiting. The investigations revealed elevated SGOT, SGPT, alkaline phosphatase and serum bilirubin levels significantly. Ultrasonogram showed massive hepatic necrosis. The reason behind this could be?

A. Halothane
B. Enflurane
C. Methoxyflurane
D. Enflurane

Answer: A

Solution

- There are two distinct types of hepatic injury with clinical exposure of halothane
- Subclinical hepatotoxicity-occurs in 20% of adults who receive halothane which is characterized by mild postoperative elevation of AST and ALT but is reversible and innocuous. Anaerobic halothane reduction by CYP2A6 to a 2-chloro-1,1,1 triflouroethyl radical mediates this mild hepatic injury
- Fulminant hepatitis, commonly known as **Halothane hepatitis** (rare 1 in 5000-35000 administrations in adults) but is fatal in between 50-75% cases. This is characterized by elevated ALT, AST, bilirubin and alkaline phosphatase levels and massive hepatic necrosis

- Halothane hepatitis is a hypersensitivity reaction associated with oxidative metabolism of halothane
- It is due to antibodies against highly reactive trifluoroacetyl chloride which is a oxidative metabolite of halothane react with nearby liver proteins. Hepatic damage is due to immune response against the modified protein which acts as a neoantigen
- Risk factors for halothane hepatitis:
  - Prior exposure to halaothane or other volatile agents
  - Multiple exposures to halothane at short intervals
  - Middle-aged obese women – because halothane undergo extensive metabolism in obese patients
  - Familial predisposition to halothane
- The liver in halothane hepatitis shows centrilobular necrosis
- Fever, rash, arthralgia, eosinophilia are clinical features suggestive of immune reactivity
- Other volatile agents such as enflurane, isoflurane and desflurane are also associated with fulminant hepatic necrosis but incidence is rare and mechanism of toxicity is same as that of halothane(highly reactive intermediary metabolites covalently modify hepatic proteins)
- Cases of hepatitis and rapid death are associated with sevoflurane anaesthesia but there was no evidence of immune mediated mechanism

Reference: Miller's textbook of Anaesthesia 9th edition Page no: 528

Q. A 45 year old male who is a known hypertensive on treatment, a case of subacute intestinal obstruction posted for laparatomy. Resection and anastamosis done under general anesthesia. During the postoperative period the patient had increased urine output, dyselectrolytemia. The reason behind this would be?

A. Ether
B. Isoflurane
C. Methoxyflurane
D. Sevoflurane

Answer: C

Solution

- Methoxyflurane undergoes extensive metabolism (including cytochrome catalysed oxidation) and produces huge amount of inorganic fluoride, causes nephrotoxicity. We need more than 50 micromol/litre of fluoride in blood to be nephrotoxic resulting in severe renal dysfunction and increased mortality
- Methoxyflurane is the most nephrotoxic among inhalational anesthetics which is metabolized to a larger extent within the kidneys producing high intrarenal fluoride concentrations- It causes polyuric renal failure and it is no longer used in clinical practice
- The amount of fluoride ions produced: (Typical peak fluoride concentrations after 2-3 MAC hours)
  - Methoxyflurane: 80μM
  - Sevoflurane: 20-30 μM
  - Enflurane: 20μM
  - Isoflurane and Desflurane: 5μM
- Compared with methoxyflurane, absence of renal toxicity with newer volatile agents due to the combination of factors
  1. Their lower tissue solubilities particularly in kidney
  2. Lower overall degrees of biotransformation
  3. More rapid respiratory clearance
- Neither the peak level nor duration of exposure clearly explains the nephrotoxic effects of halogenated anaesthetics and individual variability among patients in the degree of apparant renal injury after methoxyflurane exposure was observed. Genetic heterogeneity, drug interactions and pre existing renal disease likely influence these differences

Reference: Miller's Anesthesia 9th edition, Page no: 530

Q. A 10 year old male child who was a case of acute appendicitis posted for emergency appendicectomy. He was a known case of bronchial asthma and the history revealed that he had low grade fever, cough with expectoration for the past 1 week. The anesthetic agent to be avoided in this case is?

A. Halothane
B. Nitrous oxide
C. Desflurane
D. Enflurane

Answer: C

Solution

- Desflurane is a fluorinated methyl ethyl ether. This fluorination enhances molecular stability and decreases potency and increase vapour pressure (decreases intermolecular attraction), Its high vapour pressure makes it to boil at a room temperature so it needs heated and pressurized vapourizer that requires electrical power.
- Desflurane is pungent compared to Sevoflurane and Halothane. When >6% inspired desflurane administered to awake patient, produces airway irritation, salivation, breath holding, coughing or laryngospasm.So it is unlikely to use as inhalational induction agent
- Compared to others, produces highest concentrations of carbon monoxide, results from degradation by strong base present in dessicated carbon dioxide absorbants
- The propensity for CO production correlates with anesthetic concentration in the breathing circuit
- Though sevoflurane, methoxyflurane, and halothane also degrade in the presence of strong bases, they do not produce CO
- CO production is predominantly seen with **absorbents** that **contain** barium hydroxide and when the water content of soda lime or Baralyme falls below 1.4% and 5%
- Amsorb is a CO2 absorbent which is more inert than soda lime and baralyme and so associated with lesser degradation of anesthetics and so less carbon monoxide production
- Factors increasing the production of carbon monoxide and risk of carboxyhemoglobinemia
  1.Inhaled anaesthetic used (Desflurane > Enflurane > Isoflurane >> Halothane = Sevoflurane)
  2.Degree of desiccation of the absorbent
  3.Type of absorbent (KOH or NaOH containing)
  4.High temperature
  5.High concentration of anaesthetic
  6.Low- fresh gas flow rates
  7.Small patient size
- Desflurane has lower blood: gas partition coefficient (0.45) and MAC (6.6%) which permit rapid achievement of alveolar partial pressure that is necessary for anesthesia, followed by prompt awakening after discontinuation of desflurane
- Lower blood gas solubility, more precisely control over delivery of anesthesia and more rapid recovery from anesthesia distinguishing it from others. This may be particularly advantageous in the morbidly obese patient as it is poorly soluble and the duration of administration on time to recovery is minimal
- Soluble anesthetics such as halothane, isoflurane causes prolonged recovery in proportion to the duration of anesthesia. Intermediate solubility of Enflurane in blood permits intermediate onset and recovery

Reference: Stoelting's pharmacology and physiology in anesthetic practice 5th edition, Page no. 99,100,101,110
Miller's textbook of Anaesthesia, 9th edition, page no. 610

10 INHALATIONAL ANESTHETIC AGENT PART - II

Pharmacodynamic properties 00:00:16

- Effect of inhalational agent on different organ system

CNS COUPLING 00:01:08

- Cerebral Blood Flow (CBF) α Cerebral Metabolic Oxygen Requirement (CMRO)
  - If ↑se $CMRO_2$ - ↑se CBF
  - If ↓se $CMRO_2$ - ↓se CBF
- Inhalational anaesthetic agent does not follow the rule of coupling
- They have a direct effect on the blood vessel, they dilate the blood vessel
- Instead of ↓se CBF as a result of ↑se $CMRO_2$ due to the coupling effect, they ↑se CBF
- This is because of the direct effect of inhalational agent
- IV anaesthetic agent follow the rule of coupling

Important Information

- Halothane is the worst uncoupler increasing the ICP most
- Halothane is contraindicated for neurosurgery

CNS

Refer Table 10.1

Comparison of IV & Inhalational Agent on CNS

Inhalational	IV
• They do not follow the rule of coupling	• They follow the rule of coupling
• They ↑se ICP	• They ↓se ICP

Important Information

- I = D in ↑se ICP followed by S
- Neurosurgery agent of choice
  Desflurane > Isoflurane > Sevoflurane

EFFECT ON EEG ACTIVITY 00:08:58

EEG ↓se	EEG ↑se
• All inhalational and intravenous anaesthetic	• N_2O, • Ketamine } Sympathomimetic
• Hypoxia • Hypercapnia • Hypovolemia • Hypothermia	Early-stage of • Hypoxia • Hypercapnia • Hypovolemia • Hypothermia } Activation of CNS

Important Information

- Enflurane (Isomer of Isoflurane) abandoned from clinical practice because it precipitates epilepsy

Important Information

- Sevoflurane is the second agent after Enflurane which can cause seizure

How to remember

- E – Enflurane
- E – Epilepsy
- S – Sevoflurane
- S – Seizure

CARDIOVASCULAR SYSTEM 00:12:30

Refer Table 10.2

Coronary Steal Phenomenon 00:20:02

- Stealing of blood from non-ischemic to ischemic area

HYPOTENSIVE ANESTHESIA OR CONTROLLED HYPOTENSION 00:22:33

Agents

I. Sodium Nitroprusside (SNP)
II. Nitroglycerine (NTG)
III. Esmolol

} $t_{1/2}$ 3 – 4 min

IV. **Inhalational Anesthetic agent**
- Isoflurane: Best, ↓se systemic vascular resistance max
- Sevoflurane
- Desflurane

V. **IV anesthetic agent**: Propofol

RESPIRATORY SYSTEM

00:25:56

Halothane	Isoflurane	Sevoflurane	Desflurane

I. Depress the respiratory center
II. Blunt hypoxic and hypercapnic drive
III. Very good bronchodilator
IV. Blunts hypoxic pulmonary vasoconstriction

Important Information

- Halothane
  - Best bronchodilator
  - Best agent for Bronchial Asthma pt.

LIVER

00:30:16

Halothane	Isoflurane	Sevoflurane	Desflurane
I. Autoimmune hepatitis		Hepatic Sx	
II. Disrupts dual blood supply • C/I hepatic surgery			

How to remember

- H - Halothane
- H - Hepatitis

Important Information

Agent of choice for hepatic surgery
Desflurane > Sevoflurane > Isoflurane

KIDNEY

00:32:50

Halothane	Isoflurane	Sevoflurane	Desflurane
No direct effect	No effect	Vinyl halide ↓ Nephrotoxic	No effect

NEUROMUSCULAR JUNCTION

00:34:04

Halothane	Isoflurane	Sevoflurane	Desflurane

I. Decreases muscle tone
II. Stabilizes postsynaptic membrane at NMJ
III. Muscle relaxation

Important Information

Best muscle relaxant
Desflurane > Sevoflurane > Isoflurane > Halothane

UTERUS

00:35:55

Halothane	Isoflurane	Sevoflurane	Desflurane
Best uterine relaxant	Uterus relaxation		

Important Information

Halothane has good and bad effect
Good: Best uterus relaxation during procedure in uterus (manual removal of placenta)
Bad: During GA in caesarean section can precipitate post-partum

MALIGNANT HYPERTHERMIA

00:38:07

- It is a rare genetic hypermetabolic muscle disease that appears due to exposure to certain anesthetics
- Perioperative complication not necessarily intraoperative

I. **Biochemical cause**
- Uncontrolled release or increase of intracellular Ca^{2+} in skeletal muscle

- This sudden Ca^{+2} release from the sarcoplasmic reticulum removes the inhibitory effect on troponin, resulting in sustained muscle contraction
- Markedly increase Adenosine Triphosphatase activity which would increase aerobic and anaerobic metabolism in skeletal muscle

II. Gene for Ryanodine receptor is located on chromosome 19

III. Drugs triggering Malignant Hyperthermia 00:44:13

1. Succinylcholine
2. Potent inhalational anesthetic
   - Halothane
   - Isoflurane
   - Sevoflurane
   - Desflurane
   - Enflurane
   - Methoxyflurane
   - Ether
   - Chloroform
3. Lignocaine

IV. Clinical features 00:45:40

Hypermetabolism	Skeletal muscle activity
• ↑se O_2 consumption	• Muscle spasm/ rigidity
• ↑se CO_2 production, early clinic features	• Metabolic acidosis hyperkalaemia
• ↑se core temperature, late clinical features	• Rhabdomyolysis
• ↑se BP	• Myoglobinuria
• ↑se HR	• Acute renal failure

V. Management 00:50:17

- Stop triggering agent
- **Dantrolene**: Drug of choice
  - Stops Ca^{+2} release from SR
  - Dose: 2.5 mg/Kg BW, every 5 min → max10 mg/kg BW
  - Maintenance (Next 6 hr): 1 mg/kg BW

VI. Side effect 00:52:22

Acute therapy

- Muscle weakness
- Respiratory insufficiency
- Thrombophlebitis

Chronic therapy: Liver dysfunction

VII. Symptomatic management 00:53:55

- Hyperventilation
- Cooling of the patient
- Antiarrhythmic

VIII. Anesthetic agent safe in MH

- Total intravenous anesthesia
  - Propofol agent of choice
- Nondepolarizing neuromuscular blocker

IX. Diagnosis 00:56:15

- Genetic diseases
- Muscle biopsy
  - Expose to halothane caffeine test → Contracture develop → pt. has MH gene

X. Differential diagnosis 00:57:20

- Thyroid storm
- Pheochromocytoma
- **Drug induced hyperthermia (Serotonin syndrome)**
  - MAOI (Monoamine oxidase inhibitor) + Meperidine (Sympathetic overactivity)
  - MAOI + SSRI (selective serotonin reuptake inhibitor)

↓

↑se CO_2 absorption in blood during laparoscopic procedure

↑se CO_2 → ↑se Sympathetic activity

Previous Year's Questions

Q. A patient is undergoing a surgery where anesthesia is maintained on Halothane. The patient developed muscle rigidity and hyperthermia which of the following agent would have also contributed to this condition? (NEET PG 2021)

A. Succinylcholine
B. D-tubocurarine
C. Rocuronium
D. Atracurium

NEUROLEPTIC MALIGNANT SYNDROME

01:02:10

- Not a perioperative complication
- Mimics Clinical features of malignant hyperthermia

Important Information

- Earliest clinical features: Muscle spasm
- Early clinical features: Hypercapnia
- Electrolyte abnormality: Hyperkalaemia

CARRIER GAS

01:05:02

- **Nitrous oxide**
  - Earliest anesthetic agent
  - **1845**: Horace wells tried to demonstrate, but he failed
  - Later on, it was discovered that it's not a complete anaesthetic agent.
  - Potency is very less
  - Low molecular weight, odourless gas
  - Also called laughing gas
  - **Separated by** Joseph Priestley

I. MAC – 104

- Least potent
- Not complete anesthetic

II. B: G solubility: 0.45

- Fast agent
- Second gas effect
- Diffusion hypoxia

III. Good Analgesic

- Entonox: 50% N_2O + 50% O_2
- Entonox was made to use the analgesic property of N_2O
- Pin index: 7
- Use
  - Obstetric analgesia
  - Dental analgesia

> **Important Information**
>
> - **Entonox has no role for anesthesia**

IV. Supporter of combustion

V. It expands air containing cavity of body

- It is 35 times more soluble than N_2

VI. Absolute C/I

01:11:51

- Pneumothorax/ Pneumopericardium
- Intestinal obstruction
- Cochlear implant surgery
- Vitreoretinal surgery
- Laser surgery (It is supporter of combustion)

VII. Sympathomimetic

- ↑se BP, ↑se HR, ↑se pulmonary vasoconstriction, ↑se pulmonary artery pressure

VIII. It inhibits Vit B_{12} dependant enzyme

- Cause peripheral neuropathy
- Megaloblastic anaemia

IX. Bone marrow depression

Phenomena with low B: G solubility

01:15:54

I. Second gas effect

- Effect of N_2O to increase the concentration of accompanying gas in alveoli
- Good effect makes speed of induction fast

II. Diffusion hypoxia

01:19:23

- Also called 3rd gas effect
- Bad effect seen during reversal of GA
- Hypoxia produced by rapid diffusion of N_2O from blood to alveoli during reversal of general anesthesia

Treatment

- 100% O_2

Risk

- Risk of diffusion hypoxia is only for 3 – 5 min

Summary N_2O

01:24:07

1. MAC: 104
2. B:G solubility: 0.45
3. Good analgesic

} Good Points

4. Sympathomimetic - CVS unstable
5. Supporter of combustion
6. Peripheral neuropathy
7. Megaloblastic anaemia
8. Bone marrow depression
9. Diffusion hypoxia

} Bad points

XENON

01:25:39

- Inert gas: Non-reactive

I. MAC: 70

- More potent than N_2O

II. B: G solubility- 0.11

- Lowest B:G solubility
- Fastest inhalational anesthetic
- Better analgesic than N_2O

III. CVS stable
IV. Not supporter of combustion
V. Metabolic inert agent
VI. Environmental friendly
VII. Very costly

> **Important Information**
>
> - **All Inhalational and IV Anesthetic agents act on GABA and Glycine receptor in CNS**
> - **Only N_2O, Xenon and Ketamine acts on NMDA receptor**

Table 10.1

Halothane	Isoflurane	Sevoflurane	Desflurane
I. ↓se $CMRO_2$ ↓ CBF ↑↑se ICP ↑↑↑se	↓se $CMRO_2$ ↓ CBF ↑se ICP ↑se	↓se $CMRO_2$ ↓ CBF ↑se ICP ↑se	↓se $CMRO_2$ ↓ CBF ↑se ICP ↑se
II. C/I for neurosurgery	2nd agent of choice	3rd agent of choice	1st agent of choice
III. ↓se EEG	↓se EEG	↓se EEG	↓se EEG

Table 10.2

Halothane	Isoflurane	Sevoflurane	Desflurane
I. Direct Myocardial depressant ↓ ↓se SA node activity ↓ ↓se HR CO = SV x HR • If CO ↓se - BP ↓se • Cause Bradycardia Hypotension	• Cardio stable • ↓se systemic vascular resistance • ↓se Diastolic blood pressure • HR ↓se • Hypotension • Tachycardia	• Cardio stable • ↓se systemic vascular resistance • ↓se Diastolic blood pressure • HR ↓se • Hypotension • Tachycardia	• Cardio stable • ↓se systemic vascular resistance • ↓se Diastolic blood pressure • HR ↓se • Hypotension • Tachycardia
II. Sensitizes the myocardium to the arrhythmogenic effect of catecholamines			
III	Coronary Steal Phenomenon		
IV. Avoid halothane for cardiovascular surgery and patients with cardiovascular comorbidity	3rd choice for CV surgery	2nd choice for CV surgery	• Most Cardio stable • 1st choice for CV surgery

CLINICAL QUESTIONS

Q. A 50 year old female patient came to the preanesthetic assessment clinic for a hysterectomy. History revealed that she had undergone laparotomy 5 years back and intraoperatively she had malignant hyperthermia and was treated for the same. Further details came to know from the previous hospital records. The anesthetic agent suitable for this case is?

A. Sevoflurane
B. Desflurane
C. Succinylcholine
D. Xenon

Answer: D

Solution

Xenon is Non- teratogenic

Option A: Xenon has a very low blood-gas solubility coefficient (0.115) and produces rapid induction and emergence from anesthesia

Option B: Xenon produces no greenhouse effect or ozone depletion and is environmentally safe as it is prepared from the fractional distillation of atmospheric air, unlike the other inhaled anesthetics.

Option C: Xenon does not trigger malignant hyperthermia

Other advantages of xenon

- Stable: Chemically Inert -No metabolism and low toxicity, Non-explosive, Non-pungent, odorless
- Cardioprotective:
  - It produces minimal cardiovascular depression, and it is not arrhythmogenic.
  - Has potent hypnotic and Analgesic activity - reduces intraoperative opioid requirements
- Neuroprotective: without psychomimetic behavioral changes

Disadvantages of Xenon

- High cost
- Nausea, Vomiting
- Xenon gas has a very high density (5.9 g/L) resulting in increased flow resistance and work of breathing. Thus, it may be a poor choice for patients with compromised respiratory function
- Succinylcholine and all halogenated volatile anesthetics trigger malignant hyperthermia. So, it should be avoided.

Reference: Miller's textbook of Anaesthesia-9th edition page no. 567
Stoelting's Pharmacology and Physiology-5th edition page no. 102
Morgan and Mikhail's Clinical Anesthesiology, Page no: 164

Q. A 40 year old male patient, known hypertensive and chronic smoker posted for laparoscopic cholecystectomy under general anesthesia. The patient was induced with Inj. propofol, and endotracheal intubation facilitated with Inj. succinylcholine. Anesthesia was maintained with halothane, nitrous oxide, and Inj. vecuronium. Intraoperatively, the patient develops a masseter muscle spasm with blood pressure-180/100, pulse rate-150/minute, irregularly irregular rhythm, SpO_2: 95%, $EtCO_2$: 50 mmHg, Temperature: 102° F. The most probable diagnosis is?

A. Neuroleptic malignant syndrome
B. Malignant hyperthermia
C. Thyroid storm
D. Myasthenic crisis

Answer: B

Solution

- Malignant hyperthermia is a pharmacogenetic disorder inherited as an autosomal dominant pattern. Its susceptibility is linked to mutations in the skeletal muscle Ryanodine receptor (RyR1) and voltage-gated calcium channel gene (CACNA 1S) that encode calcium channels necessary for skeletal muscle excitation contraction coupling.

Triggering agents: Halogenated volatile anesthetics such as Halothane and depolarizing neuromuscular blocking agents (Succinylcholine)

Signs of Malignant hyperthermia (Hypermetabolic state)

Early signs

- Elevated end tidal carbon dioxide
- Tachypnea and/or tachycardia
- Masseter spasm if succinylcholine has been used
- Generalized muscle rigidity
- Mixed metabolic and respiratory acidosis
- Profuse sweating
- Mottling of skin
- Cardiac arrhythmias
- Unstable blood pressure

Late signs

- Hyperkalemia
- Rapid increase of core body temperature
- Elevated creatine phosphokinase levels
- Gross myoglobinuria
- Cardiac arrest
- Disseminated intravascular coagulation

Treatment

- Discontinue all triggering anesthetics
- Administer Dantrolene
- Supportive measures

Reference: Miller's Textbook of Anaesthesia 9th edition p.g. 1123

Q. 1 year old male child, case of dislocation of hip posted for spica cast. Inhalational induction with 8% sevoflurane done and intubated with 3.5 mm endotracheal tube. Rationale for using sevoflurane in this case include?

A. Sevoflurane appears to have a greater therapeutic index than halothane
B. Sevoflurane appears to produce the least degree of airway irritation
C. Produces bronchodilatation
D. All

Answer: D

Solution

Sevoflurane

- It is a fluorinated methyl isopropyl ether
- The vapour pressure of sevoflurane is similar to isoflurane and halothane
- Blood-gas-partition coefficient of sevoflurane is 0.69 which is adequate for induction and recovery after anesthesia
- It is non pungent and has minimal odour
- It causes bronchodilatation similar to isoflurane
- It causes minimal airway irritation among the other available inhaled anaesthetic
- It differs from halothane which is a metabolite to reactive acyl halide intermediate, which can cause hepatotoxicity

Reference: Stoelting's Pharmacology and Physiology in Anaesthetic Practice, 5th edition, pg 101

Q. A 35 year old male admitted with traumatic brain injury due to road traffic accident. Primary survey showed unconsciousness with blood pressure of 160/100 mmHg and pulse rate is 56/minute. He was posted for emergency decompressive craniotomy under general anesthesia. The inhalational anesthetic agent to be avoided for this patient is?

A. Halothane
B. Isoflurane
C. Sevoflurane
D. Desflurane

Answer: A

Solution

- Isoflurane, sevoflurane, desflurane increase cerebral blood flow (CBF) and intracranial pressure (ICP) in dose dependent manner in concentrations of >0.6 MAC. Halothane's vasodilating effect on cerebral blood vessel is more than that of others to increase intracranial pressure

Reference: Stoelting's Pharmacology and Physiology in anaesthetic practice 5th edition pg 119

Q. A 50 year old female known case of coronary artery disease underwent percutaneous trans luminal coronary angioplasty. Now posted for Modified radical mastectomy under general anesthesia. The inhalational anesthetic agent to be avoided is?

A. Isoflurane
B. Sevoflurane
C. Desflurane
D. Halothane

Answer: A

Solution

- If a coronary artery provides blood to two or three distal branches and one of them is narrowed, administration of the vasodilator may cause preferential vasodilatation of the normal vessel leading to increase in blood flow to the area which is supplied by the normal anatomy. This causes relative decrease in the blood flow to the area of the heart which is supplied by the stenotic vessel. This is known as **coronary steal.**
- Isoflurane more than other inhalational agents increases coronary blood flow many times beyond that of the myocardial

oxygen demand, thereby, creating potential for "Steal".

Reference: Clinical Practice of Cardiac Anaesthesia Deepak K. Tempe 3rd edition, page 34, 147

Q. A 45 year old who is a known hypertensive on treatment, a case of acute intestinal obstruction posted for laparotomy under general anesthesia. Inj. propofol 100 mg was used for induction of anesthesia, endotracheal intubation facilitated with Inj. succinylcholine and anesthesia maintained with oxygen/nitrous oxide, halothane and cisatracurium. During the intraoperative period, a sudden increase in end tidal carbon dioxide, tachycardia, muscle rigidity and unstable blood pressure followed by cardiac arrythmias was noted. The diagnosis of malignant hyperthermia was made and treated with Inj. Dantrolene sodium. The side effect which is not expected in this patient would be?

A. Muscle weakness
B. Phlebitis
C. Respiratory insufficiency
D. Renal dysfunction

Answer: D

Solution

Common side effects of IV Dantroleum

- Muscle weakness (21.7%) Gastrointestinal upset, Excessive secretion, Phlebitis, Hyperkalemia, Respiratory failure, Excessive secretions

Reference: Miller's textbook of Anaesthesia 9th edition, page. 1124

11 INTRAVENOUS ANESTHETIC AGENTS

Classification

Non-opioids	Opioids
• Barbiturates (salts of barbituric acid) o Thiopentone o Thiamylal o Methohexitone • Propofol (Di-isopropyl alcohol) • Etomidate (Salt of Imidazolone) • Ketamine (Phencyclidine) • Benzodiazepines o Midazolam o Diazepam o Lorazepam	• These are pure agonists of opioid receptors • Include o Morphine o Fentanyl o Alfentanil o Remifentanil o Sufentanil
• Most of these are Cardiovascular unstable	• Cardiovascular stable at any dose
• These are short-acting & once they are stopped, the effect on the respiratory system is stopped • Hence, used for induction & maintenance of anesthesia	• For routine general anesthesia, these are used in analgesic dose which is very low, as high dose causes prolonged respiratory depression & reversal would be delayed • For example, if we are using Morphine as analgesia only 0.05-0.1mg/kg body weight. But for anesthesia 2-3mg/kg body wt. is required which cause prolonged respiratory depression • Use of opioid in anesthetic dose is reserved only in severe CVS compromise

BARBITURATES

00:06:55

- Salts of barbituric acid
- By replacing 2nd & 5th carbons with different elements (carbon/oxygen/sulfur etc.) or drugs or phenyl etc. different barbiturates come to existence
- Thiobarbiturates contain sulfur atom on 2nd carbon of the barbituric ring

Thiobarbiturates	Oxy-barbiturates
• Include Thiopentone, Thiamylal • IV injections are not painful • Anticonvulsant	• Methohexitone • IV injections are painful • Pro- convulsant • Anesthetic agent of choice in Electro Convulsive Therapy

THIOPENTONE

00:10:23

- Ultra short-acting barbiturate
- Even though its an ultra-short acting drug, it can show prolonged effect if infused for a prolonged period of time
- Final metabolism of the drug is very delayed & a lot of intermediate by products are formed which may show the effect

Commercial preparation

- Yellowish powder
- PH>10.5, highly alkaline, which contributes to bacteriostatic property
- Normal saline / distilled water is used to reconstitute (no acidic fluids are used)
- 2.5% concentration is used clinically

Additive

- 1 Part of sodium thiopentone is mixed with 6 parts of anhydrous sodium carbonate (Na_2CO_3)
- Anhydrous sodium carbonate is added to prevent precipitation of insoluble acid of drug with atmospheric CO_2
- Liquid formulation of Sodium Thiopentone
  - Stable at room temperature for 6-7 days
  - In refrigerator stable for 1 month

Clinical use

00:15:57

- Induction dose: 4-5mg/Kg body weight

- Within brain arm circulation (i.e 11-14sec), the patient becomes unconscious
- Within 6-7 mins after a single dose, the patient regains his consciousness

Important Information

- Rapid awakening after a single dose is due to redistribution (not metabolism)

Redistribution

- After giving single dose of Thiopentone, it goes to highly perfused organs like brain, binds to its receptors & produce effect (unconsciousness)
- Once serum concentration decreases, it comes out of receptors of brain & gets redistributed to lesser perfused organs like muscles, bones etc.
- Drug is active, not metabolized, but it isn't at the target organ i.e. brain
- Hence, patient regains consciousness

- Other drugs like Propofol, Etomidate, Ketamine etc. can redistribute
- In fact, all anesthetic agents have to redistribute, only then when they are given in continuous infusion & stopped, patient regains consciousness immediately
- But the final effect of the drug goes away when it is metabolized
- Drug being a good agent is decided by the fact on how fast drug gets metabolized
- Though Thiopentone is redistributed, its final metabolism is delayed

Metabolism

- Occurs in liver & kidney
- Demethanization occurs in the liver & by-products are excreted by the kidney
- Metabolism of single dose takes place in 24-48 hrs
- If continuous infusion is given, it takes weeks to metabolize
- Hence, it isn't used for maintenance

PHARMACODYNAMIC PROPERTIES 00:21:28

CNS

- Decreases cerebral metabolic oxygen requirement (protects from ischemic injury)
- Decreases cerebral blood flow
- ↓ICP
- Decreases EEG activity (i.e from β α θ δ)
- Cerebroprotective

Cerebral protection

- Decrease the global cerebral activity of the brain & gives protection
- So, it needs cerebral activity for this effect
- Hence, not useful in post-cardiac arrest patients
- Hypothermia offers cerebral protection even at silent EEG
- Per degree decrease in core temperature, cerebral activity decreases by 6-7%

Important Information

- Best drug for cerebral protection: Thiopentone
- Best modality for cerebral protection: Hypothermia

CVS 00:26:50

- It is CVS unstable, causes myocardial depression
- It decreases systemic vascular resistance which decreases blood pressure resulting in increased heart rate due to sympathetic stimulation (reflex tachycardia)
- Hence, contraindicated in shock

Respiratory system 00:28:29

- Causes respiratory center depression
- Blunts respiratory drive to hypoxia & hypercapnia
- Bronchospastic, especially in pts. with bronchial hyperactivity. Hence, C/I in Bronchial Asthma

Liver & Kidney 00:29:57

- Metabolism is entirely dependent on liver & kidney
- All barbiturates are enzyme inducers. Hence, contraindicated in Porphyria

Important Information

Contraindications of Thiopentone

- Shock
- Bronchial Asthma
- Porphyria

Uses of Thiopentone 00:31:30

- Used for induction (but not anesthetic agent of choice)

Important Information

- Methohexitone is DOC for Electro-Convulsive Therapy [ECT]
- In ECT, electric shock is given to pt. as a treatment modality & to see effectivity of treatment
- Hence, pro-convulsant like Methohexitone help us to decide whether treatment modality is successful or not

- **DOC for Narcoanalysis**
  - Barbiturates are known as Truth Serum. Used for lie detection test
  - Other drugs like Scopolamine, Amyl nitrate etc. also have this effect but are not used routinely as they cause several side effects

- **DOC for cerebral protection**
  - It decreases cerebral activity by 50% drug can reduce
- Barbiturates are rarely used in anesthesia now adays, it is replaced by Propofol

Previous Year's Questions

Q. Which of the following is contraindicated in acute intermittent porphyria? (FMGE August 2020)

A. Sodium Thiopentone
B. Propofol
C. Ketamine
D. Etomidate

PROPOFOL

00:35:03

- Appearance → Milky white in color
- Chemical nature → Di isopropyl phenol
- Concentration used → In India 1% [i.e. in 1ml of drug, 10mg of Di-isopropyl alcohol is present]; In USA 1 & 2% is used

Commercial preparation

- Have 1% Di isopropyl phenol
- It isn't soluble intravenously. Hence, it is prepared as lipid emulsion to give intravenously
- **Additives**
  - E - Egg Lecithin (Egg allergy doesn't occur clinically but theoretically it can cause Egg Allergy)
  - G - Glycerol
  - S - Soybean oil

How to remember

EGS

Important Information

- Propofol is the Agent of choice for day care surgery because of
  - Rapid metabolism with no residual effect
  - Anti-emetic effect
  - Gives pleasant recovery

Pharmacokinetic properties 00:42:08

- Onset in 30-60 secs
- Duration: Rapid awakening after single dose (i.e in 6-7 minutes)

Metabolism

- 80% by liver & kidney
- 20% by extra-hepatic, extra-renal route
- Final metabolism is never delayed even in hepatic & kidney dysfunction as extra-hepatic & extra-renal routes take over it

PHARMACODYNAMIC PROPERTIES 00:44:22

CNS

- ↓ Cerebral metabolic oxygen requirement
- ↓ Cerebral blood flow
- ↓ ICP
- ↓ EEG activity
- Anti- convulsant
- Cerebro-protective
- Anti-emetic effect
  - By inhibitory effect on vomiting center & also by having a diffuse effect on subcortical centers, exact MOA is unknown)
- No analgesia is provided

CVS

- Myocardial depression
- Decrease in systemic vascular resistance
- ↓ Blood pressure
- ↓ HR (Bradycardia related deaths has been documented)
- Hence contraindicated in shock

Respiratory system

- Respiratory center is depressed
- Hypoxic or Hypercapnic drive is blunted
- Good bronchodilator

- Ketamine is the best bronchodilator
- But, if Ketamine is unavailable, Propofol can be used in asthmatic pts.

- Maintains hypoxic pulmonary vasoconstriction
- Upper airway reflexes are blunted maximally by Propofol
  - Hence, instrumentation procedures like endoscopy, bronchoscopy or check laryngoscopy are easily done by giving Propofol

Hepatic & Renal: No effect

Uses of Propofol 00:51:21

- In general anesthesia, for both induction & maintenance
  - It is anesthetic agent of choice in daycare surgery
  - Neurosurgery
  - Thoracic surgery
  - Pre-existing kidney & liver dysfunction
  - Porphyria
  - Malignant Hyperthermia
  - Endoscopic procedures

- Sedation in ICU as metabolism isn't delayed
  - Its use is restricted for < 48 hrs, as prolonged use may cause Propofol Infusion Syndrome
  - Not used in pediatric for prolonged infusion

- Anti-emetic
- Anti-pruritic

Side effects 00:56:35

- Most common S/E: Local pain at the site of injection
  - Propofol reacts with the intimal layer of a blood vessel resulting in the local inflammatory release of bradykinin, which causes pain
  - To minimize this pain following can be done
    - → Mix 2% 1 ml of Lignocaine with 9 ml of 1% Propofol
    - → Prior IV opioid (like fentanyl) is given
    - → Cooling of drug
    - → Thick vein is used

- **Propofol Infusion Syndrome**
  - If Propofol is given for > 48 hrs; a metabolite of Propofol accumulates in the body & inhibits mitochondrial enzymes affecting ETC, fatty acid oxidation resulting in lactic acidosis, myocardial dysfunction /death in some cases

- Pancreatitis (rare)
- Rarely on induction convulsions (Tonic Clonic) has been reported

Previous Year's Questions

Q. Which of the following is used for daycare surgery? (FMGE JUNE 2019)

A. Ketamine
B. Thiopentone
C. Propofol
D. Etomidate

ETOMIDATE 01:02:30

- Imidazolone derivative
- Appearance: 2 preparations are available
  - Milky white in color similar to Propofol
  - Transparent
- Metabolism: By liver & kidney

Pharmacodynamics properties 01:03:52

CNS

- ↓ Cerebral metabolic oxygen requirement
- ↓ Cerebral blood flow
- ↓ ICP
- ↓ EEG activity
- Cerebro-protective
- No analgesia is provided
- After using Etomidate, Myoclonus is commonly noted

CVS

- Cardiovascular stable. Hence, used in cardiovascular compromised patient

Important Information

- **Non-opioid I.V anesthetic agent which is CVS stable is Etomidate**

Respiratory system

- Causes respiratory center depression
- Hypoxic & hypercapnic drive is blunted
- Bronchodilator

Adrenal gland

- Even a single dose can temporarily suppress adrenal cortex
- It inhibits 11 β-hydroxylase enzyme, which is essential for the synthesis of cortisol

Side effects

- Pain on IV injection
- Myoclonus
- Adrenal suppression
- High incidence of nausea & vomiting

Previous Year's Questions

Drugs does not causes cardiac depression?

(NEET Jan 2019)

A. Propofol
B. Ketamine
C. Etomidate
D. Thiopentone

KETAMINE

01:09:07

- Phencyclidine derivative
- Routes of administration: IV / IM / Oral / Rectal/ Intra-thecal
- It is the only IV anesthetic agent that can be given by multiple routes

DISSOCIATIVE ANESTHESIA (AKA) THALAMOCORTICAL DISSOCIATION

- Seen at a low dose of Ketamine [i.e at 1/10th of normal dose]
- Patient remains conscious but not oriented in time or place
- Due to Thalamocortical & Limbic dissociation
- **Use:** Simple superficial painful procedures can be done under dissociative anesthesia

Pharmacokinetics

01:13:43

- Onset: 60-90 sec
- Duration: 7-9 mins (after single dose the drug redistributes)
- Ketamine causes sympathetic stimulation by inhibiting metabolism of catecholamines
- In absence of catecholamines no sympathetic stimulation occurs

PHARMACODYNAMIC PROPERTIES

01:16:20

CNS

- ↑ Cerebral metabolic oxygen requirement (due to sympathetic stimulation)
- ↑ Cerebral blood flow
- ↑ ICP
- ↑ EEG activity
- Cerebro-protective (through NMDA antagonism)
- C/I in Neurosurgery & in patients with a history of Epilepsy

Important Information

- I.V anesthetic agent that increases oxygen tension of brain Ketamine

CVS

- In presence of catecholamines: ↑ BP, ↑ HR
- In absence of catecholamines: Myocardial Depressant
- Hence, it is C/I in Ischemic Heart Diseases, critically ill pts (catecholamine depleted state) & hypertensive pts.
- **Agent of choice in** Acute Shock & Cyanotic Heart Diseases

Respiratory system

- Respiratory center depressant
- Hypoxic & hypercapnic drive blunted
- **Best bronchodilator:** Hence, agent of choice in Bronchial Asthma

Hepatic & Renal: No effect

Important Information

Ketamine

Agent of choice	Contraindications
• Shock / Acute shock • Bronchial Asthma • Cyanotic Heart Disease	• Ischemic Heart Disease • Hypertension • Neurosurgery • H/o Epilepsy • Glaucoma • Chronic critically ill patient

- **Most common side effect of Ketamine** → Postoperative delirium & hallucination

Predisposing factors for Delirium & Hallucinations

01:24:36

- Patient being given anticholinergic drugs like Atropine, Glycopyrrolate etc.
- Adults (less in children)
- **Treatment & Prevention:** IV Benzodiazepine (Midazolam)

Previous Year's Questions

Q. **Which of the following anaesthetic agents causes postoperative delirium and hallucinations?**

(FMGE DEC 2020)

A. Ketamine
B. Propofol
C. Thiopentone
D. Etomidate

Previous Year's Questions

Q. Intravenous agent does not cause pain?
(NEET Jan 2019)

A. Methohexital
B. Propofol
C. Ketamine
D. Etomidate

BENZODIAZEPINES

01:27:45

- Comparatively slow onset. Hence, less commonly used for induction
- If used for long-duration, recovery from anesthesia is delayed. Hence, not commonly used as a maintenance agent

Effects

- Major property is Anxiolysis. Hence, used as pre-medication for anxiety
- Sedation (anxiolytic effect >> sedative effect)
- Anti-convulsant
- Spinal Cord mediated skeletal muscle relaxation
- Anterograde Amnesia

	Midazolam	Diazepam	Lorazepam
Onset	Fastest	-	-
Dose	0.1-0.3mg/kg body wt	0.3-0.5mg/kg body wt	0.05mg/kg body wt (most potent benzodiazepam)
Duration of action	shortest	-	-
Elimination time	1-4 hrs	21-37 hrs	10-20 hrs

MIDAZOLAM

01:31:36

- Fastest & shortest acting. Hence, it is only benzodiazepine which can be used for induction & maintenance of anesthesia
- Water soluble drug
- 2-3 times more potent than diazepam
- Among benzodiazepines, it has shortest elimination time

Pharmacokinetics

- Slow effect site equilibrium
- It takes 5.4 mins to reach brain. Hence, induction is slow
- Slow elimination: takes 1-4 hrs
- Metabolism: Hepatic

PHARMACODYNAMIC PROPERTIES

01:33:59

CNS

- ↓ Cerebral metabolic oxygen requirement
- ↓ Cerebral blood flow
- ↓ ICP
- No Neuro-protective effect
- Anti-convulsant

CVS

- Decrease BP by decreasing systemic vascular resistance
- Minimal or no myocardial depression

Respiratory system

- Depress the respiratory center
- Blunts respiratory drive

Uses

- Preoperative medication in both adults & children for anxiolysis
  - For children, oral Midazolam is available: given at a dose of 0.25 -0.75mg/kg body wt
  - Even at an oral dose of 1mg/kg body wt, ventilatory depression is much less
  - Given 20-30 minutes before separation from parents, cause minimal separation anxiety
- As sedation during regional anesthesia
  - 1-2mg IV dose can provide anterograde amnesia for 1-2hrs
- For induction & maintenance
- Anti-convulsant
- No pain on IV injection

DIAZEPAM & LORAZEPAM

- Not used for anesthesia now a days
- Lorazepam is sometimes used for sedation, as it is more potent, cheaper & long acting
- Diazepam causes pain on IV or IM injection

Important Information

Drugs causing pain on IV injection

- Methohexitone
- Propofol
- Etomidate
- Diazepam

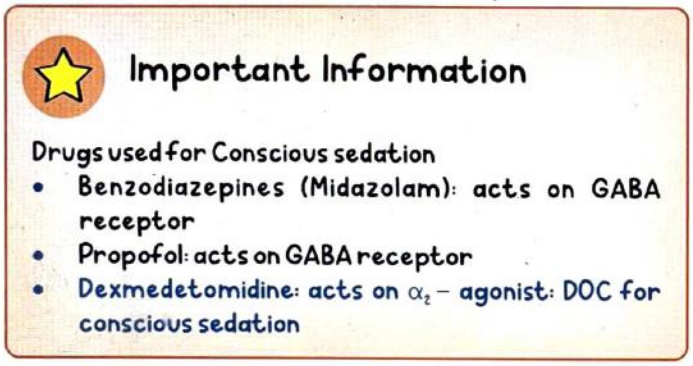
DEXMEDETOMIDINE

- Most commonly used as an adjuvant along with anesthesia
- Pure α_2 agonist

- Sensitivity for α_2: α_1 is 1640:1
  - Clonidine is another α2 agonist & its sensitivity for α_2:α_1 is 90:1

Properties
- Provides
  - Good sedation
  - Good analgesia
  - Minimal cardiovascular compromise (sometimes, if at all CVS side effects occur, it would be hypotension & bradycardia)
  - Minimal respiratory depression

Conscious sedation
- Sleep like state from which the patient can be easily aroused
- Useful in surgeries where the patient has to be aroused (like brain surgery near vital centers etc.)



Uses of Dexmedetomidine
- Sedation
- As adjuvant during general anesthesia
- As adjuvant by mixing up it with local anesthesia during peripheral nerve block
- Proven to increase the duration of local anesthesia

ACCIDENTAL INTRA-ARTERIAL INJECTION OF DRUG

01:48:18

- Arterial injection can cause spasm of the artery, leading to ischemia & gangrene of the area supplied by it
- **1st Symptom:** Pain
- **1st sign:** Pallor
- Thiopentone causes intense arterial spasm

Management
- Leave the cannula on site to maintain access
  - If the cannula is removed mistakenly, put cannula proximal to that artery to do local treatment for spasm
- 500 units of Heparin is given through cannula to dissolve clots & keep it patent
- 10ml of 1% Lignocaine is given to decrease pain & vasodilation
- Other arterial dilators like Papaverine can be given
- If nothing works, Stellate Ganglion Block can be done

STELLATE GANGLION BLOCK

01:51:55

- Stellate ganglion is sympathetic ganglion supplying ipsilateral half of face & ipsilateral upper limb
- When blocked, vasodilation occurs
- Done under USG Guidance
- **Surface landmark:** Tubercle of C7 vertebra known as CHASSAIGNAC TUBERCLE
- Drug is put below tubercle & look for signs of block

Signs of successful Stellate Ganglion Block
- Flushing due to vasodilation
- **Horner Syndrome:** Miosis, Ptosis, Anhidrosis & loss of cilio-spinal reflex
- Conjunctival congestion (redness of conjunctiva due to increased blood flow)
- Ipsilateral nasal stuffiness: Guttmann's sign
- Ipsilateral tympanic membrane redness: Muller's sign
  - Bradycardia isn't a sign of block, its complication

Brachial Plexus Block
- If stellate ganglion block can't be done, brachial plexus block can be done
- In this both sensory & motor block is also seen. Hence, not preferred

TOTAL INTRAVENOUS ANESTHESIA (TIVA)

01:56:41

- IV anesthetic agent is used for both induction & maintenance
- Most common combination used Propofol + Fentanyl
- It ↓ $CMRO_2$, ↓CBF, ↓ICP (Cerebro-protective). Hence, preferable for neurosurgery
- Maintains hypoxic pulmonary vasoconstriction. V/Q mismatch is minimized. Hence, preferred for thoracic surgeries
- Maintains dual blood supply of liver
- Rapid metabolism
- Less incidence of post-operative nausea & vomiting
- Pleasant recovery
- Safe in Malignant Hyperthermia
- Propofol have wide range of maintenance dose (i.e. 100-300mcg/kg body wt. infusion)
  - Hence, requires BIS monitoring to decrease risk of awareness due to under-dosing of Propofol
- Costly
  - As it is costly & BIS monitoring is required, not routinely used in developing countries

CLINICAL QUESTIONS

Q. A 35 year old female who is case of fibroadenoma of left breast posted for excision biopsy under intravenous anesthesia with Proseal LMA and spontaneous ventilation. Inj. glycopyrollate, midazolam, fentanyl and Inj. propofol 100 mg given intravenously to facilitate the LMA insertion. After 10 minutes, spontaneous ventilation was resumed and anesthesia was maintained with oxygen/nitrous oxide, sevoflurane. This rapid recovery from propofol is due to?

A. Redistribution
B. Excretion
C. Biotransformation
D. D - Methylation

Answer: A

Solution

- After single bolus dose, rapid mixing of the drug within the central blood volume followed by quick distribution to highly perfused low volume tissues (Brain) then slowly redistributed from the brain to tissues which are less perfused like muscles, resulting in rapid recovery within 20 minutes
- All intravenous anaesthetic agent undergo rapid redistribution. Thus, awakening from Thiopentone, Propofol, Etomidate, ketamine is very fast

Reference: Miller textbook of Anesthesia, Page no: 824-8th edition

Q. A 40 year old male who is a chronic smoker and alcoholic posted in emergency operation theatre for laparotomy for suspected hollow viscous perforation under general anesthesia. His preoperative Blood pressure: 110/70 mmHg on noradrenaline infusion, Pulse rate: 110/minute, SpO_2:97%, Respiratory rate: 24/minute, Temperature: 101°F. Intravenous anesthetic agent to be avoided in this case is?

A. Etomidate
B. Midazolam
C. Fentanyl
D. Ketamine

Answer: A

Solution

- Etomidate causes adrenal gland suppression. It inhibits an enzyme 11 beta hydroxylase on essential enzyme for cortisol synthesis. This inhibition lasts for more than 8 hours after induction with etomidate. Patients with sepsis or hemorrhage who require intact cortical response can avoid etomidate
- Etomidate causes increases in incidence post-operative nausea and vomiting(PONV) among the intravenous anesthetics
- Propofol has antiemetic properties thereby reducing PON.

Other potential adverse effects of Etomidate

- Adrenocortical suppression
- Myoclonus
- Seizure precipitation

- Pain on injection

Reference: Stoelting's Pharmacology and Physiology in Anesthesthetic practice, Page no: 171-5th edition

Q. A 55 year old male admitted with traumatic brain injury due to road traffic accident. Primary survey showed unconsciousness with blood pressure of 150/100 mmHg and pulse rate is 50/minute. He was posted for emergency decompressive craniotomy under general anesthesia. The intravenous anesthetic agent to be avoided in this patient is?

A. Thiopentone
B. Propofol
C. Ketamine
D. Etomidate

Answer: C

Solution

- Ketamine increases cerebral blood flow, cerebral metabolism and intracranial pressure. Ketamine increases cerebral metabolic rate of oxygen due to its excitatory CNS effects which can be detected by generalised theta wave activity in EEG and petit mal seizure like activity in hippocampus. Ketamine administration may be associated with lacrimation and salivation which can be attenuated by premedication with an anticholinergic agent such as glycopyrrolate. Thiopentone, propofol, and Etomidate decrease $CMRO_2$, CBF, and ICP.

- Barbiturates causes a dose related decrease in cerebral oxygen consumption rate, rate of ATP consumption thus are cerebroprotective. Barbiturates reduce the metabolic activity concerned with neuronal signaling and impulse traffic, not the metabolic activity corresponding to basal metabolic function. When the EEG became isoelectric, Thiopentone decrease upto 50% of baseline in Cerebral metabolic activity

- Propofol is neuroprotective against ischemic injury but only if the ischemic insult is mild and not sustained. The neuroprotective effect results from attenuation of changes in ATP, calcium, sodium and potassium caused by hypoxic injury

- Etomidate reduces cerebral blood blow by 34% and cerebral metabolic rate of oxygen by 45% without altering mean arterial pressure. Cerebral perfusion pressure is maintained or increased and a beneficial net increase in cerebral oxygen supply to demand ratio occurs. Etomidate also reduces intracranial pressure to 50% in patients with already increased intracranial pressure.

Reference: Miller's Textbook of Anesthesia 8th edition, Page no: 826,834,847,852

Q. A 45 year old male patient who underwent decompressive craniotomy shifted to ICU for elective postoperative ventilation. The patient was sedated and paralysed with infusions of propofol, midazolam and Inj. vecuronium. On 3rd day, his Blood pressure: 90/60 mmHg, pulse rate-48/minute, SpO_2: 96%. Blood investigations showed Hb: 13g/dl; platelet count 1.5 lakhs/cumm; blood urea: 80 mg/dl; serum creatinine-3 mg/dl; P^H-7.15; PO_2-200 mmHg; PCO_2-20 mmHg; HCO_3-15 mmol/l; Na^+-140 mEq/l; K^+-5.8 mEq/l; blood cholesterol-350 mg/dl; triglycerides-300 mg/dl. Ultrasonogram abdomen revealed hepatomegaly. Chest X ray was normal. The most probable diagnosis is?

A. Critical illness polyneuropathy/myopathy
B. Propofol infusion syndrome
C. Hepatic encephalopathy
D. Central pontine myelinosis

Answer: B

Solution

Propofol infusion syndrome is lethal but rare syndrome. Seen when the dose of propofol infusion is > than **4 mg/kg/hour or more for 48 hours**. It is common in critically ill adults and children

Clinical features

- The first indication of propofol infusion syndrome is increasing Lipaemia
- It is due to defect in mitochondrial metabolism and electron transport chain function
- The symptoms and signs are the result of muscle injury and the release of intracellular toxic contents
- Acute refractory bradycardia leading to asystole, present with one or more
  - Metabolic acidosis (base deficit >10 mmol/L)
  - Enlarged or fatty liver
  - Hyperlipidemia
  - Rhabdomyolsis
- Cardiomyopathy with acute cardiac failure, hepatomegaly, hyperkalemia, skeletal myopathy, and lipaemia.
- Major **risk factors** .are large propofol dosage
- Cerebral injury,.poor oxygen delivery, Sepsis

Reference: Miller's Anesthesia 8th edition, Page no: 831

Q. A 30 year old male admitted in casuality with the history of road traffic accident and sustained injury to the head. His GCS-6/15, blood pressure: 150/100 mmHg; pulse rate: 50/minute; SpO_2-90%. In view of poor GCS, he was intubated in the casuality and the CT brain showed right temporoparietal subdural hematoma. Emergency decompressive craniotomy under general anesthesia was planned. The anesthetic agent which has cerebroprotective effect, suitable for this patient could be?

A. Barbiturates
B. Propofol
C. Etomidate
D. All show cerebroprotective effect

Answer: D

Solution

- Barbiturates causes a dose related decrease in cerebral oxygen consumption rate, rate of ATP consumption thus are cerebroprotective. Barbiturates reduce the metabolic activity concerned with neuronal signalling and impulse traffic, not the metabolic activity corresponding to basal metabolic function.

- When the EEG became isoelectric, Thiopentone decrease upto 50% of baseline in cerebral metabolic activity

- Propofol is neuroprotective against ischemic injury but only if the ischemic insult is mild and not sustained. The neuroprotective effect results from attenuation of changes in ATP, calcium, sodium and potassium caused by hypoxic injury

- Etomidate reduces cerebral blood blow by 34% and cerebral metabolic rate of oxygen by 45% without altering mean arterial pressure. Cerebral perfusion pressure is maintained or increased and a beneficial net increase in cerebral oxygen supply to demand ratio occurs. Etomidate also reduces intracranial pressure to 50% in patients with already increased intracranial pressure

	CBF	ICP	$CMRO_2$
Thiopentone	↓↓↓	↓↓↓	↓↓↓
Ketamine	↑↑	↑↑	↑
etomidate	↓↓↓	↓↓↓	↓
propofol	↓↓↓	↓↓↓	↓↓↓

Reference: Miller's Textbook of Anesthesia 9th edition, Page no: 663, 650, 642, 667

Q. A 38 year old male admitted with the history of road traffic accident and he had posterior dislocation of shoulder. This patient was planned for closed reduction under general anesthesia. Inj. glycopyrroltae, midazolam, propofol and succinylcholine was used. Graded doses of propofol was used and 20 mg IV given just before the completion of the procedure. This patient had no postoperative nausea and vomiting because of the antiemetic effect of propofol. The postulated mechanism(s) behind this effect could be?

A. Antidopaminergic activity
B. Depressant effect on the chemoreceptor trigger zone
C. Acts on subcortical structures
D. All of the above

Answer: D

Solution

Mechanisms of antiemetic effect of propofol

- It modulates subcortical structures
- Antidopaminergic activity
- Direct depressant effect on the chemoreceptor trigger zone
- Antiemetic dose: 10-15 mg iv
- Plasma concentration-10 mg iv followed by 10 mcg/kg/minute

Reference: Stoelting's pharmacology and physiology in Anesthetic practice-5th edition, page no. 163

12 OPIOIDS

00:00:16

Balanced anaesthesia: Use of multiple drugs in a titrated way to provide a different component of general anaesthesia

- One component required during GA is analgesia
- OPIOID, because of its anti-naive septic effect has a huge role in providing infra operative analgesia
- Apart from analgesic effect, opioid is also used as an adjuvant of other drugs
- Has a strong role in balanced anaesthesia

OPIOID

00:01:25

History

- Opium: Means juice from poppy plants
- Opiates: Natural drugs separated from opium
- Morphine: First drug to be separated from opium

OPIOIDS

00:03:22

- Natural or synthetic drugs acting on opioids receptors and producing morphine like effects

- **3 types**
  - μ (meu)
    - → μ_1
    - → μ_2
  - k (Kappa)
  - δ (delta)

Action

- Act as an agonist at stereospecific opioid postsynaptic sites in CNS and outside CNS in peripheral tissue
- Opioid receptors are located on primary afferent neurons

Classification

00:07:10

- **4 groups**

I. **Pure agonist:** With intrinsic action 1
   - Morphine
   - Pethidine (Meperidine)
   - Fentanyl
   - Sufentanil
   - Alfentanil
   - Remifentanil

II. **Partial agonist:** With intrinsic activity
   - Buprenorphine

III. **Agonist: Antagonist**
   - Pentazocine
   - Nalbuphine
   - Butorphanol

How to remember

- PNB

IV. **Pure Antagonist**
   - Naloxone
   - Naltrexone
   - Nalmefene

Important Information

- **Pure Agonist are most important opioid used during anaesthesia**

I. PURE AGONISTS

00:11:15

- Opioid agonists are most likely to be used with inhaled and intravenous anaesthesia as an adjuvant during general anaesthesia
- Large doses can be used as the sole anaesthetic in critically ill patients (CVS stable)

Morphine

00:14:31

- Is the prototype opioid agonist to which all opioids will be compared

Routes

00:15:40

- IV
- IM
- Oral

} Onset time 15 – 30, Peak effect 45 – 90 min

- Nebulization
- Intrathecal

Slow effect-site equilibrium

- Poor lipid solubility
- High degree of ionization
- High protein binding
- Rapid conjugation with glucuronic acid

Metabolism 00:18:45

- Hepatic metabolism by conjugation with glucoronic acid
- **2 intermediate products**

I. Morphine 3 – glucuronide
   - 75 – 85%
   - Inactive

II. Morphine 6 – glucuronide
   - 15 – 25%
   - Active
   - Completely eliminated through the kidney

PHARMACODYNAMICS 00:21:00

CVS

- No myocardial depression
- No hypotension
- Depresses compensatory SNS response cause bradycardia
- Little decrease in systemic vascular resistance due to histamine release
- Morphine is CVS stable

Respiratory system 00:24:29

1. Dose dependent direct depression of ventilation through effect on respiratory centre on the brain stem
2. Decrease responsiveness of ventilator centre to CO_2
3. Interferes with the pattern of breathing
   - Rhythm is disturbed with long pauses
4. Depression of ventilation is for a prolonged period
5. Depression of ciliary activity in airway

CNS 00:28:27

- ↓se Cerebral metabolic oxygen requirement
- ↓se Cerebral blood flow
- ↓se Intracranial pressure
- ↓se EEG

Skeletal muscle rigidity

- Thoracic
- Abdominal rigidity
- Due to ↑ed skeletal muscle tone because of imbalance between Dopamine & GABA

Miosis

- Due to an excitatory action in the ANS component of the Edinger Westphal nucleus of the oculomotor nerve

Biliary tract 00:33:23

- Spasm of biliary smooth muscle resulting in ↑ed intrabiliary pressure

CTZ center

- Nausea & vomiting
- Caused by direct stimulation of chemoreceptor trigger zone (CTZ) in the form of 4th ventricle

Genitourinary system 00:35:00

- Increases tone and peristaltic activity of ureter
- Urinary urgency is produced because augmentation of tone of Detrusor muscle

Cutaneous changes 00:36:30

- Dilate cutaneous vessels causing flushing of face, neck and upper thorax

Overdose 00:37:25

- Morphine overdose principal manifestation
- **Triad**
   - Respiratory depression
   - Miosis
   - Coma

Treatment

- Support Ventilation
- Give Naloxone

Previous Year's Questions

Q. A 30-year-old male with a road traffic accident was given intravenous morphine. After an hour the respiratory rate decreased and BP heart rate decreased. what is the most probable reason?
(INICET Nov 2020)

A. Morphine induced decreased respiratory drive
B. Head injury induced decreased respiratory drive
C. Morphine addiction
D. None of the above

MEPERIDINE 00:39:02

- Synthetic opioid agonist on μ and k receptor

Structure

- Phenylpiperidine

- Structurally similar group to local anesthetic
   - Tertiary amine
   - Ester group
   - Lipophilic phenyl group

- It has local anesthetic effect

- Structurally resemble Atropine
   - Produces Mydriasis
   - Antispasmodic effect

Pharmacokinetics 00:42:25

- 1/10th as potent as morphine
- Duration of action: 2 – 4 hrs

Metabolism

- Liver metabolism: 90% by demethylation to Normeperidine
- Normeperidine: Eliminated by Kidney
- In presence of renal failure, Normeperidine can accumulate and cause CNS stimulation
  - Seizure
  - Myoclonus

Clinical use 00:44:51

- Principal use

1. Labor analgesia
   - Post-operative analgesia
2. As local anesthetic
   - For subarachnoid block
3. Anti-shivering agent
   - Through effect on k receptor and also by being α_2 – agonist

Important Information

- Meperidine. Pethidine is the drug of choice in managing post – operative shivering
- Meperidine has local anesthetic effect

Side effects 00:47:38

1. Tachycardia
2. Metabolite

- Normeperidine accumulation can cause CNS stimulation

3. Serotonin syndrome

- Sympathetic stimulation: ↑ BP, ↑ HR, Diaphoresis, ↑ core temp
- NMJ: Myoclonus, ↑ tone
- CNS effect: Behavioural change

Important Information

Serotonin syndrome caused by combination of

- Pethidine + MAOIs
- Pethidine + SSRIs

Fentanyl and its congener 00:51:35

- All are phenyl piperidine derivatives
- Synthetic opioids
- Drugs
  - Fentanyl
  - Sufentanil
  - Alfentanil
  - Remifentanil

Pharmacokinetics 00:52:53

[redacted] Table 12.1

Uses 01:00:17

Fentanyl

1. Low dose as an analgesic

- 1 – 2 µg/kg BW

2. Dose

- 2 – 10 µg/kg BW as an adjuvant to inhalational & intravenous anaesthetic

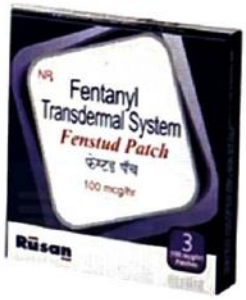
3. Dose

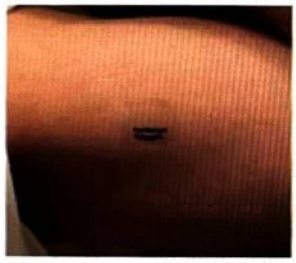
- 50 – 100 µg/kg BW as sole anesthetic
- **Advantage** as sole aesthetic
  - CVS stability
- **Disadvantage**
  - Prolonged resp. depression

4. Intrathecal

- 25 µg
  - Spinal anesthesia
  - Labour analgesia

5. Transdermal Fentanyl patch





- Patch is applied by base skin for analgesia
- 75 to 100 µg/ hr is released
- Peak effect will be after 18 hrs after application
- Once patch removed, the effect remains because of the slow release of fentanyl from the skin depots

6. Transmucosal

- Oral lozenges (Lollipops)
  - Used in pediatric as premedical
  - Dose 5 – 20 µg/kg
  - Not very popular because of the high incidence of nausea and vomiting

Sufentanil 01:06:00

- More potent than fentanyl
- Fast effect site equilibrium

Uses

1. Analgesia: 0.1 to 0.4 µg/Kg IV
2. Anesthesia: 10 to 30 µg/Kg IV
3. Sympatholytic use before laryngoscopy and intubation
4. As an adjuvant with local aesthetics for spinal anaesthesia

Alfentanil 01:08:39

- 1/10th of fentanyl
- Effect site equilibrium 1.8 min

Uses

1. As sympatholytic agent before laryngoscopy and intubation
2. Analgesia
3. Anesthesia
4. As an adjuvant to the local anaesthetic for spinal anaesthesia

Remifentanil 01:10:28

- Most potent
- Unique structure: Ester linkage: metabolized by ester hydrolysis
- Ultra short duration
- Fastest effect site equilibrium: 1.1 min

Benefit

- Brevity (small duration) of action

Uses

1. Analgesia
2. Anesthesia
3. Short procedure: rapidly metabolised (fast offset)
4. Sedation

5. **TIVA**: Propofol + Remifentanil (most popular combination)

6. **Labour analgesia**: Best opioid

- Even if it crosses the placental barrier and goes to the foetus
- It will get metabolized in the foetus because of its ester hydrolysis
- It does not require the contribution of organs for its metabolism
- Because of its unique metabolism even foetus can metabolize

Important Information

Remifentanil is one opioid which can only be given IV

Tramadol 01:15:09

- Centrally acting opioid with moderate effect on µ receptor and weak effect on k and δ receptor

Structure 01:16:18

- 4 – Phenyl – piperidine analogue of codeine (a synthetic opioid)
- Dextro (+) and Levo (-) enantiomer in equal amounts (Racemic mixture)
- Both enantiomer has a synergistic effect

- Both enhance the spinal descending inhibitory effect on pain
  - **Dextro (+)** enantiomer inhibits the uptake of serotonin
  - **Levo (-)** enantiomer inhibits the uptake of nonadrenal
  - **Dextro (+)** enantiomer has µ receptor

Route 01:20:24

- IV: 50/100 mg, max 800 mg in 24 hrs
- IM
- Oral

Metabolism: Liver

Uses 01:20:58

1. Moderate to severe pain
   - Good agent for post-operative analgesia
     - Less respiratory depression
     - Low abuse potential
2. Anti-shivering agent

Advantage effect

1. Nausea and vomiting
2. Dizziness, drowsiness, sweating
3. Dry mouth

Severe adv. effect 01:23:14

1. Seizure
2. Serotonin syndrome
3. Resp. depression

II. OPIOID AGONIST – ANTAGONIST 01:24:27

- The drugs have an Antagonist effect or on effect on receptor
- The drugs have an Agonist effect on k and δ receptor

Pentazocine

- Benzomorphan derivative

Pharmacokinetic

- Extensive first-pass metabolism
- Elimination half-life is 2 – 3 years

Clinical use
- IV or oral for mild to moderate pain
- Sequential analgesic anesthesia

Side effect
- Sedation
- Diaphoresis
- Dizziness
- Dysphoria
- Fear of death
- High risk of physical dependence

Nalbuphine 01:29:04
- Antagonist on μ receptor
- Agonist on δ and k receptor

Pharmacokinetic
- Fast onset 5 – 10 min
- Duration long 3 – 6 hrs
- Long plasma elimination time
- Hepatic metabolism

Uses
- Analgesia for acute post-operative pain and chronic pain

Butorphanol 01:31:32
- Agonist on k receptor
- Antagonist on μ receptor
- 5 - 10 times more potent than morphine
- Only parenteral preparation is available

Onset
- Fast
- Peak effect in 1 hr
- Plasma $t_{1/2}$: 2 – 3 hrs

Clinical use

I. Analgesia

1. Intraoperative period
2. Acute post-operative pain

II. Epidural analgesia

Side effect
- Drowsiness
- Sweating
- Nausea

III. PARTIAL AGONIST

Buprenorphine 01:35:21
- Thebaine derivate
- μ receptor partial agonist
- 33 times more potent than morphine

Pharmokinetics
- Highly Lipophilic
  - Strong association
  - Slow dissociation with receptor
- Slow onset
- Peak effect at 3 hrs
- Duration: 9 – 10 hrs

Metabolism: Liver

Uses
1. Analgesia in intraoperative period
2. Post-operative period

IV OPIOID ANTAGONIST 01:38:36

Naloxone
- Pure opioid antagonist

Pharmokinetics
- Short duration of action: 30 – 45 min
- Onset: 1 – 2 min

Clinical uses
1. Treat opioid induced respiratory depression
   - Post operatively dose: 1 – 4 μg/Kg/hr
2. Reverse ventilatory depression in Neonate

Side effect
1. Nausea & Vomiting
2. ↑ BP, ↑ HR

Other uses 01:42:43
1. Alcoholism
2. Post anesthetic apnea in infants
3. Benzodiazepine, Barbiturates & Alcohol reversal
4. Intractable pruritis

Naltrexone 01:44:12
- Antagonist on r, k and δ receptor
- Longer $t_{1/2}$: 8 – 12 hrs
- Decreased 1st pass metabolism
- Cardiovascular stimulation

Nalmefene 01:45:17
- Pure antagonist
- More effect on μ receptor
- Long acting
- Oral preparation available
- Parental preparation also
- Hepatic metabolism

NEUROLEPTANALGESIA – ANESTHESIA 01:46:59
- Coined by De castro and mundeler

- This technique combines a strong tranquilizer (Droperidol) + Potent opioid (Fentanyl)
- Produces detached pain free state of immobilization

Characteristics

1. Analgesia
2. No evident motor activity
3. Suppression of autonomic reflex
4. Cardiovascular stability
5. Amnesia

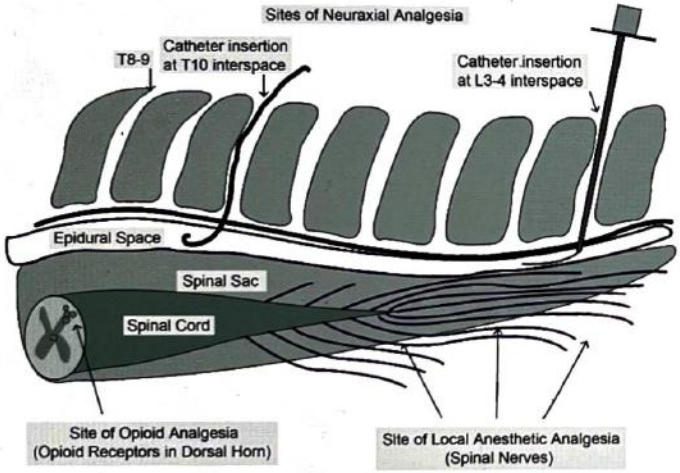
Important Information

- Droperidol + Fentanyl- Neuroleptanalgesia
- Droperiodol + Fentanyl + N_2O – Neuroleptanesthesia

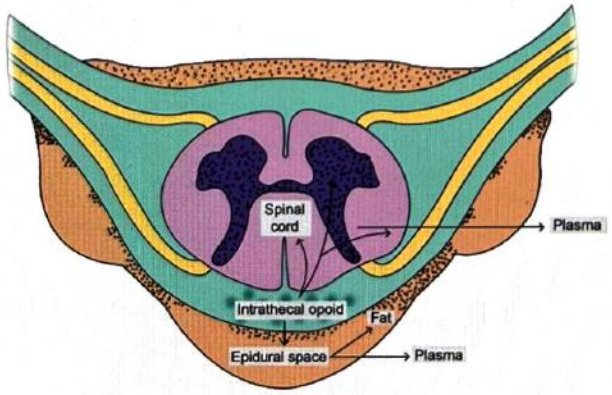
NEURAXIAL OPIOID

01:51:11

- Placement of opioids in epidural or subarachnoid space to manage acute or chronic pain
- Opioid receptor present on dorsal horn in the substantia gelatinosa of the spinal cord



- Compared to L.A it is not associated with sympathetic block, skeletal muscle weakness or loss of proprioception



OPIOIDS

01:56:30

Hydrophilic	Lipophilic
• Morphine • Less absorbed intravascular • Slowly diffuse to spinal cord but duration of action is long	• Fentanyl and its congener • Intravascular absorbed • Diffuse to spinal cord • Majority is intravascularly

Important Information

- Remifentanyl is never used in intrathecal or in epidural space

- Epidural dose is 5 to 10 times of subarachnoid space

Epidural dose

	Single dose (mg)	Infusion rate (mg/hr)
Morphine	1 – 6	0.1 – 1.0
Meperidine	20 - 60	10 – 60
Fentanyl	0.025 – 0.1	0.025 – 0.1
Sufentanil	0.01-0.06	0.01 – 0.05
Alfentanil	0.5 – 1.0	0.2

Subarachnoid dose

Morphine	0.1 – 0.3
Meperidine	10 – 30
Fentanyl	0.005 – 0.025

Epidural

01:58:58

Opioid	Local anesthetic
• No sympathetic block	• Sympathetic block
• No Hemodynamic imbalance	• Hemodynamic imbalance
• No motor block	• Motor block possible
• Better analgesia	• Inferior analgesia

Side effects / Epidural opioid

- **4 classical side effects** 02:00:44

1. Pruritis

- Most common
- Localized to the face, neck or upper thorax
- More common in obs. patient

Mechanism

- Cephalad migration of the opioid in CSF and subsequent interaction with opioid receptor in trigeminal nucleus

Treatment

- Naloxone

2. Urinary retention

- More common with epidural opioid than IV opioid

Mechanism

- Interaction of drug with sacral opioid receptor
- Inhibit sacral parasympathetic outflow

Treatment

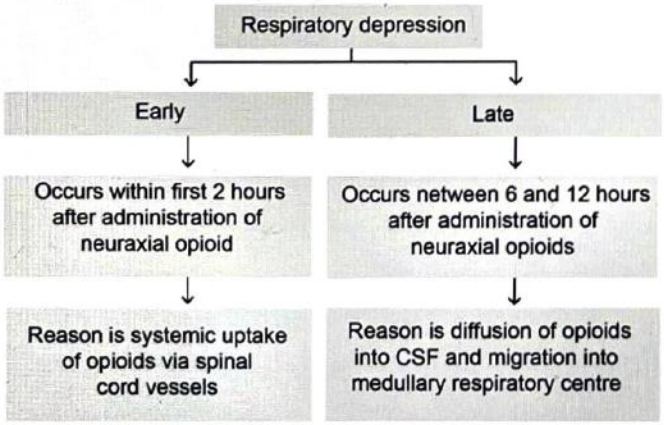
- Naloxone

Important Information

- Urinary retention is the side effect of opioid but it is not from the overdose of epidural opioid

3. Depression of ventilation

- Respiratory depression
- **2 types**



1. Early: IV uptake (systemic effect)
2. Late: Cephalad migration of drug through spinal cord

Important Information

- Epidural opioid is less practice in pediatric due to respiratory depression

Management

- Ventilation
- Naloxone

4. Nausea & Vomiting

- This is due to cephalad migration of drug to CT2 centre

Less common

5. Sedation

6. CNS excitation

Post operative analgesia 02:09:55

	Adults	Pediatrics
Major surgery	Epidural opioid	IV opioid
Minor surgery	IV/ IM oral NSAID	IV/ IM rectal NSAID

Refer Table 12.1

	Fentanyl	Sufentanil	Alfentanil	Remifentanil
Chemical nature	Phenylpiperidine derivative	Thienyl analogue	Analogue of Fentanyl	Unique structure-ester linkage
Analgesic potency	75 – 125 times more potent than morphine	5 – 10 times more potent than Fentanyl	1/5 – 1/10th Fentanyl potency	Most potent
Effect site equilibrium	6.4 min	6.2 min		1.1 min
Metabolism	Hepatic & Renal	Hepatic & Renal	Hepatic & Renal	Hydrolysis by non-specific esterase
Side effects	Non-histamine release. Depression of ventilation chest wall rigidity			
	Seizure like activity	Seizure like activity	Seizure like activity	-

CLINICAL QUESTIONS

Q. A 46 year old male who was a known case of depression on MAO inhibitor therapy for the past 2 years posted for emergency laparatomy for hollow viscous perforation. The drug to be avoided in the intraoperative period would be?

A. Dexmedetomidine
B. Morphine
C. Fentanyl
D. Buprenorphine

Answer: C

Solution

- Meperidine (and methadone) inhibits the neuronal reuptake of serotonin leading to serotonergic overactivity which can cause Serotonin Syndrome in patients receiving antidepressants like monoamine oxidase inhibitors (MAOI), fluoxetine
- Meperidine has modest **atropine like qualities** which increase heart rate in contrast to morphine
- The **serotonin syndrome** symptom complex includes autonomic instability, fluctuations in blood pressure, tachycardia, diaphoresis, hyperthermia, confusion, agitsation, hyperreflexia when drugs capable of increasing serotonin administered. In severe cases, coagulopathy, metabolic acidosis, convulsions, coma, and death. Delirium and seizures are due to normeperidine accumulation
- Thus it is not co-administered with mono amine oxidase inhibitors or is used 14 days after the discontinuation of mono amine oxidase inhibitors
- Some opioid analgesics are associated with a risk of serotonin syndrome in combinations with MAOIs due to their serotonergic properties
  1. Dextromethorphan,
  2. Methadone,
  3. Pethidine,
  4. Tramadol or
  5. Fentanyl should be avoided in patients on MAO inhibitor.

Reference: Stoleting's Pharmacology and Physiology in Anaesthetic practice 5th edition, page 230, 233, 237

Q. A 38 year old male patient who is a case of mitral stenosis posted for mitral valve replacement surgery. The patient induced with Inj. Fentanyl 10 mcg/kg and Inj. Thiopentone 100 mg intravenously. The anaesthesiologist was not able to do mask ventilation after induction. Inj. Vecuronium 6 mglvgiven and mask ventilation followed by intubation done. Probable reason for this is?

A. Fentanyl
B. Thiopentone sodium
C. Vecuronium
D. All of the above

Answer: A

Solution

- Rapid administration of larger doses of opioids (fentanyl, sufantanyl, Remifentanil and alfentanyl) can induce generalized skeletal muscle rigidity which is severe enough to prevent adequate bag and ventilation mask.

- Laryngeal musculature contraction causes resistance to ventilation.
  - Opioid induced increased skeletal muscle tone is due to striatal release of gamma amino butyric acid and increased dopamine production.
  - Treatment is muscle relaxation with neuromuscular blockade or opioid antagonism with naloxone.

Reference: Stoelting'sPharmacology and Physiology in Anaesthetic Practice 5th edition, pg 223

Q. A 55 year old male who was a case of intra axial mass lesion of brain posted for excision under awake craniotomy technique. Total intravenous anesthesia with propofol and remifentanil infusion was used. Not a feature(s) of remifentanil in this case would be?

A. Metabolized by tissue esterase
B. Can be used as an adjuvant to local anesthetics in spinal anesthesia
C. Can be used for day care surgery
D. Muscle rigidity is seen with large doses
E. It can't be antagonized by opioid antagonists such as naloxone

Answer: B, E

Solution

- Remifentanil is a selective 'mu' opioid agonist with similar analgesic potency of fentanyl. It is structurally unique because of its ester linkage, making it susceptible to ester hydrolysis by nonspecific plasma and tissue esterases to inactive metabolites. This unique pathway of metabolism leads to,
  1. Brief action
  2. Precise and rapid titration due to its rapid onset and offset
  3. Lack of accumulation
  4. Rapid recovery after discontinuation

Uses

1. Suppression of transient sympathetic response
2. Retrobulbar block-where profound analgesia desired transiently
3. Patient controlled analgesia
4. Labour analgesia-rapid clearance from neonatal circulation
5. Longer surgical procedures where quick recovery time is desired (neurological assessment, wake up test)
6. Analgesia and sedation
7. Attenuate the acute hemodynamic responses to electroconvulsive therapy
8. No histamine release and no changes in intraocular and intracerebral pressures. It decreases cerebral blood flow and cerebral metabolic oxygen requirements without impairing cerebrovascular carbon dioxide reactivity

Side effects

1. All fentanyl analogs induce seizure like activity
2. Nausea and vomiting
3. Depression of ventilation
4. Mild increases in systemic blood pressure and heart rate
5. Acute tolerance
6. Hyperalgesia
7. The neuraxial administration is not recommended as the safety of the vehicle (glycine, an inhibitory neurotransmitter) or opioid is not determined
8. Fentanyl and its derivatives cause muscle rigidity with rapid administration of large doses asin cardiac surgery. Inhibition of striatal release of GABA and dopamine production are likely explanations for opioid induced increased skeletal muscle tone. Treatment of rigidity is muscle relaxation with neuromuscular blocking agents or administration of naloxone.

Reference: Stoelting'sPharmacology and Physiology in Anaesthetic practice, 5th edition, page 237-239, 223

Q. A 60 year old male who was a case of pancreatic carcinoma with liver secondaries on palliative treatment came to pain clinic. He was prescribed with opioid for pain management. The route administration of opioid which is not possible in this patient could be?

A. Intravenous
B. Intramuscular
C. Oral
D. Intradermal

Answer: D

Solution
Opioids can be administered

- Intravenous, intramuscular, transdermal (fentanyl, buprenorphine), transmucosal, oral, intrathecal, epidural and iontophoresis (morphine and fentanyl).
- For management of acute moderate to severe postoperative pain, fentanyl hydrochloride iontophoretic transdermal system, is a novel patient controlled analgesia that has been approved in the USA and Europe

Reference: Miller's Anaesthesia, 9th edition, page 724

Q. The case of biliary duct stricture with retching and vomiting, given 3 mg morphine epidurally daily, one day 12 mg of morphine mistakenly given through epidural route. Which of the following side effect is not seen with this high dose of epidural morphine?

A. Itching
B. Urinary retention
C. Increase vomiting
D. Overstimulation of respiratory centre

Answer: D

Solution
Side effect of high dose epidural opioid

- Nausea and vomiting
- Pruritis
- Urinary retention
- Respiratory depression

1. High dose of opioid can spread centrally and stimulate CTZ center and can precipitate nausea and vomiting.
2. Pruritis due to morphine is not due to histamine release, high dose morphine can spread centrally, act on trigeminal nerve and cause pruritis.
3. Urinary retention in morphine use is due to it's action on sacral spinal cord, therefore it can happen even at normal dose and not related to high dose.
4. Respiratory depression in morphine overdose due to migration of morphine centrally.

Reference: Miller's anesthesia, 9th edition

13 NEUROMUSCULAR BLOCKER

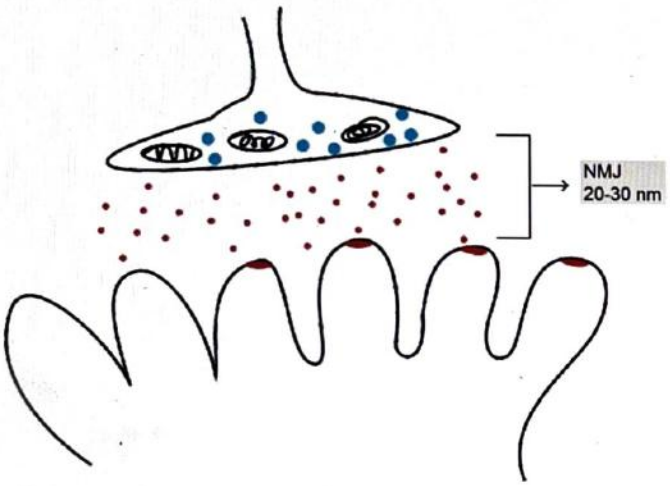
NEUROMUSCULAR BLOCKING AGENTS (NMBA)

00:00:57

- Their principal pharmacological effect is to stop nerve impulse transmission at Neuromuscular Junction (NMJ)

PHYSIOLOGY OF NMJ

00:02:54



- Ach is synthesized in the cytoplasm of the nerve and then they are packed in vesicles
- One vesicle may have 5-10,000 molecules of Ach

NICOTINIC CHOLINERGIC RECEPTOR (NCR)

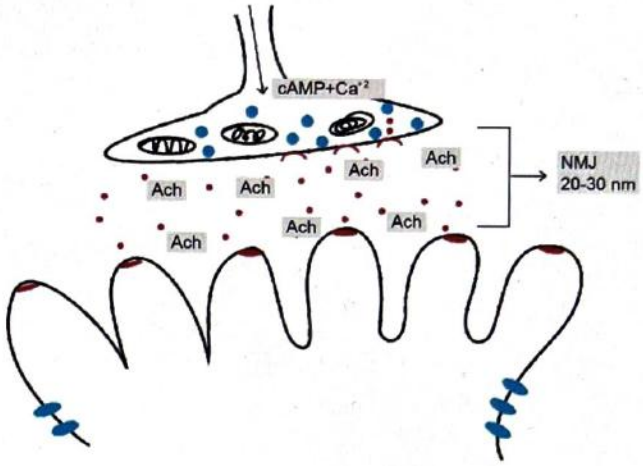
00:04:57

- Is called post junctional (synaptic)
  I. Junctional: Present at NMJ
  II. Extra junctional: Are away from the junction, everywhere in the muscle

JUNCTIONAL NCR

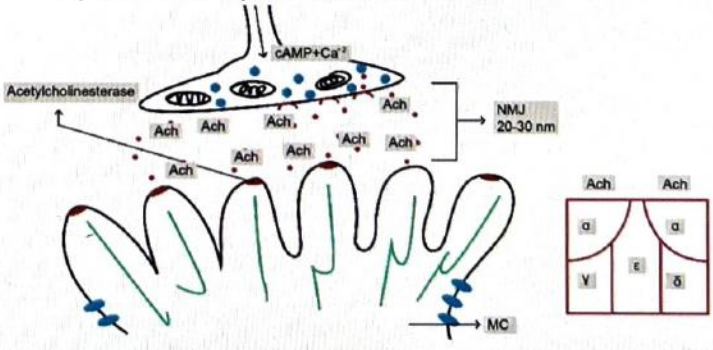
00:06:30

- Are the site where the Ach molecule will act and neuromuscular transmission will take place
- Nerve impulse travels through the nerve and cAMP pathway activated and synthesizes AMP
- AMP combines with the Ca^{2+} which combines with Ach vesicles
- Ach vesicles break and release Ach molecule in neuromuscular cleft
- Millions of Ach molecules released in neuromuscular cleft



NICOTINIC JUNCTIONAL RECEPTOR

- NJR has **5 subunits**
  - 2α (alpha)
  - γ (gamma)
  - ε (epsilon)
  - δ (delta)
- Ach molecule will attach to both the α subunit
- NCR opens and allows the passage of the ions Na^{+} & Ca^{+2} will move in and K^{+} will move out
- Transmembrane potential would reach the threshold potential
- The nerve impulse depolarizes and results in muscle contraction
- On Neuromuscular cleft, very important enzyme present Acetylcholinesterase
- This is a very fast enzyme, attach to the Ach in junctional receptor and immediately breaks down into Acetic Acid and Choline
- Choline is reabsorbed in the nerve ending for the synthesize of Ach
- Receptor becomes free from Ach and goes back from depolarized to repolarized state

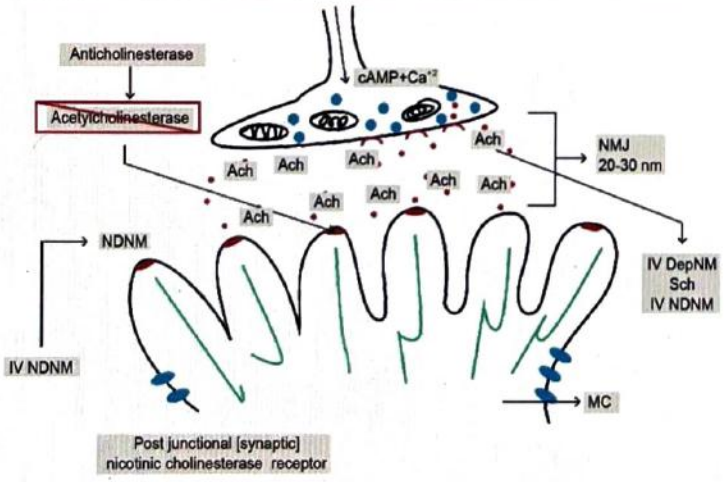


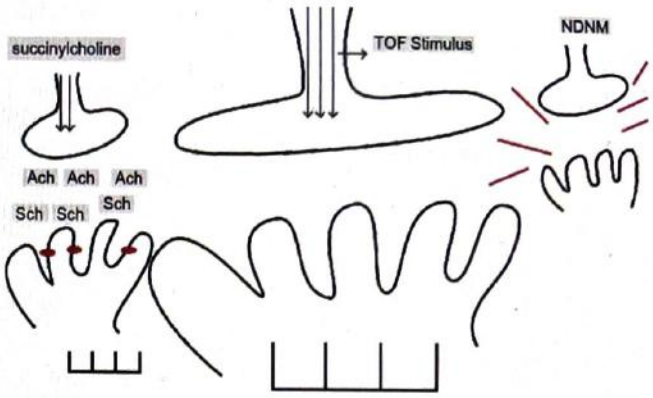
- Any problem in depolarization or repolarization will result in muscle paralysis

NMB DIVIDED IN 2 GROUPS

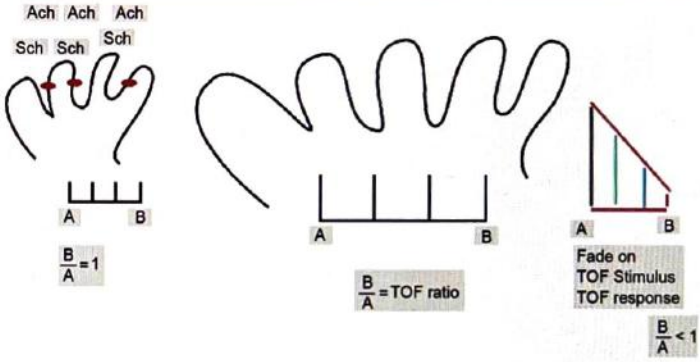
00:11:33

Depolarizing	Nondepolarizing
MOA of Succinylcholine	
1. Persistent/ prolonged depolarization of postsynaptic junctional nicotinic cholinergic receptor • They attach to the NCR and mimic the action of Ach • They keep attached to NCR for a longer period as they do not have enzymes to metabolize them at NMJ • Keep attach for a longer time period • Receptor remains open	1. Competitive antagonist • They sit on the receptor so the Ach action is blocked • Receptor remains closed
2. Fasciculation precedes paralysis	2. No fasciculation is seen
3. Postoperative myalgia/ muscle pain may be witnessed	3. No postoperative myalgia
4.Potentiated by Anticholinesterase Neostigmine	4. Reversal by Anticholinesterase
5. No Train of Four response (no fade on ToF stimulation)	5. Train of four response seen (fade on ToF stimulation)
6. ToF ratio = 1	6. ToF ratio < 1





Depolarizing	Nondepolarizing
1. Train of four monitoring (NM monitoring) is not done	1. ToF monitoring is done
2. No post-tetanic facilitation (PTF) seen	2. Post - tetanic facilitation is observed



SUCCINYLCHOLINE/SUXAMETHONIUM SCOLINE

00:46:50

1. Dicholine ester (two acetylcholine molecules)
2. Persistent depolarization of Nicotinic Cholinergic Receptor
3. Fasciculation precedes paralysis
4. Post-op myalgia
5. Reversal by Neostigmine is not seen
6. No Train of Four response
7. ToF ratio = 1
8. ToF monitoring not done
9. Post tetanic facilitation not seen
10. **Onset of action is fastest: 30-50 s**
- Duration of action is shortest: 6-8 min

Important Information

- In preoxygenation patient, the apnea produced by Succinylcholine would get reversed before any hypoxia

11.Metabolism: Pseudocholinesterase

- Liver manufactured Butyrylcholinesterase also called Plasma cholinesterase

Important Information

- Same enzyme has 3 names Pseudocholinesterase, Butyryl cholinesterase and Plasmacholinesterase
- Succinylcholine is metabolized by Plasmacholinesterase

12.Succinylcholine apnea / Suxamethonium apnea

- Single normal dose of Succinylcholine producing prolonged apnea
- **2 reasons**

I. Deficiency of Pseudocholinesterase

- Liver disease
- Neostigmine

II. Atypical Pseudocholinesterase

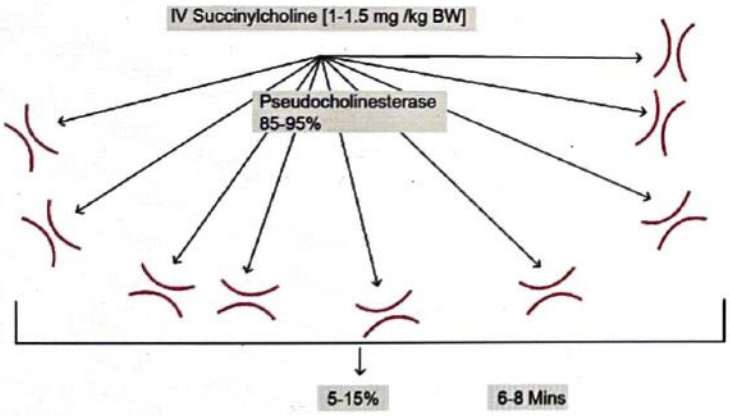
- Genetic cause of scoline apnea
- Enzyme is faulty

Diagnose

- Dibucaine number 01:01:35

DIBUCAINE

- Amide LA will inhibit the activity of normal Pseudocholinesterase by 80% and atypical Pseudocholinesterase by 20%



- **Dibucaine No. 80**: Normal Pseudocholinesterase
- **Dibucaine No. 20**: Atypical Pseudocholinesterase

Management

- Support of ventilation

Supportive management

1. Plasmapheresis
2. FFP

13.Succinylcholine produces **2 types of block**

Phase I	Phase II
• Depolarizing NMB o Train of Four response -ve o Post tetanic facilitation -ve o ToF ratio =1 • Depolarizing block	• Starts resembling the properties of Non-depolarizing NMB o ToF response +ve o Post tetanic facilitation +ve o ToF ratio <1 • Desensitizing block • Management o Mechanical ventilation • Can happen on repeated dosing / very high dose

Important Information

- ToF is shown by either Non-depolarizing NMB or Phase II block of Succinylcholine

14. Side effects 01:14:10

1. Fasciculation
2. Postoperative myalgia
3. I. Increases intraocular pressure

   II. Increases intracranial pressure

   III. Increases intragastric pressure
4. Hyperkalemia

- **Exaggerated hyperkalemia**

1. Muscle Dystrophy
2. Neuromuscular disease
3. Paraplegia
4. Burn
5. Trauma

DUCCHENE'S MUSCLE DYSTROPHY 01:20:59

- X-linked MD
- <2-3 years (hidden MD)
- Incidence 1 in 3300
- If Succinylcholine is given <2-3 yrs, can cause
  - o Hyperkalemia
  - o Rhabdomyolysis
  - o Death

5. Cardiac Dysrhythmias

- Due to its effect on the cardiac muscarinic receptor, it causes Dysrhythmias

6. It can trigger a complication Malignant Hyperthermia

7. It can cause histamine release

Previous Year's Questions

Q.A patient is undergoing a surgery where anesthesia is maintained on Halothane. The patient developed muscle rigidity and hyperthermia which of the following agent would have also contributed to this condition?

(NEET PG 2021)

A. Succinylcholine
B. [redacted]
C. Rocuronium
D. Atracurium

15. Uses 01:25:57

I. Rapid Sequence Induction / Intubation (RSI)

Indication

- Emergency surgery when pt's are at high risk of aspiration

Aim

- To prevent aspiration

Steps

1. Preoxygenation is mandatory
   - 100% O_2 for 3-5 min
   - 8-10 min, No hypoxia will happen
2. Cricoid pressure applied /Sellick's maneuver
   - 25-35 newton
3. IV Thiopentone + IV Succinylcholine given (fastest onset)
   - For induction & muscle paralysis
4. Positive pressure ventilation by bag and mask is contraindicated
5. Laryngoscopy + Intubation

II. Very short duration general anesthesia

- Electroconvulsive therapy (ECT) modified

III. Difficult airway (Anticipated)

- Succinylcholine of Intubation

Storage		Shelf life
• Refrigerator 2-4°C	-	2 years
• Room temp.	-	6 month

NON-DEPOLARIZING NEUROMUSCULAR BLOCKER (NDMB) 01:39:17

1. Competitive Antagonist
2. No fasciculation / no myalgia
3. Reversal by Neostigmine
4. Train of Four response seen
5. ToF ratio <1
6. Post tetanic facilitation seen

7. Chemically divided in **2 broad groups** 01:42:00

BENZYLISOQUINOLION	AMINOSTERIOD
• Long-acting > 2hrs o d-tubocurare o Doxacurium	• Long-acting > 2hrs o Pancuronium o Pipecuronium
• Intermediate <45 min o Atracurium o Cisatracurium	• Intermediate <45 min o Vecuronium o Rocuronium
• Short-acting < 15 min o Mivacurium	• Short-acting < 15 min o Rapacuronium
• Histamine release o Bronchospasm o Flushing o Hypotension } CVS unstable o Tachycardia }	• Non histamine release o Cardiovascular stable

Important Information

- Vecuronium and Rocuronium are most common Non-depolarizing NMB used

Important Information

- Atracurium and Cisatracurium has unique metabolism. They are organ independent
- In liver and kidney dysfunction, they become muscle relaxant of choice

Important Information

CVS unstability due to Non-dep. NMB

- Histamine releases
- Cardiac muscarinic receptor
- Autonomic blockade (parasympathetic blockade)

BENZYLISOQUINOLION

1. d-Tubocurare 01:50:29

- 1st neuromuscular blocker to be used for producing paralysis during general anesthesia
- In **1943**- Harold Griffith
- Maximum histamine release

Important Information

- **Histamine release**
  - **d-Tubocurare >>> Atracurium = Mivacurium > Doxacurium**

2. Atracurium 01:52:52

- Intermediate acting
- Duration 30-45 min
- Hist[illegible]release
- Bronchospasm
- Flushing
- Hypotension
- Tachycardia
- CVS unstable

Metabolism (UNIQUE)

- Non-organ elimination

2 Pathway

i. Nonspecific ester hydrolysis
ii. Hoffman degradation

- Self-degradation through internal rearrangement

From both these 2 pathways produces

- Laudanosine
  - By product of metabolism
  - Accumulation causes CNS stimulations
  - Epilepsy

Atracurium because of these 2 pathways becomes

- Muscle relaxant of choice
  1. Acute / chronic liver dysfunction
  2. Acute/ chronic kidney dysfunction
  3. Pregnancy
  4. Pediatric in children (immature liver & kidney)
  5. Old age

Important Information

- **Atracurium**
- **Good-metabolism (unique)**
- **Bad**
  - **Histamine release**
  - **Laudanosine production**

Atracurium is a mixture of 10 isomer

- Cis- Cis
- Cis-Trans
- Pure Cis isomer was separated which had all the good effects of Atracurium but eliminated bad effects
- The **new drug produced** called Cisatracurium

3. Cisatracurium 01:58:11

- Pure Cis isomer of Atracurium
- Non histamine releaser
- CVS stable
- **Better drug than Atracurium**

Metabolism

- Nonspecific ester hydrolysis
- Hoffman degradation
- Produces less laudanosine

Potency

- 5 times more potent than Atracurium
- Less does-less byproduct

Important Information

- **Important Information**
- **Cisatracurium is better drug than Atracurium**
- **Produces less laudanosine than Atracurium**

Previous Year's Questions

Q.Cisatracurium is better than atracurium because?
(NEET Jan 2019)

A. Less histamine release
B. Less half life
C. Low Drug Dose
D. Low cost

4. Mivacurium 02:00:34

- Short acting
- Onset-slow
- **Shortest duration** among all Non-depolarizing
- Duration of action: 14-15 min

Metabolism

- Pseudocholinesterase

AMINOSTEROID 02:02:24

1. Pancuronium

- Long acting
- No histamine release
- Vagal blockade (parasympathetic)
  - ↑se BP
  - ↑se HR
- CVS unstable

2. Vecuronium 01:04:23

- One of the commonest used Non-depolarizing neuromuscular blocker
- Intermediate acting
- CVS stable

Metabolism

- Liver
- Kidney
- 40% drug gets excreted unchanged in bile

3. Rocuronium 02:05:25

- Intermediate acting
- Aminosteroid
- Onset of acting: 90 sec

Important Information

- Fastest onset : Succinylcholine: 30-45 sec
- Fastest Non-depolarizing – Rapacuronium: 75 sec
- 2nd fastest Non-dep.- Rocuronium: 90 sec
- Rest all - late onset: 3-5 min

Important Information

- Rocuronium – fastest among clinically available NDNM

- It can replace Succinylcholine for Modified Rapid Sequence Intubation

Metabolism

- Liver
- Kidney

4. Rapacuronium 02:09:20

- Sympathetic activity
- Onset fastest- 75 sec among NDNM
- Abandoned because of its side effect

Side effect

- Bronchospasm

OXIME-CHLOROFUMERATE GANTACURIUM 02:10:11

- NM depolarizing
- Onset and duration comparable to Succinylcholine
- Onset: 40-50 sec
- Duration : 8-10 min

Metabolism

- Self-degradation
  - L-cysteine degradation

DRUGS AND CLINICAL CONDITIONS POTENTIATING NEUROMUSCULAR BLOCKER 02:12:32

1. Volatile Inhalational Anesthetic

- Dose dependent increased magnitude and duration of muscle paralysis

Direct effect

- Have stabilizing effect on membrane potential

Central effect

- Decreased tone of skeletal muscle

Important Information

- Max → Min potentiation
- Desflurane > Sevoflurane > Isoflurane > Halothane

2. Antibiotic

- A - Aminoglycosides
- T - Tetracycline
- P - Polypeptide

How to remember

- ATP

- ↓es releases of Ach molecule

3. Local Anesthetic

- Enhance the effect by blocking normal NM transmission
- By decreasing release of Ach
- Stabilizer transmembrane Potential

4. Antiarrhythmics

- Quinidine
- Lidocaine

5. Diuretics

- Furosemide

6. Mg^{+2}

7. Lithium

8. Hypothermia

- By decreasing metabolism of drug

9. Acidosis

- Affects metabolism of drug

- Has negative effect on normal impulse transmission through NMJ

10. Hypo/hyperkalemia

- Hypokalemia
  - An acute decrease in extracellular concentration of K^+ increases transmembrane potential causing hyperpolarization
  - Resistance to depolarizing NMB
  - ↑ed sensitivity to NDNMB
- Hyperkalemia
  - Decrease transmembrane potential
  - Partial depolarization of cell membrane
  - ↑ed effect of depolarizing NMB
  - Oppose the effect of NDNMB

11. Thermal injury/Burn

- Potentiate the effect of NMB

REVERSAL AGENTS

02:25:00

I. Indirect
II. Direct

I. Indirect

- Neostigmine + Atropine/Glycopyrrolate (Myopyrolate)
- Vecuronium blocks the action of Ach for 30-45 min
- After 30-45 min Ach will attach and muscle power will came
- Give Neostigmine (Anticholinesterase) which temporarily block the action of Ach esterase

Important Information

- **Atropine / Glycopyrrolate given to counteract muscarinic side effect**

- Quantity of Ach will ↑ with very huge amount
- Strong depolarization and proper muscle contraction will happen
- IV Neostigmine has muscarinic side effect like Bradycardia, Ise secretion

Previous Year's Questions

Q.A person was given a muscle relaxant that competitively blocks nicotinic receptors. Which of the following drugs is used for reversal of muscle relaxation after surgery? (NEET Jan 2020)

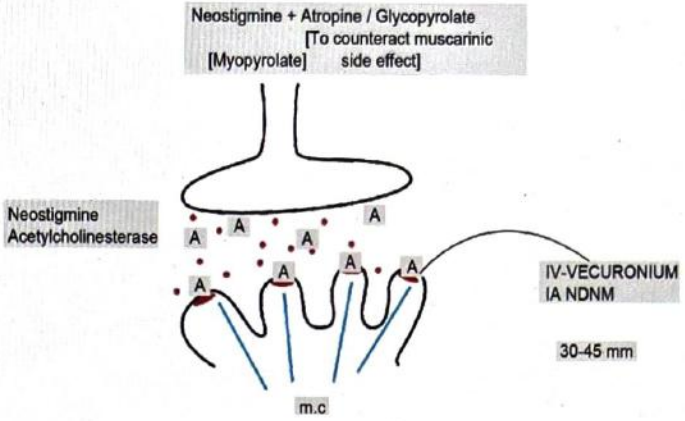
A. Neostigmine
B. Carbachol
C. Succinylcholine
D. Physostigmine

DIRECT REVERSAL AGENT

02:29:26

1. Sugammadex

- Cyclodextrin compound (ring structure)



- IV Sugammadex combine with Vecuronium l:l ratio
- Detached Vecuronium from receptor
- Direct reversal agent
- Acts on **only** Aminosteroid
- Acts best on Rocuronium and Vecuronium

2. Calabadion 02:32:36

- Direct reversal agent
- Can bind both to benzyl Isoquinoline and Aminosteroid group directly

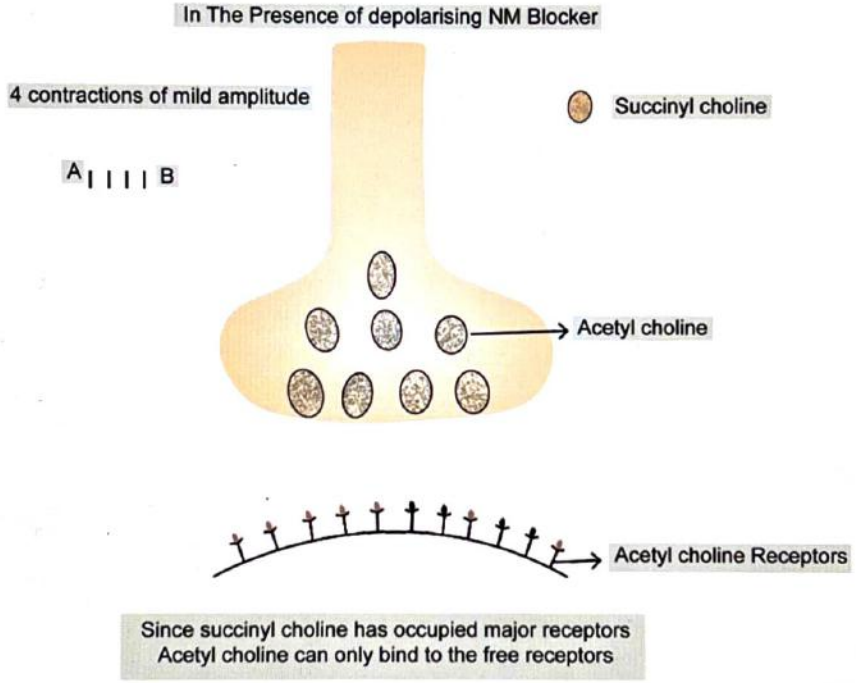
CLINICAL QUESTIONS

Q. A 45 year old female patient posted for modified radical mastectomy under general anaesthesia. She was induced with Inj. Thiopentone sodium 250 mg and then Inj. Succinylcholine 100 mg given intravenously to facilitate endotracheal intubation. The patient developed fasciculations and once the fasciculations stopped, the patient was intubated. Mechanism behind this neuromuscular blockade in this patient is?

A. Depolarizing – Persistent depolarization
B. Depolarizing - Competitive inhibition
C. Non-depolarizing – Persistent repolarization
D. Depolarizing – Persistent repolarization

Answer: A

Solution



Mechanism of action

- Depolarizing neuromuscular blockers such as succinylcholine stimulates cholinergic receptors at neuromuscular junction, nicotinic (ganglionic) and muscarinic autonomic sites which opens ionic channel in acetylcholine receptor
- Ionic channel of the acetylcholine receptor is closed in the resting state. Simultaneous binding of two acetylcholine molecules to the alpha subunit of nicotinic acetylcholine receptor initiates conformational changes that open the ionic channel
- It is a depolarizing neuromuscular blocker which acts as a agonist (they are similar in structure to acetylcholine) at post synaptic nicotinic acetylcholine receptor and causes prolonged depolarization of the end plate region resulting in
  1. Desensitization of nicotinic acetylcholine receptor

2. Inactivation of voltage gated sodium channels at the neuromuscular junction
3. Increases potassium permeability in the surrounding region

- The end result is failure of action potential generation and neuromuscular blockade
- Succinylcholine is the only depolarizing neuromuscular blocker currently in clinical use
- Single molecule of non-depolarizing neuromuscular blocker (a competitive antagonist) to one alpha subunit is sufficient to produce neuromuscular block

Reference: Stoelting's Pharmacology and Physiology in Anaesthetic Practice 5th edition, pg. 323

Q. A 26 year old primigravida, term, severe pre-eclamptic women on magnesium therapy posted for emergency lower segment caesarean section under general anaesthesia with rapid sequence induction (RSI). Neuromuscular monitoring with peripheral nerve stimulator was used and the maintenance doses were given accordingly during the intraoperative period. At the end of surgery, when the train of four (ToF) ratio > 0.9, the patient was reversed with Inj. Neostigmine and glycopyrrolate then extubated. This ToF response is not seen in?

A. Succinyl choline
B. Mivacurium
C. Vecuronium
D. Rocuronium

Answer: A

Solution

- Depolarising neuromuscular blockers (Succinylcholine) does not show fade in train of four response. Non depolarising neuromuscular blockers (Vecuronium, Mivacurium, Rocuronium) show fade in train of four response

Single twitch

- Application of a single supramaximal stimulus every 10 seconds. The twitch height falls steadily to zero as the nicotinic post synaptic receptor occupancy increases from 25% or 80% upto 100%

Train of four

- Train of four stimulation is the application of four supramaximal stimuli each of which is similar to the single twitch, administered at 2Hz every 0.5 seconds. The degree of neuromuscular blockade assessed by calculating the ratio of fourth (T4) and first(T1) measured twitch heights(T4/T1)

Post tetanic count

- It describes the counting of responses to single twitch stimulation following a tetanic stimulation of 50Hz or 100Hz for 5 seconds. This method can produce a response at relatively high levels of receptor occupancy under post tetanic count less than 5 indicates profound neuromuscular blockade

Double burst stimulation

- It is introduced to remove the manual assessment of fade. This consists of two tetanic bursts at 50Hz each burst is separated by 750milliseconds, two contractions(T1,T2) .The ratio of T2/T1 is more sensitive in detecting fade than the train of four ratio

Non depolarising neuromuscular blocker	Depolarising neuromuscular blocker
Decrease in twitch tension	Decrease in twitch tension
Fade during repetitive stimulation(TOF or tetanic)	No fade during repetitive stimulation(TOF or tetanic)
Post tetanic potentiation	No Post tetanic potentiation

- For normal neuromuscular transmission, only 20% of the receptors of the motor end plate are required. Neuromuscular blockade is not complete until 90-95% of receptors are occupied. This percentage varies from muscle to muscle. Tetanic stimulation is the most sensitive test. The response to stimulation at 50Hz starts to diminish when 65% of receptors are occupied

Reference: Stoleting's Pharmacology and Physiology 5th edition, pg 324
Miller's Textbook of Anaesthesia 8th edition, pg 99
Lee's Synopsis of Anaesthesia, pg 197

Q. A 45 year old female patient who is a known case of systemic hypertension, diabetes mellitus on treatment for the past 2 years. She was optimized preoperatively and posted for right modified radical mastectomy under general anesthesia. Induction of anesthesia done with Inj. Propofol and endotracheal intubation facilitated with Inj. Atracurium. While doing mask ventilation after the administration of muscle relaxant, the monitor showed Blood pressure-75/40 mmHg, pulse rate-130/minute and flushing of the face which was treated with intravenous fluid bolus and Inj. Hydrocortisone 100 mg Iv. Probable reason could be due to?

A. Histamine release
B. Effects mediated by autonomic nicotinic cholinergic receptors
C. Reduced peripheral vascular resistance by propofol
D. Preoperative use of antihypertensives

Answer: A

Solution

- Histamine release by benzylisoquinolinium compounds like atracurium, mivacurium, and tubocurarine cause decrease in blood pressure, skin flushing, systemic vascular resistance and tachycardia. Has positive chronotrophic and ionotrophic effect on myocardial H2 receptors. The clinical effects are seen when the administration of the drug is rapid
- Cisatracurium, vecuronium or rocuronium may be appropriate for patients with hemodynamic instability due to less or no histamine release. Slow administration of benzylisoquinolinium compounds over 60 seconds and prophylaxis with combined H1 and H2 blockers maintains cardiovascular stability
- NMB agents interact with nicotinic and muscarinic cholinergic receptors within the autonomic nervous system and at the nicotinic receptors of the neuromuscular junction. Tubocurarine causes marked **ganglionic blockade** resulting in hypotension due to peripheral venous and arteriolar dilatation via stimulation of the vascular H1 and H2 receptors
- Pancuronium produced a profound **vagolytic** response by blocking the symphathetic postganglionic nerve terminals. This is characterized by tachycardia, reduction in heart rate variability and baroreflex sensitivity

Reference: Stoelting's Pharmacology and Physiology in Anaesthetic Practice 5 thedition, pg no:333

Q. A 40 year old male who is known case of systemic hypertension controlled with regular intake of antihypertensives posted for emergency laparotomy under general anesthesia with rapid sequence induction and epidural analgesia for acute intestinal obstruction. He had a past history of 27% burns 10 months back. Neuromuscular blocker of choice in this case?

A. Atracurium
B. Succinylcholine
C. Cisatracurium
D. Rocuronium

Answer: D

Solution

- Rocuronium is the fastest acting non depolarising neuromuscular blocker and it can be used for rapid sequence induction because succinylcholine is contraindicated in burns upto 1 year
- Mivacurium is the only short acting nondepolarising neuromuscular blocker currently available in europe and is metabolised by butyrylcholinestrases at about 70-88% the rate of succinylcholine to a monoester, dicarboxylic acid

Non depolarising neuromuscular blockers	Longer duration (>50 minutes)	Intermediate duration (20-50 min)	Short (10-20 min)
Steroidal compounds	Pancuronium	VecuroniumRocuronium	
Benzylisoquinolinium compounds	Tubocurarine	Atracurium Cisatracurium	Mivacurium

Reference: Stoelting's Pharmacology and Physiology in Anaesthetic Practice 5 thedition, pg. 330.

Q. A 30 year old female who was a case of fibroadenoma of left breast posted for lumpectomy under general anesthesia. Anesthesia was induced with Inj. Propofol and endotracheal intubation was facilitated with Inj. Vecuronium. At the end of surgery, the neuromuscular blockade was reversed with Inj. Neostigmine and extubated. The drug which is used to antagonize the visceral side effects of neostigmine during reversal of vecuronium blockade in this patient would be?

A. Atropine
B. Adrenaline
C. Pilocarpine
D. Pyridostigmine

Answer: A

Solution

- Anticholinergic drugs (e.g. atropine, glycopyrrolate) are routinely administered with anticholinesterases in order to **attenuate the undesirable muscarinic effects (Bronchoconstriction, increased airway resistance, increased salivation and increased bowel motility)** during reversal of neuromuscular blockade
- Atropine (7-10 mcg/kg) matches the onset of action and pharmacodynamic profile of rapid acting edrophonium (0.5-1 mg/kg) or glycopyrrolate (7-15 mcg/kg) matches slower acting neostigmine (40-70 mcg/kg) and pyridostigmine to prevent muscarinic side effects
- Glycopyrrolate is used as a pre-anesthetic agent for reducing the secretions and it can be used in patients with pre-existing cardiac disease (Anticholinesterases and anticholinergic should be administered slowly)

Reference: Stoelting's pharmacology and physiology in anesthetic practice-5th edition, Page no: 335

Q. A 50 year old male who is a case of acute intestinal obstruction posted for laparotomy under general anesthesia with rapid sequence induction by using succinylcholine as a muscle relaxant. Spontaneous ventilation from succinylcholine was not returned from succinylcholine and prolonged apnea was suspected. The management of this patient includes?

A. Exchange transfusion
B. Estimation of plasma cholinesterase
C. Continuation of mechanical ventilation

D. Reversal with neostigmine

Answer: C

Solution

Suxamethonium apnea and phase 2 block are managed with adequate sedation and mechanical ventilation till recovery of the TOF ratio to 0.9 or more.

Neostigmine or edrophonium do not consistently result in adequate antagonism of neuromuscular blockade. Therefore there administration is controversial

Because of the risk of iatrogenic viral infectious, fresh frozen plasma can augment the patient's endogenous plasma pseudocholinesterase activity. mechanical ventilation is the best option to continue

Reference: Miller's Anesthesia-9th edition, Page no: 795,796
Stoelting's pharmacology and physiology in Anesthetic practice, 5th edition, page 326

14 REGIONAL ANESTHESIA

1. LOCAL ANESTHETIC

00:02:03

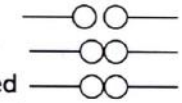
Mode of Action

- Local Anesthetic prevents transmission of nerve impulse through conduction blockade by inhibiting the passage of sodium ions through sodium channels located on the nerve membrane
  - Sodium channel becomes impermeable
  - Stop depolarization of nerve membrane
  - Stop propagation of the impulse

Important Information

- LA does not effect the resting membrane potential

- **Sodium Channel** exist in three different states during the various phase of action potential
  1. Activated open
  2. Resting closed
  3. Inactivated closed



- Local anesthetic attach to sodium channel in the inactivated closed state and keep it in this state
- LA bind to Na^+ channel to a specific site located on its inner membrane
- It can gain access to receptor fast only when Na^+ channel is in activated open state
- Active nerve fiber which goes into various state is most sensitive to the effect of LA

PERIPHERAL NERVES

00:15:40

- **3 types**
  - Myelinated A and B
  - Unmyelinated C

- **A divided into 4 types**
  1. A - alpha (M)
  2. A - beta (M)
  3. A - gamma (M)
  4. A - delta (M)

     B - Myelinated

     C - Unmyelinated

Important Information

- **Diameter:** Increase from C→A
- **Conduction:** Increase from C→A

I. A- alpha M 00:17:50

- Innervation of skeletal muscle
- Proprioception

II. A- beta M

- Touch
- Pressure

III. A - gamma M

- Muscle spindle
- Skeletal muscle tore

IV. A - delta M

- Fast pain
- Touch
- Temp.

B - M

- Preganglionic autonomic fibers

C - UM

Slow pain

- Post ganglionic nerve fibers

Cm 00:20:33

- Dose of local anesthetic required to block the nerve conduction

The sequence of sensitivity of nerve fibres to LA

- B > C=A delta > A gamma> A beta > A alpha
- Autonomic transmission → Sensory transmission→ Motor transmission

Sensory

- Temperature > Pain > Touch > Motor > Proprioception

Clinical Implication 00:23:41

- **Bupivacaine**
  - 0.5% blocked A, S, M
  - 0.25%-0.125% blocked A, S

ADDITIVES WITH LOCAL ANESTHETICS

Addition of Epinephrine

- The duration of action of a LA is proportional to the time the drug is in contact with nerve fibers
- If along with LA we add Epinephrine
  - It will constrict the blood vessel surrounding this nerve fiber
  - Systemic absorption of LA will be prevented
- Epinephrine added is 5 ug/ml i.e. 1:200000 dilution

Advantages

1. Limits systemic absorption
- ↓ed systemic toxicity
2. Maintains the drug concentration in the nerve fibers
- ↓ed onset time (fast)
- ↑ed duration (prolong)
- Intensity of block is good

Disadvantages

00:32:18

1. ↑ed pain at the site of injection
2. LA + adrenaline (or any other vasoconstrictor) combination is contraindicated for site with end arteries

Clinical Implication: Contraindication for

- Toe block
- Finger block
- Penile block
- Other vasoconstrictor can also be used as additives
  - α_2 against
    - → Clonidine
    - → Dexmedetomidine

Alkalization of Local Anesthetic

- LA are weak base
- Physiological pH
  - Ionized
  - Unionized
    - → Lipid soluble
    - → Only block Na^+ channel
  - $NaHCo_3$ is added to present ionization of the drug

Clinical Implication

I. **Addition of LA + $NaHCo_3$**
   1. Makes the block onset faster
   2. Prolong the duration of the block
   3. Better intensity of the block
   4. Decrease the local pain of injecting the drug

II. **Acidosis in the environment into which local anesthetic is injected decreases the quality of block**

SYSTEMIC ABSORPTION OF LA FROM ITS SITE OF INJECTION INTO SYSTEMIC CIRCULATION IS AFFECTED BY

I. Site of injection
II. Dosage
III. Pharmacological profile of the drug

I. Site

- IV > Tracheal > Intercostal block > Caudal block > Lumber epidural > Brachial plexus> Sciatic
- **Clinical Implication** of site of injection
  - Whenever LA is injected at the site which is very vascular, the chances of
  - Systemic absorption is high
  - Systemic toxicity is high

II. Distribution of LA

- Highly perfused organ
  - Brain
  - Heart
- Redistributed to less perfused

Clinical Implication

- Decrease dose of LA if used in the patient with low cardiac output/ hypovolemic shock cause ↑ed risk of systemic toxicity

LOCAL ANESTHETICS

- Are weak bases, Pko near to physiological pH
- It consists of the lipophilic aromatic ring and hydrophilic tertiary amine ring
- Connected by hydrocarbon
- Bond between hydrocarbon chain and aromatic ring 2 type
  1. **Ester** - CO –
  2. **Amide** – NHC –

00:48:30

Ester	Amide
SA • Cocaine • Procaine • Chloroprocaine	**IA** • Lignocaine • Mepivacaine • Prilocaine
LA • Benzocaine • Tetracaine	**LA** • Bupivacaine • Levobupivacaine • Ropivacaine • Dibucaine

How to remember

- Ester- has I (i)
- Amide- has 2 (i)

Ester	Amide
• All ester LA except cocaine are metabolized by an enzyme in plasma Pseudocholinesterase	• Cocaine and Amide LA • Hepatic metabolism
• An intermediate by product of metabolism called Para Amino Benzoic acid (PABA) is produced	• No para amino benzoic acid
• PABA- allergen can cause an allergic reaction	• No allergy

Clinical Implication 00:55:08

I. Ester LA are more responsible for allergic reaction

II. In liver dysfunction or conditions with decreased hepatic blood flow
- Metabolism of amide LA would be decreased
- ↑se chances of systemic toxicity
- Dose needs to be reduced

III. Condition with deficiency or Atypical Pseudo cholinesterase
- Metabolism of Ester LA ↓ed
- Decrease dose of Ester LA

COCAINE 00:58:10

1. It was introduced as the 1st LA in 1884 by Kollar for use in ophthalmology
2. Cocaine is Ester of benzoic acid (natural)present in huge amount in leaves of the coca plant
3. **1885:** Halstead, used cocaine for Brachial block
4. Cocaine is a vasoconstrictor because its sympathomimetic drug
5. Metabolism is by the liver

PROCAINE 01:01:21

1. 1st synthetic LA
2. **1905:** Separated by Einhorn.

CHLOROPROCAINE 01:02:20

- Chlorine atom was added to the benzene ring of procaine
- Increases rate of hydrolysis by 3.5 times by plasma cholinesterase
- Shortest duration

Clinical Implication
- LA of choice
  - In daycare surgery
  - Least chances of placental crossing

BENZOCAINE 01:04:42

Important Information

- **It's a weak acid**
- **Completely ionized at physiological pH**

- Role in topical anesthesia
- A complication called Methemoglobinemia can be seen with this drug

TETRACAINE 01:06:42

- Longest acting Ester LA
- Used mostly for topical anesthesia

AMIDE LA 01:07:24

- Hepatic metabolism
- Dose modification required in liver disease
- Dose modification required in pregnancy
- No PABA
- Least chance of allergy

LIGNOCAINE / LIDOCAINE / XYLOCAINE 01:08:29

- **1943**: Lofgren
- Most commonest used LA
- Safest LA
- Only LA which can be given IV
- Multiple roles apart from regional anesthesia
  - Antiarrhythmic
  - Analgesia

INTRAVENOUS REGIONAL ANESTHESIA (IVRA) OR BIER'S BLOCK

- Lignocaine is local anesthetic of choice
- Maximum safest dose of lignocaine alone: 3 mg/Kg BW
- Lignocaine + Adrenaline maximum safest dose 7 mg /kg BW

PRILOCAINE

01:12:35

- Because of association of methemoglobinemia

BUPIVACAINE

01:13:55

- LA
- Amide LA
- Hepatic metabolism
- No PABA
- No allergic
- Most cardiotoxic LA
- Chiral drug
  - Asymmetric carbon atoms
  - The drug has left (S) or Right (R) handed configuration
  - S(-) enantiomer of R (+) enantiomer both present in equal amount in bupivacaine
  - Bupivacaine is a racemic mixture
- Both enantiomers differ in
  - Pharmacokinetics
  - Pharmacodynamics
  - Toxicity
- S (-) enantiomer less cardiotoxic
- **2 pure S (-) enantiomer of bupivacaine** made
  - Ropivacaine
  - Levobupivacaine
- **Cardiotoxicity**
  - B >>> LB > R
- **Motor Block**
  - B > LB > R

ROPIVACAINE

- Long-Acting Amide
- Pure S(-) isomer of Bupivacaine
- Less cardiotoxic
- Less motor block
- Best drug for post-op analgesia and labor analgesia

DIBUCAINE

01:19:42

- Slowest rate of metabolism
- Longest duration

Duration

- D > T > B

How to remember

Longest duration

- **DTB**

Delhi to Bombay

Shortest duration

- Chloropropane > Procaine > Cocaine

COMPLICATIONS OF LOCAL ANESTHETICS

01:20:56

- This is due to excess of LA into blood/plasma

I. Site of injection LA

II. ↓ed systemic absorption if a vasoconstrictor is added

III. Dose
  - More dose- higher chance

IV. Physiochemical properties of drug

CNS toxicity

01:24:05

- Circumoral numbness (1st clinical feature)
- Restlessness
- Sense of impending doom
- Vertigo
- Tinnitus
- Skeletal muscle twitches
- Drowsiness
- Tonic clonic seizure
  - CNS depression
    - → Hypotension
    - → Apnea

Treatment

1. Symptomatic
2. O_2 inhalation
3. Intubation & ventilation (hyperventilation)
4. IV benzodiazepine
   - Midazolam
   - Diazepam
5. 20% intralipid emulsion causes lipid escape of LA

CVS toxicity

01:28:50

1. It causes arteriolar vascular smooth muscle relaxation

2. It causes myocardial depression
   - Both will lead to hypotension

3. It binds to Na^+ channel of heart& cause
   - Dysrhythmias

4. Heart block
5. Cardiac arrest

Management

01:30:22

1. Symptomatic
2. Antiarrhythmic
   - Amiodarone
3. CPCR in cardiac arrest
4. 20% intralipid emulsion

Previous Year's Questions

Q. An anaesthetist was doing shoulder block with 0.25% bupivacaine. the patient become unresponsive, and pulse become unrecordable. The best management in this patient would be?

(NEET PG 2021)

A. CPR with 20% intralipid emulsion
B. CPR with dobutamine
C. CPR with Calcium
D. CPR with sodium bicarbonate

CC / CNS Ratio 01:31:15

- Dose at which CVS toxicity / Dose at which CNS toxicity
- High ratio -safe LA
- Lignocaine is considered as safest local anesthetic
- **Bupivacaine**
  - Has lowest ratio
  - Most cardiotoxic

METHEMOGLOBINEMIA 01:32:48

- Hb is oxidized to methemoglobinemia
- Cannot carry O_2 or CO_2
- Lead to cyanosis
  - Benzocaine
  - Prilocaine
  - **EMLA (lignocaine + Prilocaine)**

Treatment

- 1-2 g/kg BW methylene blue (reducing agent)

Neurotoxicity 01:34:53

- Direct toxicity to nerve fibres

1. Lignocaine: not preferably used for spinal anesthesia
2. Chloroprocaine

Allergy

- <1%
- Mostly with Ester LA

USES OF LOCAL ANESTHETIC 01:36:15

- It is used for regional anesthesia and depending upon the site the regional anesthesia is divided

- Topical anesthesia
  - LA is deposited on mucous membrane of nose, oral, tracheobronchial tree, esophagus
  - Nebulization can also produce topical anesthesia of lower respiratory tract

COMMON ANESTHETIC USE

1. Cocaine is very popular for T.A
   - Because it is vasoconstrictor
   - Constrict surrounding blood vessels
   - Clear surgical field

2. Procaine
3. Benzocaine
4. Tetracaine
5. Lignocaine

EMLA 01:40:35

- Eutectic (easily melted) mixture of local anesthetic
- Cream based solution having
  Lignocaine + Prilocaine 1:1 ration
  - Both present in 2.5% concentration each

How to use

1. Clean the skin surface
2. Inspect it for any breach
3. Apply cream 1-2 g/ 10 cm^2 surface area
4. Apply occlusive dressing

Contact period

- Min. 60 min

USE

1. Venous cannulation/ arterial cannulation
2. Circumcision
3. Portwine excision
4. Split skin grafting

Contraindications

I. Mucous membrane
II. Neonate (they don't have mature liver)
III. Any breach in skin continuity (systemic absorption can happen)

2. LOCAL INFILTRATION 01:45:30

- Infiltration in extravascular space around the site to be anesthetized

Field block

- Diamond or square form LA is infiltrated around the area of interest

- Local infiltration
  - LA + adrenaline (1:20000|) should be mixed

3. PERIPHERAL NERVE BLOCK 01:48:54

- LA is deposited around the tissues surrounding nerve trunks

4. INTRAVENOUS REGIONAL ANESTHESIA (IVRA) OR BIERSBLOCK ⏱ 01:49:50

- Discovered by Dr. August Bier
- Given in limbs upper or lower
- Tie tourniquet and inflate the tourniquet, double the blood pressure of the patient
- Block the circulation of the limb from body systemic circulation
- Put IV cannula
- Give LA which remains in that limb and sensitized all nerve fibers of that limb
- If tourniquet gets open, drug can go into systemic circulation result in systemic toxicity
- In order to give things safe. We use safest drug
  - Lignocaine: is the drug of choice
  - Bupivacaine: C/I
  - Ropivacaine: C/I

Contraindication

I. Peripheral vascular disease
II. Raynaud's disease
III. Sickle cell anemia

Important Information

- IVRA is absolutely contraindicated because with tourniquet the acidosis can precipitate sickle cell anemia

5. CENTRAL NEURAXIAL BLOCKADE ⏱ 01:52:53

- Spinal Anesthesia
- Epidural Anesthesia

CLINICAL QUESTIONS

Q. A 47 year old chronic smoker and alcoholic admitted with the history of road traffic accident and sustained injury to the right upper limb. This patient was planned for open reduction and internal fixation with plating for both bone fracture right forearm under brachial plexus block. Inj. 2% Lignocaine and Bupivacaine 0.5% was used for brachial plexus block and the intraoperative course was uneventful. The patient was not able to move his right upper limb for more than 12 hours. The reason behind this could be?

A. Liver cirrhosis
B. Acute renal failure
C. Pseudocholinesterase deficiency
D. Chronic renal failure

Answer: A

Solution

- In hepatic dysfunction dose reduction is necessary as they slow down the clearance of amino amide local anesthetics and drug levels may accumulate
- They undergo varying rates of metabolism by microsomal enzymes located primarily in the liver
- The first step is conversion of amide based to amino carboxylic acid under cyclic aniline derivative. Complete metabolism involves hydroxylation of the aniline moiety and N-dealkylation of the amino carboxylic acid
- Ester local anesthetics undergo hydrolysis by cholinesterase enzyme principally in the plasma and to a lesser extent in the liver.
- The exception to hydrolysis of ester local anesthetics in the plasma is cocaine which undergoes significant metabolism in the liver

Reference: Stoelting's Pharmacology and Physiology in Anaesthesia Practice 5th edition, Page no -289, 290

Q. A 45 year old male who was a known case of alcoholic liver disease admitted with both bone fracture right forearm, posted for open reduction and internal fixation with plating under brachial plexus block using local anesthetics. The drug which do not need dose reduction in this patient would be?

A. Lignocaine
B. Bupivacaine
C. Cocaine
D. Procaine

Answer: D

Solution

- All ester LA except cocaine are metabolized by an enzyme in plasma Pseudocholinesterase
- Increases rate of hydrolysis by 3.5 times by plasma cholinesterase
- Shortest duration
- In liver dysfunction or conditions with decreased hepatic blood flow

metabolism of amide LA would decreased, ↑se chances of systemic toxicity, dose needs to be reduced

- Condition with deficiency or Atypical Pseudocholinesterase, metabolism of Ester LA ↓ed, decrease dose of Ester LA

Aminoesters

- Cocaine
- Procaine
- Chloroprocaine
- Benzocaine
- Tetracaine

Aminoamides

- Lidocaine
- Mepivacaine
- Bupivacaine
- Levobupivacaine
- Ropivacaine
- Prilocaine
- Dibucaine

Reference: Stoelting's Pharmacology and Physiology in Anaesthesia Practice 5th edition, Page no. 289,290
Miller's Textbook of Anaesthesia 9th Edition, Page no-2380

Q. A 30 year old male who was a case of both bone fracture right forearm posted for open reduction and internal fixation with plating under brachial plexus block using 0.5% Ropivacaine. Not a feature of Ropivacaine in this patient would be?

A. It is enantiomer of Bupivacaine
B. Can be safely used in labour analgesia in lower concentrations
C. It is less potent and less lipid soluble than Bupivacaine
D. Cardiotoxicity is similar to as that of Bupivacaine

Answer: D

Solution

- Long Acting Amide
- Pure S(-) isomer of Bupivacaine
- Less cardiotoxic
- Less motor block
- Best drug for post-op analgesia and labor analgesia

Central nervous system and cardiovascular system effects

- Ropivacaine is less lipophilic than bupivacaine and with its stereoselective properties, Ropivacaine have a significantly higher threshold for cardiotoxicity and CNS toxicity than bupivacaine in animals and healthy volunteers
- The very slow reversal of sodium channel blockade after a cardiac action potential which is characteristic of bupivacaine, is considerably faster with ropivacaine. Ropivacaine is less potent than bupivacaine (1:1.3 to 1:1.5). It is highly bound to alpha 1 acid glycoprotein

Reference: Stoelting's Pharmacology and physiology in Anaesthetic practice, 5th edition, page 290
Miller's textbook of Anaesthesia, 9th edition, page 885,886

Q. A 30 year old male who was a case of both bone fracture right forearm posted for open reduction and internal fixation with plating under brachial plexus block using local anesthetics. The type of nerve fibre which is least susceptible to local anaesthetic blockade in this patient would be?

A. A beta
B. A alpha
C. B fibers
D. C fibers

Answer: D

Solution

Most sensitive → Least sensitive for Local Anaesthetics

- Autonomic > Sensory > Motor
- Temperature (Cold) >Pain> Touch> proprioception

Fiber class	Subclass	Myelin	Diameter (Micrometer)	Conduction velocity(m/sec)	Location	Function	Susceptibility to local anesthetic block
A	α β δ	+ + +	6-22 6-22 3-6	30-120 30-120 15-35	Efferent to muscles Afferent from skin and joints Efferent to muscle spindles	Motor Tactile, proprioception Muscle tone	++ ++ ++++
B		+	<3	3-15	Preganglionic sympathetic	Various autonomic function	++
C	sC	-	0.3-1.3	0.7-1.3	Postganglionic sympathetic	Various autonomic function	++
	dC	-	0.4-1.2	0.1-2	Afferent sensory nerve	Various autonomic function, Pain, Warm temperature	+

- Different fiber types have different sensitivity to local anaesthetic blockade.
- The most susceptible to impulse suppression are Small myelinated axons (Aγ motor and Aδ sensory fibers)
- Small non-myelinated C fibers are least susceptible than large myelinated fibers Aα and Aβ

Reference: Miller's Textbook of Anaesthesia 9th edition, Page no. 869,874

Q. A 30 year old male who was a case of proximal humerus fracture posted for open reduction and internal fixation with plating under interscalene approach of brachial plexus block using Inj. Lignocaine with Adrenaline. Which of the following is not an indication for using Lignocaine?

A. Ventricular fibrillation
B. Grandmal seizures
C. Analgesia
D. Atrial fibrillation

Answer: D

Solution

Uses of Lignocaine

- Topical, infiltration and regional anaesthesia (epidural, spinal, Bier's block)
- Prevent or treat ventricular cardiac dysrhythmias
- Prevent or treat increases in intracranial pressure
- Analgesia
- To treat grandmal seizures
- Anti-inflammatory effect

Reference: Stoelting's pharmacology and physiology in Anesthetic practice, 5th Edition, Page no: 298

15 CENTRAL NEURAXIAL BLOCKADE

- Blocking spinal nerve roots either by spinal anesthesia or epidural anesthesia is known as Central Neuraxial Blockade

ANATOMY

Vertebral Column

- Have vertebrae & intervertebral discs
- It has
  - **7** Cervical vertebrae
  - **12** Thoracic vertebrae
  - **5** Lumbar vertebrae
  - **5** Sacral vertebrae - Fused to the sacrum
  - Rudimentary coccyx
- Spinal cord is encased & protected by the vertebral column
- At every level, a pair of spinal nerves exit out

Spinal Canal Contents

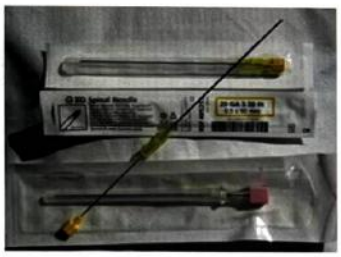
- Spinal cord with its covering (meninges), loose fatty tissue, venous plexus
  - Anterior & posterior spinal nerves fuse together & form spinal root, which pierces all 3 layers of the spinal cord, exit out & then divide again
- If a drug is injected between Pia & Arachnoid mater (subarachnoid space), it is Spinal Anesthesia
- If the drug is injected outside Dura mater (epidural space), it is Epidural Anesthesia
  - Either way, the spinal nerve root is blocked
- Space between Dura & Arachnoid matter (subdural space) is poorly formed. It doesn't retain drugs. Hence, not used
- Spinal cord: normally extends
  - From the Foramen Magnum to lower border L_1 in adults
  - Upto lower border of L_3 in children
  - Thus, spinal anesthesia has to be given below this level

DIFFERENCE BETWEEN SPINAL & EPIDURAL ANESTHESIA

00:08:04

Subarachnoid block/Spinal Anesthesia	Extradural block/Epidural Anesthesia
• Drug is given in subarachnoid space	• Drug in extradural space
• Fast onset o Drug mixes with CSF, distributes uniformly & produce fast effect	• Slow onset o Don't contain CSF. Depending on amount of drug used, some drug ascends, some descends & come in contact with different roots slowly
• Dense block	• Patchy block
• Amount of drug used is less	• Large volume of drug is required depending on number of segments to block
• No risk of systemic toxicity	• As large volume of drug is used, more risk of systemic toxicity
• Drug is mixed with dextrose to make it hyperbaric & level of block is controlled	• Isobaric drug is used
• Layers pierced o Skin → Subcutaneous Fascia → Supra & Interspinous Ligaments → Ligamentum Flavum → Dura Mater → Arachnoid Mater o Now, take stellate out & return of CSF is seen o Give the drug	• Layers pierced o Skin → Subcutaneous Fascia → Supra & Interspinous Ligaments → ligamentum Flavum (sudden loss of resistance is felt) → Epidural Space is reached o Give the drug
• Easy to give	• More expertize is required
• Low incidence of failure	• High incidence of failure
• Fixed duration of action	• Duration can be extended by putting catheter & giving drug regularly

• Used only for intra-operative anesthesia	• Used for both intra-operative anesthesia & post-operative analgesia
• Segmental block isn't possible	• Segmental block is possible
• More hemodynamic imbalance	• Less hemodynamic imbalance
• Given at levels o **L2-L3** Most dense block o **L3-L4** Safest o **L4-L5**	• Can be given at thoracic/ lumbar/ sacral levels
• Needle used o **Dura cutting**: Quincke's needle o **Dura splitting**: Sprotte & Whitacre needles o **Whitacre**: Spinal needle with least incidence of postdural headache	• Tuohy's needle: thicker than spinal needle with markings



Previous Year's Questions

Q. The last layer to be pierced to enter lumbar cisternae is? (NEET PG 2021)

A. Duramater
B. Arachnoid mater
C. Ligamentum flavum
D. Supraspinous ligament

Previous Year's Questions

Q. Spinal anaesthesia in an adult is given at this level? (FMGE June 2019)

A. T12 - L1
B. L1 - L2
C. L3 - L4
D. L5 - S1

Previous Year's Questions

Q. Identify the following needle? (FMGE August 2020)

A. Sprotte Needle
B. Whitacre Needle
C. Quincke Needle
D. Tuohy's Needle

Previous Year's Questions

Q. Which of the following layers is pierced during the Spinal Anesthesia? (FMGE June 2021)

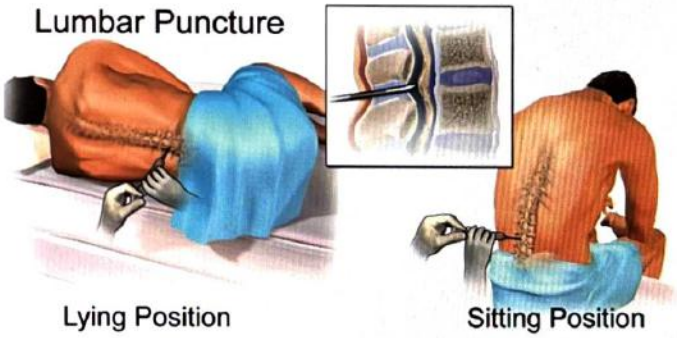
A. Skin - Subcutaneous fascia - Supraspinous and interspinous ligament - Ligamentum flavum
B. Skin - Subcutaneous fascia - Supraspinous and interspinous ligament - dura mater
C. Skin - Subcutaneous fascia - Ligamentum flavum - Supraspinous and interspinous ligament
D. Skin - Subcutaneous fascia - Supraspinous and interspinous ligament - Intervertebral disc space

PROCEDURE

00:34:12

POSITIONS

- Sitting
- Lateral
- Prone or Jack Knife Position



Approach

- Midline
- Para-median

Indications

00:35:35

- It is used alone as the sole anesthetic technique in
  - Lower abdominal surgeries like obstetric surgeries (Cesarean Section)
  - Gynecological surgeries

- Urological surgeries
- Orthopedic surgeries

- Epidural can also be used along with General Anesthesia in
  - Thoracic surgeries
  - Other upper abdominal surgeries

COMBINED SPINAL & EPIDURAL ANESTHESIA

- We give spinal anesthesia & get a block immediately
- Then, we leave an epidural catheter, which can prolong the block, also useful for post-operative analgesia
- Uses in
  - Lower Abdominal Surgeries
  - Orthopedic Surgeries
  - Urological Surgeries
  - Gynecological Surgeries

COMPLICATIONS OF CENTRAL NEURAXIAL BLOCKADE

00:38:45

- From the spinal cord spinal nerves come
- Ant. and post. spinal nerve combines and forms spinal nerve root
- Blocking spinal nerve root, blocks both anterior and posterior
- **Producing**
  1. Sensory block
  2. Motor block
  3. Autonomic block
- Autonomic nervous system comprises of
  - Sympathetic (Thoraco-Lumbar)
  - Parasympathetic (Cranio-Sacral)
- Preganglionic Thoraco-Sympathetic fibers travel with Thoracic–Spinal nerve
- All Lumbar preganglionic fibers travel with Lumbar spinal nerve
- Only sacral parasympathetic fiber travel with Sacral spinal nerve
- Sacral parasympathetic fibers innervate only the bladder
- Cranial sympathetic fibers innervate rest of the body
- Cranial parasympathetic travel with vagus cranial nerve innervating maximum part of the body only except bladder
- Sympathetic fibers travel with the spinal nerve and most of them travel with cranial nerve
- When the spinal nerve is blocked, along with it sympathetic nervous system is also blocked
- Most important work of spinal nerve is to maintain blood pressure & heart rate

Important Information

- **Sympathectomy - Sympathetic nervous system is blocked leading to complications**

COMPLICATIONS

1. Hypotension

- All the spinal nerves which originate from T_4 to L_1 segment along with them travel vasomotor fibers of the blood vessels
- If block till T_4
- Sympathetic vasomotor fibers are also blocked
- Dilation of the blood vessels
- **Hypotension**: M/C complication
- Spinal >> Epidural

Management

1 IV fluids
2 IV vasopressor
   I. Phenylepinephrine: best pure alpha receptor agonist
   II. Ephedrine: acts on alpha and beta receptors both
   III. Mephentermine
- If BP does not improve even with vasopressor
  - Give IV Inotropes

Important Information

- **Phenyl epinephrine is vasopressor of choice**
  - **Cesarean section**
- **Phenyl epinephrine is given in pregnant lady's because it**
  - **Does not cause Fetal Acidosis**
  - **Cardiac disease**
  - **It does not cause tachycardia**

2. Bradycardia

- Sympathetic blockade of cardio accelerator fibers (T_1-T_4)
- Sympathetic blockade causing parasympathetic overdrive
- Cause bradycardia

Management

- IV Atropine

Important Information

Complication of high spine

- **Hypotension**
- **Bradycardia**

3. Respiratory Depression

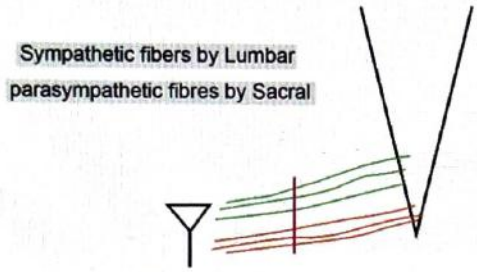
00:47:54

- Due to spinal not epidural
- As the block ascends higher, C fibers are blocked
- Cause respiratory depression
- But most common cause of respiratory depression is not because of blocking of C fibers

- It is because of hypoperfusion of Pons because of hypotension

Management
- Support the respiration
- Give 100% O_2

4. Retention of urine



Both Sympathetic and Parasympathetic gets blocked cause retention of urine
- **Most common:** Post-operative complication of spinal and epidural

Management
- **Symptomatic**
  - Most of the times bladder catheterization is done by the surgeon because of the retention of urine

5. Total Spinal Anesthesia
- If want to give epidural anesthesia to the patient
  - Pierce the skin- subcutaneous fascia-supra & infraspinous ligament- ligament flava and reach epidural space
  - If didn't get a feeling of loss of resistance
  - Pierce the dura matter and reach sub-dural space
  - If got feeling of loss of resistance, give epidural drug
  - This space does not have the capacity to hold the drug
  - This space drug will enter into subarachnoid space and also spilled in epidural space
  - Got total spinal anesthesia or high spinal anesthesia
  - Immediately after giving drug, develop
    → Hypotension
    → Bradycardia
    → Respiratory depression

- When an epidural drug is injected into the subdural space the drug will spread towards both Subarachnoid space & Epidural space causing blockade of 31 pairs of spinal nerves called Total Spinal Anesthesia / High Spinal Anesthesia
- Immediately patient will develop
  1. Hypotension
  2. Bradycardia
  3. Respiratory depression

Management 00:52:21
- Symptomatic treatment

Understand with an example

Case scenario while giving epidural
- Case1: A 28yr old female wanted epidural for labor analgesia. She was given 10ml of 1% Lignocaine with an epidural catheter. Immediately after giving the drug the patient developed hypotension, bradycardia & respiratory depression.

Q. What is the Diagnosis?
A. Total Spinal Anesthesia / Drug entered subarachnoid space
B. Systemic toxicity
C. Vasovagal
D. Allergy to the drug

6. Systemic toxicity to the drug 00:56:45

Understand with an example

Case: 28 yr old female wanted labor analgesia she was given 10ml of 1% Lignocaine with an epidural catheter. Immediately after giving the drug she developed apprehension, circumoral numbers, tinnitus, seizure. Diagnosis?

A. Total Spinal Anesthesia / Drug entered subarachnoid space
B. Systemic toxicity
C. Vasovagal
D. Allergy to the drug

7. Vasovagal

Understand with an example

Case: A 28yr old in active stage at labor with fetal bradycardia, when the Anesthetist was putting epidural catheter she became unconscious, hypotensive, bradycardia, respiratory depression.

A. Total Spinal Anesthesia / Drug entered subarachnoid space
B. Systemic toxicity
C. Vasovagal
D. Allergy to the drug

Understand with an example

A 28-year-old in active stage of labor with fetal bradycardia was given spinal anesthesia for LSCS. She was given 2ml of Hyperbaric Bupivacaine. immediately after giving the drug she developed hypotension. bradycardia. respiratory depression.

- Diagnosis: Highspinal / Total Spinal

Important Information

- Before giving the drug if pt. becomes unconscious or hemodynamically imbalance: Vasovagal
- After giving the drug. neurological symptoms are coming: Systemic toxicity
- After giving the drug these complications are coming: Total spinal anesthesia

8. Infections

- Patient painting and dropping is done with betadine, if it is not properly done, it can carry the skin commensals to them causing
  - Meningitis
  - Encephalitis

9. Epidural / Spinal Hematoma

- There is a chance that hematoma would develop, which can press the spinal cord and can result paraplegia

10. Cauda Equina Syndrome (Spinal Anesthesia)

- Due to Neurotoxicity
- Seen in
  - With Lignocaine
  - Spinal anesthesia
- Now a days Lignocaine is avoided for spinal
- Instead Bupivacaine is preferred

11. Post Dural Puncture Headache/ Spinal Headache 01:00:08

- Pathophysiology
  - Dura pierced -arachnoid pierced- CSF leak
  - ↓ ICP- traction on pial nerve fibres
- Any breach in Dura may result in PDPH
- It can follow both Spinal & Epidural

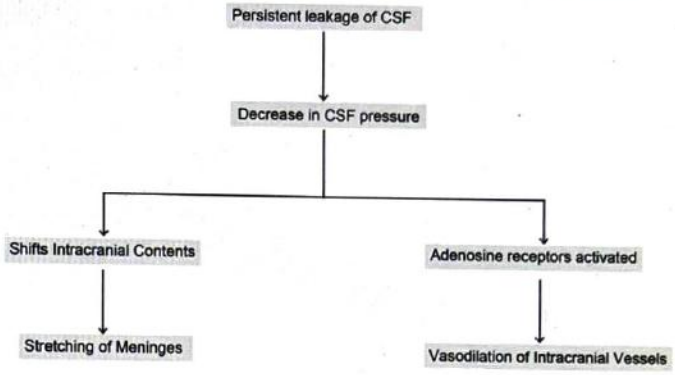
Site

- Typically, Frontal / Retroorbital / Occipital

Hallmark

- It's association with body position
- Aggravated on Standing
- Relieved by Lying

PATHOPHYSIOLOGY 01:03:51



Predisposing factors

- Dura cutting needle of larger diameter (Spinal needle)
- Wide bore needle
- Multiple attempts
- Female
- Pregnancy

Management

- Divided into symptomatic or conservative management

a. Symptomatic Management

1. Analgesic (NSAIDS)
2. Caffeine
3. Fluids-Oral, IV
4. Supine position

b. Definitive management

- Increasing CSF pressure by epidural blood patch
- 90% immediate relief
- Not first line of management

c. Newer Management

- Sphenopalatine block

CONTRAINDICATIONS OF CENTRAL NEURAXIAL BLOCKADE 01:09:08

Absolute Contraindication

1. Raised intracranial pressure
2. Local infection of the site
3. Patients refusal
4. Severe hypovolemic shock
5. Severe heart disease
6. Coagulation Disorder: PLT count<50,000 (absolute contraindication)

OBSTETRIC ANESTHESIA 01:14:06

Anesthesia for cesarean section (CS)

1. Spinal Anesthesia
2. Epidural Anesthesia
3. General Anesthesia

- **Level of block** in central neuraxial blockade: T_4 for CS

1. CS: Spinal Anesthesia is the most common anesthesia used worldwide
2. **Epidural anesthesia**

- Any co-morbidities like
  - Severe pre-eclampsia
  - Eclampsia
  - Heart disease

3. **General anesthesia in CS is not preferable**

Demerits of General Anesthesia in CS 01:17:50

1. Risk of difficult airway
2. Risk of aspiration
3. Anesthetic agents can pass the fetoplacental barrier
4. The patient will not have immediate contact with the child

Indications of General Anesthesia in CS 01:19:14

1. Emergency CS
2. Contraindication to central neuraxial blockade

Surface landmark that corresponds to Dermatome Level

- Inguinal Ligament - T12
- Umbilicus - T10
- Tip of xiphoid process - T7
- Nipple - T4
- Fifth / Little finger - C8

CENTRAL NEURAXIAL ANALGESIA 01:23:10

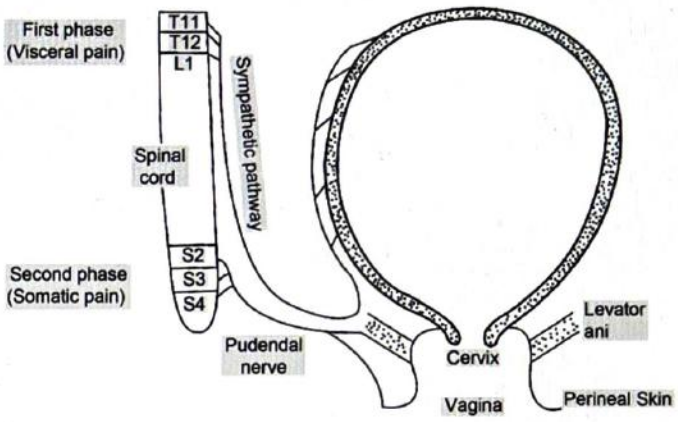
- Neuraxial analgesia comprises of only epidural
- Epidural catheter
- Can give LA
  - Use lesser concentration. Don't use motor concentration, use sensory concentration
  - 0.5% of bupivacaine is for the motor block. If we reduce 0.25% or further, spare the motor fibres
- Can give opioids
  - Sensory block, spare the motor

LA	Opioid
• Motor block possible • Hemodynamic imbalance is possible • Narrow gap between doses • Respiratory depression not common	• No motor block • No hemodynamic imbalance (better analgesia) • Wide gap between doses • Respiratory depression more com

POST-OPERATIVE ANALGESIA 01:28:29

	Adult	Pediatric
Major surgery	• Epidural Opioid • Gold standard	• IV Opioid • Infusion
Minor surgery	• IV / IM / ORAL / Rectal NSAID	• IV / IM / Rectal / NSAID

LABOR ANALGESIA 01:30:00



Systemic	Regional

1. Inhalational agents
• Sevox,
• Endonox
2. IV Opioids
• Remifentanyl
  ○ Easily metabolized in the fetus
  ○ Metabolized by esterase
  ○ Does not need mature liver to metabolize it
	1. Neuraxial technique
	• Epidural (Gold standard)
	• Pudendal nerve block

EPIDURAL ANALGESIA FOR LABOR 01:33:10

- L3-L4 space - Epidural catheter
- When pain starts
  - Bolus: Bupivacaine 0.25%/ 0.125%
  - Ropivacaine 0.2% / 0.1% + 50-100 mcg fentanyl
- Infusion - Bupivacaine / Ropivacaine: 0.0675% (0.1%) + 1 mcg fentanyl/ml
- Depending on the Stage of Labor
- If any case gold standard not possible
- Go for IV

CLINICAL QUESTIONS

Q. A 45 year old perimenopausal women admitted with the history of abnormal uterine bleeding for the past 6 months. She was posted for total abdominal hysterectomy with bilateral salphingooopherectomy. The plan of anesthesia was spinal anesthesia with epidural catheter for postoperative analgesia. Postoperative pain scores were low and the patient was comfortable postoperatively. Epidural catheter was removed after 48 hours. This epidural analgesia is suitable for?

A. Rib fracture
B. Lower abdominal Surgery
C. Thoracotomy
D. All of the above

Answer: D

Solution

- Epidural anaesthesia is very suitable as independent anaesthesia technique and as accompanying technique for analgesia with general anaesthesia.
- Thoracic epidural for Thoracic surgery, rib fracture
- Lumbar Epidural for upper and lower abdominal surgeries.
- Orthopedic Surgeries
- Urological Surgeries
- Gynecological Surgeries

Reference: Collin's regional anaesthesia, 3rd edition

Q. A 55 year old female who was a case of periampullary carcinoma, posted for whipple's procedure under general anesthesia with epidural analgesia. Epidural morphine was preferred over epidural local anaesthetic for analgesia in this patient because?

A. Less respiratory depression
B. No retention of urine
C. No motor paralysis
D. Less dose required

Answer: C

Solution

- Sympathectomy, sensory block or weakness are not seen with epidural opioid in contrast to local anesthetics. Epidural narcotics did not cause sympathetic depression or bladder dysfunction, and analgesia was segmental
- The ideal opioid must cross the dura rapidly and enter the spinal cord, where it should bind with strong affinity to the opioid receptors in the substantia gelatinosa
- Complications of epidural opioids even at these reduced doses still include nausea and vomiting (30-40%), sedation, respiratory depression (1%), as with parenteral routes, but to these can be added pruritus (10-50%) and urinary retention (5-40%)
- Pruritus is not due to histamine release (interaction with opioid receptors in trigeminal nucleus) but may respond to antihistamines; it will always respond to a small dose of naloxone without reducing analgesia

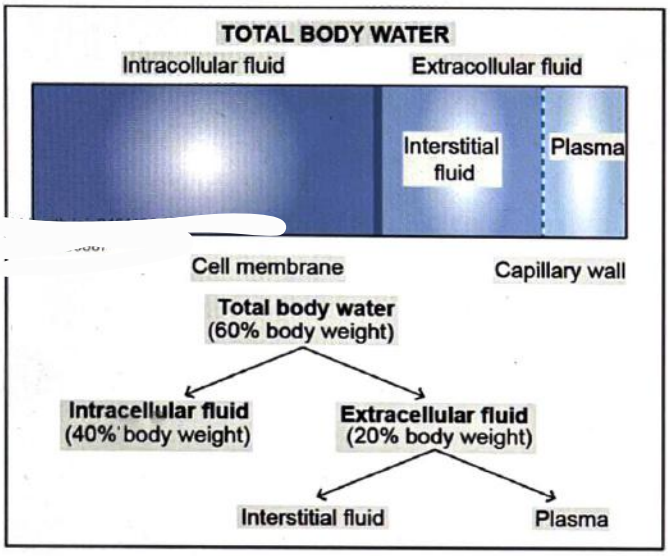
Reference: Stoleting's pharmacology and physiology in Anesthetic practice, 5th edition, page-248

16 PERIOPERATIVE FLUID

PHYSIOLOGY

00:00:48

- Total Body Water (TWB) divided into 3 compartments
- **TBW:** 60% BW
  - o **Intracellular fluid:** 40% BW
  - o **Extracellular fluid:** 20% BW
- Plasma: 5% plasma
- Interstitial: Rest



- **TBW:** 5% present in plasma is target fluid
- This fluid, which is maintaining the perfusion (BP) in the body
- This is where, infuse fluid to the patient

TYPES OF FLUID

00:02:25

- **1861:** Thomas Graham while doing his experiments on diffusion divided substances into 2 types according to their diffusion through parchment membrane
- IV fluids are divided into 2 types according to the ability to pass through capillary endothelium

I. Crystalloid
II. Colloid

DIFFERENCE BETWEEN COLLOID AND CRYSTALLOID

00:04:28

Crystalloid	Colloid
• Aqueous solution of low molecular weight ions/ electrolyte with/without glucose	• Aqueous solution of high molecular weight substance
• Can easily pass through capillary endothelium	• Cannot pass through capillary well
• Replacement ratio 3:1	• Replacement ratio 1:1
• $t_{1/2}$ in plasma is 20 – 30 min	• $t_{1/2}$ in plasma 2 – 8 hrs
• Cheap	• Expensive
• No risk of Anaphylaxis	• Risk of Anaphylaxis
• No such complications	• Some colloids can impair coagulation profile and can be nephrotoxic

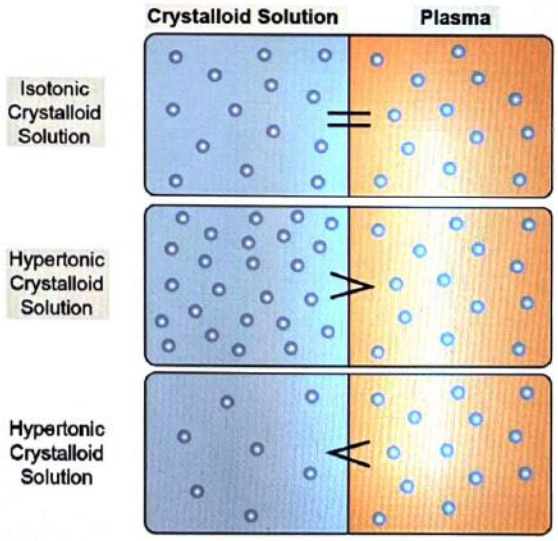
TYPES OF CRYSTALLOID

00:10:16

3 TYPES

1. Isotonic
2. Hypotonic
3. Hypertonic

Crystalloid	Colloid
Hypo/ Iso/ Hyper	Iso



Isotonic

- Normal Saline (NS)
- Ringer's Lactate (RL)

Hypertonic
- 3% NS
- 6% NS

Hypotonic
- 5% dextrose

Solute	Plasma	Crystalloids			
		Normal Saline	Ringer's Lactate	Hartmann's Solution	Plasma-lyte
Na^+	135 - 145	154	130	131	140
K^+	4.0 - 5.0	0	4.5	5	5
$Ca2^+$	2.2 - 2.6	0	2.7	4	0
$Mg2^+$	1.0 - 2.0	0	0	0	1.5
Cl^-	95 - 110	154	109	111	98
Acetate	0	0	0	0	27
Lactate	0.8 - 1.8	0	28	29	0
Gluconate	0	0	0	0	23
Bicarbonate	23 - 26	0	0	0	0
Osmolarity	291	308	280	279	294
Colloid	35 - 45	0	0	0	0
Osmolarity (mOsm/L); Colloid (g/L); All other solutes (mmol/L)					

SOLUTE PLASMA CRYSTALLOIDS
- NS osmolarity is 308 (near to plasma osmolarity, but it's Na^+ and Cl^- are more than serum osmolarity)
- If a huge amount of NS is given then hypernatremia can [illegible] in the patient

Important Information
- RL is the most physiological fluid. Even in children it is considered to be safe

Important Information
- RL: Na^+ & Cl^-, K^+, Ca^{2+} conc. is within normal and osmolarity is close to plasma osmolarity

USES OF CRYSTALLOID
00:15:35

1. Fluid and electrolyte supplement to patient's in wards and ICU
2. Perioperative fluid
- **Hypotonic**: 5% Dextrose
  - Dextrose present in fluid metabolized, remaining only free water
  - Diffuse anywhere, do not remain in intravascular space
  - Cannot be used to achieve perfusion in the patient, as a replacement fluid for the blood loss
  - Only use is for the treatment of
    → Dehydration
    → Protein sparing effect
    → Not a resuscitative fluid
- **Hypertonic:** 3% & 6% NS
  - Treatment of hyponatremia
  - Hypovolemic shock
3. Treatment of hyponatraemia and hypokalaemia
4. Resuscitative fluids

COLLOIDS
00:19:18

- Replacement ratio 1:1
- Always Isotonic

Divided into 2 types

Natural	Artificial
• Blood • Blood substitutes • Human albumin	• Starch • Gelatin

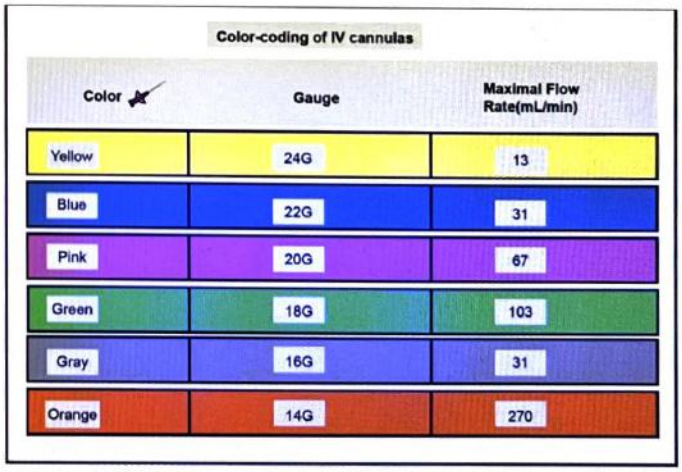
Intravenous fluids	mEq/l Na^+	Cl^-	K	Ca	Osmolarity[a] (mOsm/l)	Oncotic pressure (mm Hg)
Fresh-frozen plasma	168	76	3.2	8.2	≈ 300	21
5% Albumin					290	19
Dextran (10%) 40 in 0.9% saline	154	154			≈ 310	61
Dextran (6%) 70 in 0.9% saline	154	154			≈ 310	19
Hetastarch (6%) in 0.9% saline	154	154				31
Hetastarch (10%) in 0.9% saline	154	154			≈ 310	82

[a] Osmolarity = calculated value (osm/l = mg-molecular weight X 10 X valence

Use of colloid
- Resuscitative fluid

IV CANNULATION
00:21:33

- Technique in which a cannula is put through venous access



Color coding of IV cannulas
Purple
- Thinnest IV cannula
- 26 G

Color	Gauge size	External Diameter (mm)*	Length (mm)*	Water Flow Rate (ml/min)*	Recommended Uses
Orange	14G	2.1mm	41mm	- 240 mL/min	Trauma, Rapid blood transfusion , Surgery
Gray	16G	1.8mm	45mm	- 180 mL/min	Rapid fluid replcement, Trauma, Rapid blood transfusion
Green	18G	1.3mm	32mm	- 90 mL/min	Rapid fluid replcement, Trauma, Rapid blood transfusion
Pink	20G	1.1mm	32mm	- 60 mL/min	Most infusions, Rapid fluid replcement, Trauma, Routine blood transfusion
Blue	22G	0.9mm	25mm	- 36 mL/min	Most infusion Neonates, pediatrics, older adults, Routine blood transfusion
Yellow	24G	0.7mm	19mm	- 20 mL/min	Most infusion Neonates, pediatrics, older adults, Routine blood transfusion, Neonate or pediatric blood transfusion
Purple	26G	0.6mm	19mm	- 13 mL/min	Pediatrics, Neonates

Orange
- Trauma victims
- CVS surgery

Grey
- Rapid fluid replacement
- Cardiac surgery

Green
- Wards
- Intraoperative period
- 90-100 ml/min

Pink
- Wards
- Intraoperative period
- 60 – 65 ml/min

Important Information

Maximum flow rate
- **Green cannula : 90 – 100 ml/min**
- **Pink cannula: 60 -67 ml/min**

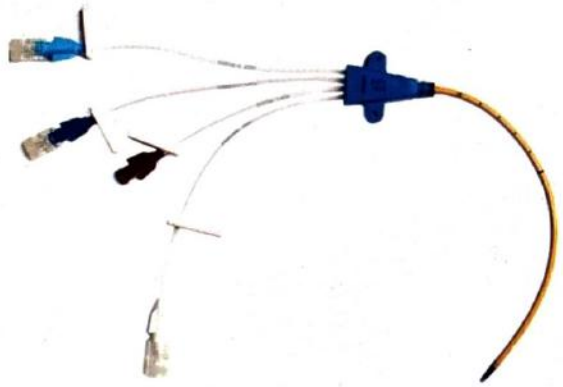
Blue and yellow
- Used in Pediatric patient

Purple
- Premature infants
- Very old patient

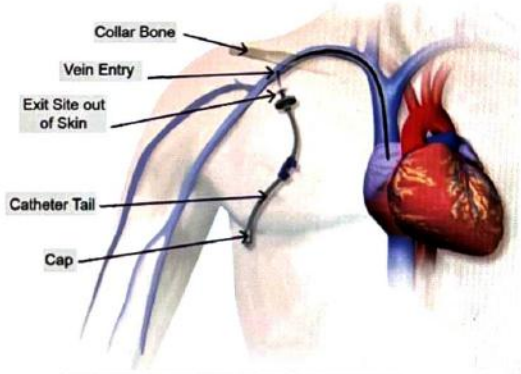
CENTRAL VENOUS CANNULATION 00:26:54

- Catheter in junction of SVC and Right Atrium

Indication
- Difficult peripheral line
- Hypertonic drugs
- Parenteral nutrition
- Transvenous pacing
- Haemodialysis
- Central venous pressure monitoring

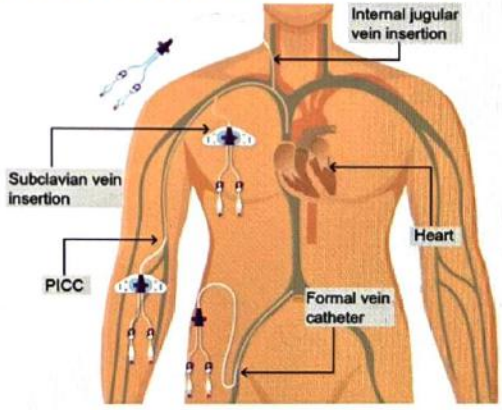


CVC
Multi-lumen central venous catheter



Non-Tunneled Central Venous Access Device

MULTIPLE SITES (WAYS) TO PUT CVC



- Through internal jugular vein
- Through subclavian vein
- Femoral vein
- Cephalic vein

COMPARISON OF DIFFERENT SITES 00:29:40

Internal jugular vein	Subclavian vein	Femoral vein
• Right IJV most common site	• Least infection	• Least preferred site
• It has valveless communication	• Patient comfort	• Huge incidence of infection
• Ease of visibility through ultrasound	Contraindication • Impaired coagulation profile • In case the subclavian artery got pricked, It will be difficult to compress the subclavian artery	• Dislodgement more common

PICC (PERIPHERALLY INSERTED CENTRAL CANNULATION) 00:32:22

- Basilic vein
- Catheter is advanced
- 52–54 cm

Measure

- Antecubital fossa to the shoulder
- Shoulder to right sternoclavicular joint
- Right sternoclavicular joint down to 3rd Intercostal space
- Tip of the catheter is in lower 1/3rd of SVC
- Not a good site for measuring the CVP
- Used for giving rapid fluid to the patient
  - Complications are little less.
  - With less expertise, very preferred way of central cannulation

CALCULATION OF FLUID REPLACEMENT FOR INTRAOPERATIVE PERIOD 00:35:31

1. Calculation of pre-existing, fluid deficit (Fasting Fluid Deficit)
2. Maintenance fluid requirement
3. Replacement fluid for 3rd space loss

MAINTENANCE FLUID 00:37:27

- 4–2-1 formula or Holliday Segar Formula
- **Calculate**
  - 4ml/Kg/hr for 1st 10 kg BW
  - 2ml/Kg/hr for 2nd 10 kg BW
  - 1ml/Kg/hr for each Kg above 20 kg

Understand with an example

60 kg

- 10 kg = 10 x 4 = 40 ml
- 10 kg = 10 x 2 = 20 ml
- 40 kg = 40 x 1 = 40 ml

  100 ml
- For 60 kg maintenance fluid 100ml/hr requirement

FASTING FLUID DEFICIT (FFD) 00:39:36

- Multiply MF x NPO (Nil per oral)

Understand with an example

- If NPO for 6 hrs

  100 x 6 hrs

  = 600 ml
- ½ of FFD replaced in 1 hr of surgery
- ¼ of FFD replaced in 2rd hr
- ¼ of FFD replaced in 3rd hr
- So. 600 ml

  300 ml – 1st hr

  150 ml – 2nd Hr

  150 ml – 3rd hr

REPLACEMENT FLUID

- Minor/ Moderated surgery: 4 – 6 ml/kg/hr
- Major surgery: 6 - 12 ml/ kg/hr

Understand with an example

60 kg adults posted for cataract surgery. what is his 1st hr fluid replacement. if he was NPO for 8 hrs

M.F = 100 ml

F.F.D = 100 x 8 = 800 ml

R.F = 60 x 4 = 240 ml

↓

Cataract is minor surgery

1st hr = $\frac{1}{2}$ FFD + M.F + R.F

= 400 ml + 100 ml + 240 ml

= 740 ml

Restrictive fluid has shown good results than liberally fluid

17 POST ANESTHESIA CARE UNIT & SCORING

POST ANESTHESIA CARE UNIT AND SCORING (PACU)

00:00:58

- Is designed and staffed to monitor and care for patients who are recovering from the immediate physiologic effects of surgery and anesthesia

EARLY POSTOPERATIVE PHYSIOLOGIC CHANGES

00:02:20

- Emergence from General Anesthesia and Surgery may be accompanied by a number of physiologic disturbances affecting multiple organs of the body

Most common

- PONV (PostOperative Nausea & Vomiting)
- Hypoxia (due to edema of airway, paralysis, anesthetic agents)
- Circulatory disturbances (hypotension, hypertension)
- Post-op hypothermia
- Post-op complication incidence -24%
- PONV-9.8%

Important Information

- **PONV is most common post-op complication**

RECOMMENDATION FOR PATIENT ASSESSMENT AND MONITORING IN PACU

00:05:37

- **Respiratory**
  - Airway patency-look, listen, talk
  - Respiratory rate- seeing chest movement
  - Oxygenation – pulse oximeter
- **Cardiovascular**
  - Heart rate
  - Blood pressure
  - ECG in required cases
- **Neuromuscular**
  - Clinical examination
- **Mental Status**
  - Consciousness
- **Temperature**
  - Pain
    - → Adult pain score: VAS (Visual Analyses Score), NRS (Numeric Rating Score)
    - → Children pain score: FLACC, CHEOP
- **Nausea & vomiting**
- **Hydration**
- **Urine**
- **Drainage & bleeding**

POSTOPERATIVE COMPLICATIONS

00:10:46

1. Respiratory
- Upper airway obstruction
- Hypoxemia
- Pulmonary edema

2. Cardiovascular system
- ↑BP ↓BP
- ↑HR ↓ HR
- Arrhythmias
- **Myocardial infarction**: Commonest cause of death in post-op patients

3. Renal dysfunction
4. Postoperative nausea & vomiting
5. Postoperative hypothermia and shivering
6. Postoperative delirium
7. Emergence excitement
8. Delayed recovery

1. RESPIRATORY

I. Upper Airway Obstruction 00:13:55

A. Loss of pharyngeal muscle tone: M/C cause

- Tongue fall
- Would not maintain the patency of the airway
- The passage of the air to the alveoli will be restricted

Management

- Simple maneuver
  - Jaw thrust
  - Head tilt & chin lift
- Simple airway adjuncts
  - Oropharyngeal airway
  - Nasopharyngeal airway

B. Residual neuromuscular blockade 00:16:22

- Incomplete recovery from neuromuscular blockers

Common factor

- Respiratory distress
- Agitation

Diagnosis

- ToF (Train of Four) ratio ≥0.9 (Adequate reversal)

Clinically – look

- Handgrip
- Tongue protrusion
- Leg lift
- Head lift for 5 sec
  - If sustained head lift for 5 sec
  - Best sign of adequate reversal

Management

1. Support ventilation
2. Repeat reversal agent

C. Laryngospasm 00:19:50

- Closure of laryngeal opening (vocal cords) due to tonic contraction of laryngeal muscle
- Airway irritants
  - Secretions
  - Blood

Management

1. Remove airway irritant
2. Jaw thrust and continuous positive airway pressure
3. IV Succinylcholine + Intubation

D. Edema and Hematoma

Surgery

- M/C seen in
  - Oral, head and neck surgery

Position

- Prone and Trendelenburg
- Fluid overload

Management

- Support the ventilation
- Dexamethasone 4mg IV

II. D/d of arterial hypoxemia in the PACU 00:24:22

- Atelectasis
  - M/C cause
- Alveolar hypoventilation
  - Due to the residual effect of anesthetic agent
  - Respiratory center can be depressed
- Diffusion hypoxia-N_2O
  - Due to the rapid diffusion of N_2O from blood to alveoli
  - Due to its low blood gas solubility
  - $\downarrow O_2$ conc. in alveoli
  - Happens 5-10 min post stoppage of N_2O

Management

- 100% O_2
- V-P mismatch
  - Hypoxic pulmonary vasoconstriction
- Increased venous admixture
  - Low CO
- Decreased diffusion capacity
  - Resp. comorbidity

III. Pulmonary edema 00:27:10

- Cardiogenic
  - M/C
  - Circulatory overload
  - Congestive cardiac failure
- Non- cardiogenic pulmonary edema
  1. Post obstructive pulmonary edema
  - Negative pressure PO
    - → Rare
    - → M/C in young Robust adult
  2. TRALI: Transfusion Related Acute Lung Injury
  3. TACO: Transfusion Associated Circulatory Overload

2. CARDIOVASCULAR 00:29:36

- Systemic hypertension
  - M/C in patients with hypertension as comorbidity
- Systemic hypotension
- Myocardial ischemia
  - M/C cause of death in postoperative patient
- Cardiac arrhythmia
  - Tachycardia: M/C
  - Bradycardia
  - Atrial fibrillation
  - Ventricular premature complex

3. POSTOPERATIVE HYPOTHERMIA 00:31:24

- Postoperative hypothermia is defined as the core temp. < 36°C in the postoperative period
- M/C cause
  - Heat loss
    - → Radiation
    - → Convection
    - → Evaporation
    - → Conduction (M/C)
- Core temp. monitoring is must

Risk factors

- Young age: M/C

- Endoprosthetic surgery
- Core hypothermia

4. POSTOPERATIVE SHIVERING

- Post-op hypothermia
- Young age
- Core hypothermia

Etiology

- Hypothermia
- Uninhibited spinal reflexes
- NMDA
- Opioid receptor

Prevention

- Core temperature monitoring
- Forced warm air blanket
  - Most effective way of preventing heat

Treatment 00:36:58

- Medication
  - Opioids
  - Ondansetron
  - Ketamine

Important Information

- Drug of choice for monitoring post-op shivering is
  - Pethidine (12.5-25 mg)
  - Tramadol (50 mg)

Important Information

- Most common way of heat loss in intra operation
  - Conduction

Important Information

- Best mechanism of preventing intra-op heat loss
  - Post warm air blankets

5. POSTOPERATIVE NAUSEA AND VOMITING

00:38:42

- Without proper anti-emetic prophylaxis incidence very high 10-50%

Risk factors

- Female gender
- Non-smoker
- History of PONV/ motion sickness
- Post-op opioid

Therapy

- Equally effective in preventing PONV
- Droperidol 1.25 mg
  - Dexamethasone 4 mg
  - Ondansetron 4 mg

Intra-op Modification

- Use Propofol (anti-emetic)
- Use N_2 instead N_2O
- Use Remifentanil- least incidence PONV

Drug of choice

- Ondansetron (4 mg-8 mg)
  - Anti-cholinergics - Scopolamine
  - Steroids - Dexamethasone
  - Prokinetics - Metoclopramide

Important Information

- M/C post-op complication
- Nausea
- Vomiting

6. DELIRIUM

00:43:12

Post Operative Delirium (POD)

- Acute fluctuation of attention and awareness in a post-op patient
- Appearance from immediate post-op period to 5 days

Risk factors

- Age >65 yrs
- Cognitive impairment
- Severe illness
- Hearing or visual impairment
- Presence of infection

Drug of choice

- Haloperidol -0.5-1mg IV/IM

7. EMERGENCE EXCITEMENT

- M/C in Pediatric after reversal from Desflurane **and** Sevoflurane

Treatment

- Midazolam
- Dexmedetomidine

8. DELAYED AWAKENING

00:47:38

- Patient not awakening from anesthesia after 60-90 min

DISCHARGE CRITERIA

00:48:34

- PACU-level II core
- Modified Aldrete score
  - **1970**: Aldrete
- 5 parameters with scores 0, 1, 2
  - Highest score -10
  - Score ≥ 9- pt. can shifted to level II care

Variable Evaluated	Score
Activity	
Able to move four extremities on command	2
Able to move two extremities on command	1
Able to move no extremities on command	0
Breathing	
Able to breathe deeply	2
Dyspnea	1
Apnea	0
Circulation	
SBP < 20%	2
SBP 20-50%	1
SBP > 50%	0
Consciousness	
Fully awake	2
Arousable	1
Not responding	0
Oxygen Saturation	
>92% on room air	2
>90% on supplemental O_2	1
<90% on supplemental O_2	0

More than ≥9 is required for discharge form PACU-level II

POST ANESTHESIA DISCHARGE SCORING SYSTEM (PADSS)

00:52:02

- Used for ambulatory surgery
- 5 parameters
  - 0, 1, 2
  - Max 10
- ≥9 discharge to home

Variable

Vital Sign	
SBP and HR within 20% of pre-anesthetic surgical level	2
SBP and HR within 20-40% of pre-anesthetic surgical level	1
SBP and HR within 40% of pre-anesthetic surgical level	0
Activity	
Normal	2
Require assistance	1
Unable	0
Nausea and vomiting	
None	2
Moderate	1
Severe	0
Pain	
Acceptability	
Yes	2
No	1
Surgical bleeding	
Minimal	2
Moderate	1
Severe	0

- If ≥9 pt. discharged to home

CLINICAL QUESTIONS

Q. A 40 year old female who was a case of seizure disorder posted for total thyroidectomy under general anesthesia. She had shivering in the perioperative period which was treated with Inj. Pethidine 25 mg IM. This postoperative shivering should be treated promptly because it is associated with?

A. Increase oxygen consumption
B. Decreased catecholamine release
C. Decreased heart rate and blood pressure
D. All

Answer: A

Solution

Postoperative shivering

- Postoperative shivering is usually but not always associated with hypothermia. Its incidence may be as high as 66% in general anaesthesia. Although thermoregulatory mechanisms explain shivering in hypothermic patients, different mechanisms have been proposed to explain shivering in normothermic patients. Brain and spinal cord do not recover simultaneously from general anaesthesia. More rapid recovery of spinal cord function results in uninhibited spinal reflexes manifests as clonic activity.
- Risk factors -Young age, endoprosthetic surgery, core hypothermia
- Postoperative shivering can greatly increase oxygen consumption, catecholamine release, cardiac output, heart rate and blood pressure, and intracerebral and intraocular pressure.
- Many drugs, notably meperidine, clonidine, and tramadol, clonidine, ketamine, ondansetron can be used to reduce postoperative shivering once it starts. Of those meperidine 12.5-25 mg iv most commonly used in adults. prevention of hypothermia and intraoperative dexmeditomedine infusion are prophylactic measures.

Reference: P. 2602, Miller textbook of Anaesthesia 9th edition

Q. A 40 year old obese female who is a case of symptomatic cholelithiasis planned for laparascopic cholecystectomy under general aneasthesia. She had a previous surgery of lumpectomy in the right breast under general anesthesia and she had severe nausea and vomiting in the postoperative ward. The patient was induced with Inj. Propofol 200 mg and endotracheal intubation facilitated with Inj. Succinylcholine. Anesthesia was maintained with Oxygen/Nitrous Oxide, Sevoflurane, Vecuronium. Intraoperative analgesia with 150 microgram of Fentanyl given. Intraoperative and postoperative course was uneventful. Inj. Tramadol was used for analgesia in the postoperative ward. The patient was complaining of nausea and vomiting in the postoperative ward which was treated with Inj. Ondansetron 4mg IV. The risk factor does not predict Postoperative Nausea and Vomiting (PONV) in this patient is?

A. Female gender
B. History of previous Postoperative Nausea and Vomiting
C. Non smoking
D. Obesity

Answer: D

Solution

Risk factors and predicted rates of post operative nausea and vomiting according to the apfel score

Risk factor	Scoring
Female	1
Non smoker	1
History of previous PONV	1
Postoperative use of opioids	1
Maximum possible score	4

Number of points	Risk of PONV (%)
0	10
1	21
2	39
3	61
4	79

Post discharge nausea and vomiting

Risk factors	Scoring
Female	1
Age<50 years	1
History of previous PONV	1
Postoperative use of opioids	1
Nausea in PACU	1
Maximum possible score	5

Number of points	Risk of PONV (%)
0	10.9
1	18.3
2	30.5
3	48.7
4	58.5
5	79.7

Treatment

- **Anticholinergics**
  - Scopolamine 1.5 mg transdermal patch before surgery and remove 24 hrs postoperatively
- **NK 1 receptor antagonist**
  - Aprepitint 40 mg per os within 3 hrs prior to anaesthesia
- **Corticosteroids**
  - Dexamethasone 4 mg iv after induction of anesthesia
- **Antihistamines**

- Hydroxyzine 12.5-25 mg im
- Diphenhydramine 25-50 mg iv

- **Phenothiazines**
  - Promethazine 12.5-25 mg im
  - Prochlorperazine 5-10 mg iv
- **Butyrophenones**
  - Droperidol 0.625-1.25 mg iv
  - Haloperidol 0.5-<2 mg im/iv
- **Prokinetic**
  - Metaclopromide 10-20 mg
- **Serotonin receptor antagonist**
  - Ondansetron 4 mg iv 30 minutes prior to conclusion of surgery
- **Vasopressors**
  - Ephedrine 25 mg im combined with hydroxyzine 25 mg

Reference: Miller's Textbook of Anesthesia 9th edition, Page no - 2604,2273

Q. A 40 year old morbidly obese female patient who was posted for bariatric surgery under general anesthesia. She underwent laparascopic cholecystectomy under general anesthesia few months back. Inj. Propofol 200 mg was used for induction of anesthesia, endotracheal intubation facilitated with Inj. Succinylcholine and anesthesia maintained with Oxygen/Nitrous oxide, Sevoflurane and Cisatracurium. During recovery from anaesthesia, nitrous oxide was stopped and the patient reversed and extubated. After extubation, the patient desaturated and 100% oxygen with facemask given for 10 minutes. The SpO_2 was improved and patient was shifted to ward. The type of hypoxia occurred in this patient would be?

A. Anemic
B. Histotoxic
C. Stagnant
D. Hypoxic

Answer: D

Solution

Types of Hypoxia

1. Hypoxic hypoxia also called arterial hypoxia is a result of insufficient oxygen available to the lungs.
2. Anemic hypoxia due to reduced hemoglobin and oxygen carrying capacity
3. Stagnant hypoxia due to stasis of blood results in reduced perfusion as in cases of cardiac failure
4. Histotoxic/ cellular hypoxia-Inability to use oxygen effectively in cases of cyanide poisoning

- Diffusion hypoxia occurs during recovery from general anesthesia when nitrous oxide is suddenly cut off.
- Nitrous oxide diffuses from the blood to the alveoli and replaces the oxygen which reduces alveolar O2 concentration, resulting in relative hypoxemia.
- This can beavoided by providing supplemental O2 for the first 10 minutes of recovery.
- Diffusion hypoxia is less common with xenon because its rate of diffusion from the blood to the alveoli is slower.

Reference: Miller's Anesthesia 9th edition, Page no: 526

Q. A 40 year old female who was a known case of moderate mitral stenosis on treatment, posted for modified radical mastectomy under general anesthesia. The anticholinergic premedication with sedative and antiemetic property was selected for this patient. The drug for premedication used in this patient would be?

A. Atropine
B. Glycopyrrolate
C. Hyoscine
D. Edrophonium

Answer: C

Solution

- Hyoscine (Scopolamine), is most effective medication to treat motion sickness when administered prophylactically
- On lower doses, produce CNS depression which can cause amnesia, fatigue, drowsiness, NREM sleep
- On higher doses, produce CNS excitation. Atropine cause CNS excitation
- Used before surgery to decrease saliva
- Effects begin about 20 minutes after injection and last for up to 8 hours.20-40 mg oral, IM, SC, IV can be given
- It is less potent and longer acting than atropine and it is used for esophageal and gastrointestinal spastic conditions

Reference: KD Tripati essentials of medical pharmacology, 7th edition Page no: 116

Q. A lady after undergoing surgery under general anaesthesia with no intraoperative complication, complained of respiratory difficulty following extubation. PaO_2 low and not able to lift her head and leg. What can be the cause?

A. Prolonged action of muscle relaxant
B. Respiratory acidosis
C. Pulmonary embolism
D. Fentanyl chest rigidity

Answer: A

Solution

- This is a case of inadequate reversal from neuromuscular blocker.
- Residual paralysis can occur after General Anaesthesia. The indicator of adequate neuromuscular function after the use of nondepolarizing agents: recovery of the train-of-four (TOF) ratio to > 0.70
- Tests of respiratory function (vital capacity, inspiratory force, peak expiratory flow rate) and voluntary muscle function (tongue protrusion, head-lift, hand grasp, and sustained eye opening) were reported to have returned to clinically acceptable values once the TOF ratio was > 0.70

Reversal of Neuromuscular Block: Several crude tests has been suggested to evaluate neuromuscular block

1. Head lift for 5 secs
2. Tongue protrusion
3. Hand grip
4. Ability to lift legs off bed
5. Hold jaw shut and prevent removal of tongue depressor. (most sensitive) (correlate TOF Ratio-> 0.9)

- For Recovery, target TOF ratio > 0.9
- Residual paralysis Can occur after general Anaesthesia – Patient may be conscious, unable to breathe adequate tidal volume, motor weakness, desaturation. This is managed with ventilatory support
- Reversal agent(Anticholinesterase Agent) Neostigmine – it is reversible acetylcholinesterase inhibitor. This inhibition is present at all cholinergic synapses so has potent parasympathetic activity. Thus given accompanied with

Atropine/glycoprolate.

- Pulmonary embolism, fentanyl chest rigidity and respiratory acidosis are not associated with muscle weakness

Reference: Barash Clinical Anaesthesia 7th edition, p.g. 307
Lee's synopsis of Anaesthesia, 13th edition, page no. 196-199

Q. A 52 year old male patient who was a known case of Chronic Obstructive Pulmonary Disease posted for modified radical mastoidectomy under general anesthesia. In the postoperative period supplemental oxygen was given through Oxygen concentrator. These oxygen concentrators can also be applied for?

A. Domicillary use
B. Supplying ambulance
C. Supplying anesthesia medicine
D. All of the above

Answer: D

Solution

Oxygen concentrators are widely used to provide oxygen-enriched gas for multiple use

I. Domicillary use
II. Remote locations
III. For oxygen pipeline supply
IV. Anesthesia machine

Reference: Dorsch and Dorsch Understanding Anesthesia Equipment, 5th edition, page: 112

18 OXYGEN THERAPY

00:00:13

- To give O_2 above room air concentration is called oxygen therapy

Indications of Oxygen therapy 00:01:15

1. Acute hypoxemia Pa O_2<60
   SaO_2<90%
2. Hypotension
3. Patient in respiratory distress
4. Patient's condition requiring higher O_2 concentration

- E.g: Stroke 93-94%

Oxygen delivery devices 00:04:10

Function

1. Administer oxygen
2. Regulate the amount of oxygen to be given
3. Supplement oxygen to the patient to increase arterial oxygenation

Choice

- Degree of Hypoxemia
- Ventilatory pattern
- Patient's comfort

Devices are divided in 2 groups 00:05:43

1. Low flow oxygen delivery devices

- Low flow oxygen delivery device provides a variable FiO_2 depending on the patient's inspiratory demands
- More the inspiratory demand, more air is entrained & FiO_2 is diluted

Devices

- Nasal cannula
- Oxygen mask/ Simple face mask / Hudson mask
- Oxygen mask with reservoir
  - Non-rebreathing oxygen mask reservoir
  - Rebreathing oxygen mask reservoir

Important Information

- In low flow device, FiO_2 vary according to patient

Previous Year's Questions

	Patient A	Patient B
Minute ventilation	• 30/L min • 750ml x 40bpm	• 5L/min • 10 x 500ml
Oxygen flow rate	• 2L/min	• 2L/min
Calculated inspiratory O_2 concentration	$\frac{2\times1.0+28\times0.21}{30}$ • 0.26 • 26%	$\frac{2\times1+3\times0.21}{5}$ • 0.53 • 53%

HIGH FLOW OXYGEN DEVICES 00:14:40

- High flow oxygen delivering devices gives fixed FiO_2 irrespective of patient's respiratory demand

Devices

- Venturi mask
- Air entrainment nebulizers
- High flow nasal cannula
- Mechanical ventilation
- Anesthesia bag & mask ventilation
- Ambu resuscitation bag

LOW FLOW OXYGEN DELIVERY DEVICE 00:17:25

Nasal Cannula

- Most common
- Useful in mild hypoxemia
- It delivers oxygen in nasopharyngeal space
- Flow rate: 1 to 6L/min
- Fio_2: 0.24-0.45

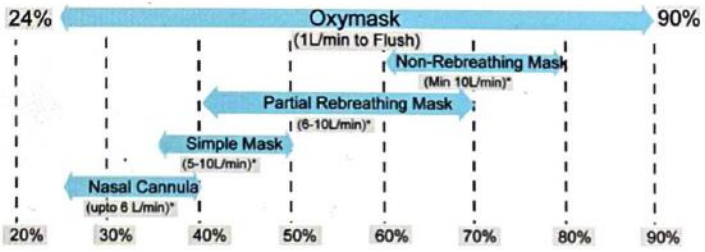
Important Information

- Oxygen concentration increases by 4% for every 1L/min till 6 liters of O2
- 21%+(1x4%): 25% (0.25)
- 21%+(2x4%): 0.29% (0.29)
- 21%+(6x4%): 45% (0.45)
- Max Fio2 achieved by nasal cannula: 0.45

Advantages
- Very convenient
- Patient can talk & eat while receiving oxygen

Disadvantages: Nasal crusting

FiO_2%	Flow / min
24-28	1-2
30-35	3-4
38-44	5-6



SIMPLE FACE MASK

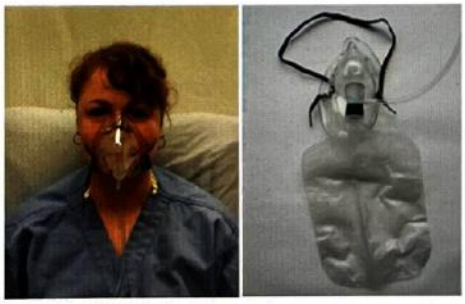
00:23:39

- Hudson mask
- It is set to deliver flow of O_2 between 6 to 10L/min (0.35-0.60)
- Useful in moderate hypoxemia
- It fits over the patient's nose & mouth and has side exhalation ports through which patient exhales CO_2
- Requires a minimum flow of 6L/min of O_2 to prevent rebreathing
- Reservoir capacity 150-200 ml

FACE MASK WITH RESERVOIR BAG

00:28:56

- It uses a reservoir bag to deliver high concentration of O_2



2 types
1. Face mask with Non Rebreathing Bag
2. Face mask with Rebreathing Bag

FACE MASK WITH NON-REBREATHING BAG

00:31:42

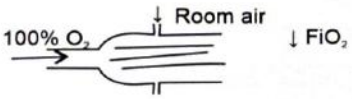
A one-way value is present between mask & reservoir bag which prevents patients expired gas to enter the bag
- Flow: 10-15L/min
- FiO_2
  - 0.8-0.95
  - 80% - 95%
- Useful in severe hypoxemia

Face mask with Rebreathing Bag
- No one way valve

High flow oxygen delivery system

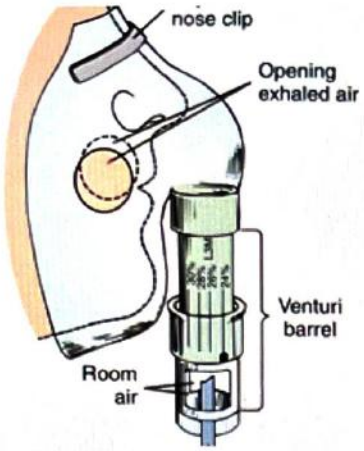
00:34:59

1. Venturi Mask
- Deliver fixed FiO_2
- Works on Bernoulli Principle to entrain room air, when 100% O_2 is delivered through small orifice



Previous Year's Questions

To calculate device flow rate for particulars FiO_2
- To achieve -FiO_2=0.6
  $\frac{1-0-6}{0.6-0.2} = 0.4 - 1:1$
- For every 1 litre of O_2 1 litre of room air will be entrained
  $\frac{1-0.4}{0.4-0.2} = 0.6 - \frac{3:1}{0.2}$
- To achieve FiO_2= 0.4
- For every 1 litre of O_2 3 litre of air will be entrained
- More gas is being entrained Fio_2 will be more diluting
- Flow rate of 10 liters of O_2. 30 liters of room air is entrained
- Total flow rate 10+30 '40 liters. FiO_2 will be 0.4



Venturi Mask

Color	FiO_2	O_2 flow
Blue	24%	2L/min
White	28%	4L/min
Orange	31%	6L/min
Yellow	35%	8L/min
Red	40%	10L/min
Green	60%	15L/min

Uses

- When inappropriately high FiO_2 needs to be avoided
- Useful in Bronchial Asthma patient
- Proximal end of mask consists of a device with recommended flow rate to provide desired FiO_2

Oxygen & Air blending system 00:43:45

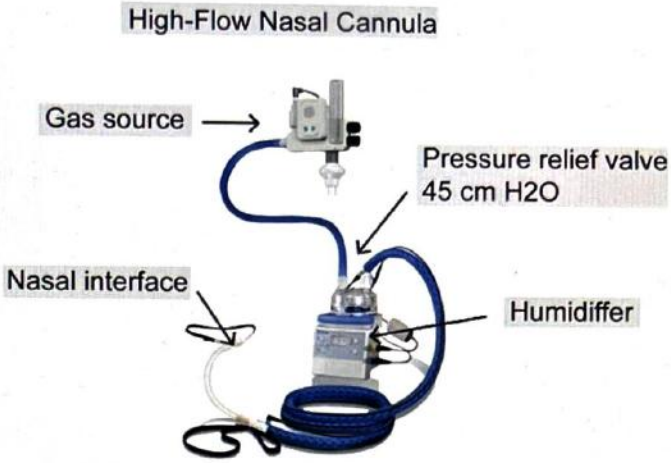
- Nebulizers
- Air O_2 is blended for precise FiO_2 & Flow

HIGH FLOW NASAL CANNULA 00:44:50

- Continues high flow oxygen washes out the upper airways thereby decreasing the dead space
- Because of the high flow a pressure is created in the airway and a minimum PEEP 3-5 ml is generated
- This high flow O_2 has shown to substantially decrease the requirement of endotracheal intubation in many cases

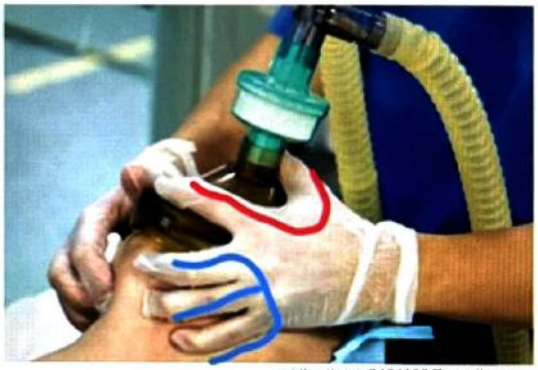
Requirement

- O_2 source is required
- Humidifier
- High pressure tubing
- Nasal interface



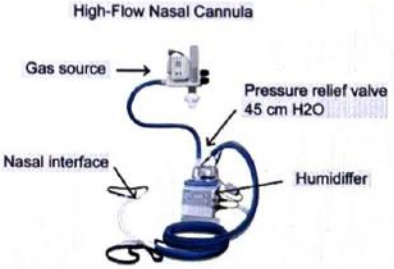
Advantage

- Flow: > 60L/min
  1. Deliver fixed FiO_2
  2. Decrease dead space
  3. Generate PEEP 3-5 cm of H_2O
  4. Prevents & reduces the requirement of intubation



Previous Year's Questions

Q. Identify the equipment in the image?
(INICET Nov 2020)



A. Nasal cannula
B. Noninvasive ventilator
C. BiPAP machine
D. High Flow Nasal Cannula

Previous Year's Questions

Q. Patient in the ICU was on a ventilator. Hemodynamically he had signs of poor perfusion. What would be the best way to increase oxygenation? (FMGE June 2021)

A. Increase FiO_2
B. Increase respiratory rate
C. Increase flow rate
D. Increase PEEP

Important Information

- Anesthesia face mask comes under high flow O_2 delivering device
- Always gives fixed FiO_2

CLINICAL QUESTIONS

Q. A 34 year old male admitted in ICU with the history of high grade fever, cough, myalgia, loss of sensation of smell for the past one week. His blood pressure: 100/60 mmHg; pulse rate: 110/min; SpO_2 90%; respiratory rate-25/minute; temperature: 102°F and his chest x ray showed peripheral ground glass opacities in both lungs. He was treated with 15 litres/minute of oxygen through non rebreathing mask, antibiotics and steroids. Maximum FiO_2 range delivered to this patient is?

A. 0.5-0.6
B. 0.8-0.95
C. 0.6-0.7
D. 1.0

Answer: B

Solution

FACE MASK WITH NON-REBREATHING BAG

A 2 one-way value is present between mask & reservoir bag which prevents patients expired gas to enter into the bag

- Flow: 10-15L/min
- FiO_2
  - 0.8-0.95
  - 80% - 95%
- Useful in severe hypoxemia

Reference: Marino's The ICU book, 4th edition

19 CARDIO PULMONARY RESUSCITATION (CPR)

FIRST AID GIVEN TO CARDIAC ARREST PATIENT

⏱ 00:00:12

I. **B**asic **C**ardiac **L**ife **S**upport (BLS)
- Given by anyone at the scene itself

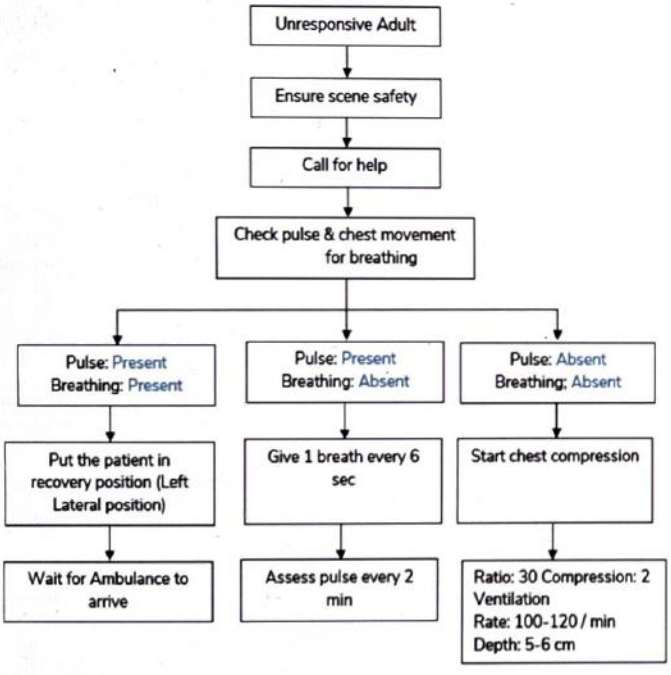
II. **A**dvanced **C**ardiac **L**ife **S**upport (ACLS)
- Given by medical person only

Important Information

- Heart attack: Perfusion problem
- Cardiac arrest: Rhythm problem (Emergency management by giving CPR to these patients to preserve them till final management is done)

BASIC CARDIAC LIFE SUPPORT

⏱ 00:01:00



HIGH QUALITY CHEST COMPRESSION

1. Rate: 100-120 compression / min
2. Push hard / Push fast
3. Allow complete recoil of chest
4. Just adequate ventilation
5. Depth 5-6 cm

} 5 cycles 30 Compression: 2 Ventilation

DO 5 CYCLES 30 COMPRESSION: 2 VENTILATION

- Put palm on the middle of the chest, other hand on the hand which has been placed already on the chest, interlock both the fingers, keep the elbow straight & start compression followed by full recoil
- After 30 compression, give 2 breaths (open airway by hand-chin and tilt lift, close nose, take a normal breath and give breath to the patient
- Watch for the chest rise
- Within 1 sec give 1 breath and other second give 2nd breath
- Resume 30 Compressions followed by 2 Ventilation
- If 2 people, one will do chest compression other will do ventilation and every 2 minutes, they will interchange their position

Refer Flow Chart 19.1

Important Information

There is no upper limit of giving the shock. If its shockable rhythm, can give no. of times
- Shockable rhythm can convert into non-shockable rhythm & vice versa
- Once AED is attached, we never disconnect it

We keep on continuing the above steps, but will stop only when there is

I. Return Of Spontaneous Circulation (ROSC)
II. Scene unsafe
III. ACLS team has arrived and taken over
IV. Exhausted & unable to continue resuscitation

Previous Year's Questions

Q. In CPR, Number of chest compressions per minute in an adult? (FMGE Jun 2019)

A. 30-50 per minute
B. 50-72 per minute
C. 100-120 per minute
D. 120-200 per minute

Previous Year's Questions

Q. All are true about high-quality chest compression in CPCR? (INI CET Nov 2020)
A. Chest compression at 100-120 per minute
B. Death of chest compression should be between 5-6cm
C. Allow complete chest recoil
D. Ventilation at the rate of 20-24 bpm
1. A, B, C Correct
2. A, B, C, D Correct
3. A correct
4. A, B correct

ADVANCED CARDIAC LIFE SUPPORT

00:22:08

I. ECG electrodes are attached. Manual defibrillators are brought
II. Advanced airway is secured
III. Intravenous line is secured

4 Rhythms are possible in cardiac arrest

I. Ventricular fibrillation
II. Pulseless ventricular tachycardia
III. Asystole
IV. Pulseless electrical activity

VENTRICULAR FIBRILLATION & PULSELESS VT

00:24:30

Shockable Rhythm

Chest compression continued
(100-120/ min)
Ventilation 8-10 breath / min
↓ 2 min
VF/PVT
↓
Charge Defibrillator
200J AC Shock
↓
Give shock
↓
Resume C: V
↓ 2 mins
Check Rhythm
↓(VF/PVT)
Give shock
(200 J asynchronized cardioversion)
↓
C: V continued for 2 min
↓
Analyze the rhythm (still patient in VF or PVT)
Again shock
↓
Resume C: V
↓
IV adrenaline 10 ml (1:10,000) give full 10 mL. Then give 20 mL bolus saline and raise the hand. Always give the drug while doing chest compression
Analyze rhythm still VF or PVT
↓
Shock
Repeat the same dose of adrenaline with C: V continued
↓
Check Rhythm
↓(VF/PVT)
Resume C: V
↓
Amiodarone 300 mg IV bolus
↓
Repeated once more
150 mg IV bolus
↓
Shock
↓
Resume C: V
↓
Adrenaline

00:30:40

Important Information

Pulseless VT/ VF:
1. Shockable Rhythm- 200 J AC shocks are given
2. Drugs Adrenaline 10 ml 1:10,000
   Repeated every 3-5 min
3. Drug Amiodarone
   300 mg IV bolus
   150 mg IV bolus
   - In VF PVT Amiodarone is given only twice
   - While Adrenaline & Defibrillation has no upper limit
4. Try to treat the cause

Previous Year's Questions

Q. A person was rushed to emergency with no carotid pulse palpable and was given shock with a defibrillator but now also rhythm is irregular. What would you do? (FMGE Jun 2021)

A. Check carotid pulse
B. Give another shock
C. CPCR
D. Adrenaline

Previous Year's Questions

Q. You find a patient lying on consciousness and park while jogging in the morning. What sequence should be followed for resuscitation? (INI CET Nov 2020)

A. Check carotid pulse, chest compression, call for help, defibrillation

B. Call for help, check pulse and breathing, chest compression, defibrillation

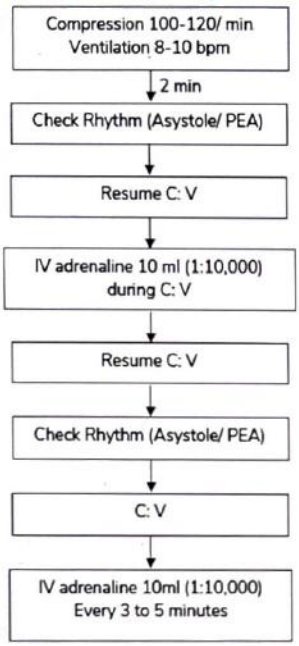
C. Call for help and observe

D. Chest compression only

ASYSTOLE & PULSELESS ELECTRICAL ACTIVITY (PEA)

00:32:13

- **Asystole:** No pulse and no rhythm
- **Pulseless:** No pulse but rhythm present



00:34:54

1. Compression + Ventilation
2. [illegible] IV adrenaline 10 ml 1:10,000
3. No Amiodarone & No shock
4. Find the cause

Previous Year's Questions

Q. Patient has no pulse on ECG, some electrical activity seen compression and ventilation being done. What is the next step? (FMGE August 2020)

A. Adrenaline

B. Atropine

C. Amiodarone

D. Defibrillation

CARDIAC ARREST CAUSES

00:35:41

5H'S	5T'S
• Hypovolemia	• Cardiac Tamponade
• Hypothermia	• Coronary Thrombosis
• H+ ion (Acidosis)	• Pulmonary Thrombosis
• Hyper / Hypokalemia	• Tension Pneumothorax
• Hypoxia	• Toxin

Important Information

- It is impossible to revive a patient in Asystole / PVT without finding the cause

Previous Year's Questions

Q. Worst prognostic factor in patient is with? (FMGE Jun 2021)

A. Pulselessness - Cardiac arrest

B. Paralysis

C. Pallor

D. Paresthesia

MONITORS

00:38:10

1. ECG
2. Capnography
   - I. Advanced Airway- To check the right placement
   - II. To see the adequacy of chest compression
     - $ETCO_2$ > 20mm Hg
   - III. Prognosis

IV Line

1. Peripheral (Always)
2. Inter Osseous

DIFFERENCE BETWEEN ADULT & PEDIATRIC BLS

00:41:28

Refer Table 19.1

TECHNIQUES OF CHEST COMPRESSION

00:44:38

Adult	2 palm technique
Pediatric	Single hand technique (or) Double hand technique
Infant	2 finger technique (single rescuer) Encircling technique (more than 1 rescuer)

Important Information

- Chest compression should always be done on hard surface
- There should be minimum interruption in chest compression

Flow Chart 19.1

5 cycles of 30C: 2V

↓

Check pulse (Carotid) within 10sec

↓

Wait for Ambulance to arrive

↓

AED (Automated External Defibrillator) arrives

↓

AED is attached, stop compression and allow AED to analyze the rhythm

Shockable Rhythm	Non-Shockable Rhythm
Resume compression & Charge AED	Continue C: V 5 cycles
↓	↓
Clear the victim & give shock	Analyze pulse
↓	↓
Start compression and complete 5 cycles (30C:2V)	Resume C: V AED analyses
↓	
Check for pulse and let AED analyze the rhythm	
↓	
No pulse	
↓	
C: V started again, AED Analyses	
↓	↓
Depending of AED analysis further management	Depending on the prompt of AED further management is done

Table 19.1

	Pulse	Ratio	Rate	Depth
Adult	Carotid	30:2	100-120 compression / min	5-6cm
Children 1 year –puberty	Femoral / Carotid	1 Rescuer 30:2 2 Rescuer 15:2	100-120 compression / min	About 5cm
Infant till 1 year excluding newborns	Brachial	Single Rescuer 30:2 Two Rescuer 15:2	100-120 compression / min	About 4cm

CLINICAL QUESTIONS

Q. A 45 year old male who was a case of polytrauma due to road traffic accident came to casuality. On examination, blood pressure was not recordable, carotid pulse was not felt and immediately cardiopulmonary resuscitation started according to ACLS guidelines. The pulse to be checked for return of pulse during cardiopulmonary resuscitation in this patient would be?

A. Carotid pulse
B. Femoral pulse
C. Brachial pulse
D. Any pulse

Answer: A

Solution

- The carotid artery is the preferred artery to palpate for >1 age.
- Apply gentle pressure, so that you do not compress the artery. The artery towards you on the side of the neck is most readily palpated.
- Carotid pulse is felt for not more than 10 sec

Reference: American Heart Association Basic Cardiovascular Life Support Provider Guidelines

Q. The sequence from A-B-C to C-A-B was changed in which year in managing cardiac arrest patient?

A. 2005
B. 2010
C. 2000
D. 2016

Answer: B

Solution

- In 2010, American Heart Association changed CPR's long standing A-B-C (Airway, Breathing, Circulation) sequence to C-A-B (Circulation, Airway, Breathing)
- This was changed because there is enough oxygen in the blood to supply the heart and the brain for several minutes following cardiac arrest, chest compression are needed to circulate this oxygen

Reference: American Heart Association Basic Cardiovascular Life Support Provider Manual- 2010 Guidelines

Q. A 45 year old male who was a case of polytrauma due to road traffic accident came to casuality. On examination, blood pressure was not recordable, carotid pulse was not felt and immediately cardiopulmonary resuscitation started according to ACLS guidelines. Not the guideline(s) included for resuscitating this patient would be?

A. Depth of chest compression in adult should be 3 cm at least
B. Compression rate should be around 100-120/min
C. Complete recoil should be allowed after every compression
D. Without advanced airways compression ventilation ratio should be 30:1
E. Interruptions should be kept minimum.

Answer: A, D

Solution

- High-quality cardiopulmonary resuscitation involves adequate chest compressions 2 inches and at least to a depth of 5 cm in adults.
- The compression depth can be increased to 6 cm, If a feedback device is used
- After each compression, allow complete chest recoil
- The compression rate should be 100-120 per minute.
- Minimize interruptions in compressions, 10 seconds or less
- If fatigued, rotate compressor every 2 minutes or earlier
- 30:2 compression- ventilation ratio, If no advanced airway

Reference: American Heart Association Basic Cardiovascular Life Support Provider Manual- 2020 Guidelines

Q. A 45 year old male who was a case of polytrauma due to road traffic accident came to casuality. On examination, blood pressure was not recordable, carotid pulse was not felt and immediately cardiopulmonary resuscitation started according to ACLS guidelines. The monitor showed asystole. The dose of Adrenaline to be given intravenously in this patient would be?

A. 10 ml, 1 in 10,000
B. 1 ml, 1 in 10,000
C. 2 ml, 1 in 1000
D. 1 ml, 1 in 1000

Answer: D

Solution

For pediatric cardiac arrest

Adrenaline(intravenous/interosseous) 0.01 mg/kg (0.1 ml/kg of the 0.1 mg/ml concentration) given IV is given in 1 in 10,000 concentration. 10 ml 1 in 10000 is given.

REMEMBER:

- 1mg/ml(1:1000) = 1mg diluted to 10 ml = 1mg/10ml = 0.1 mg/ml(1:10000)
- Maximum dose=1mg, repeat every 3-5 minutes
- If no IV/IO access,
- Endotracheal dose: 0.1mg/kg (0.1ml/kg of 1mg/ml concentration)
- For adult cardiac arrest, 1mg (1:1000) every 3-5 minutes

Reference: American Heart Association Advanced Cardiovascular Life Support Provider Manual- 2020 Guidelines

Q. A 45 year old male who was a case of polytrauma due to road traffic accident came to casuality. On examination, blood pressure was not recordable, carotid pulse was not felt and immediately cardiopulmonary resuscitation started according to ACLS guidelines. The monitor showed asystole. The guideline which is not to be followed in this patient would be?

A. Chest compressions should be started as first line measure
B. Advanced airway and capnography should be considered
C. Defibrillation is done as early as possible
D. Adrenaline is the drug of choice

Answer: C

Solution

In Asystole, defibillation is not done

- In children, the more common cause of cardiac arrest is **asphyxia** rather than ventricular fibrillation.
- Even though asphyxia is the more common cause, **pediatric resuscitation starts with chest compressions rather than rescue breaths as in adults** for simplicity in training.
- This is because the cycle of **30 chest compressions** before rescue breathing delays ventilation for only **15 to 20 seconds**.
- During cardiopulmonary resuscitation of infants and children, the ratio of chest compression to rescue breaths is 30:2 for

a single rescuer and 15:2 if 2 or more rescuers are present.

- The initial energy to be set for defibrillation is at 2 J/kg for both monophasic and biphasic waveforms. It can be increased to 4 J/kg if a second shock is to be delivered.
- In adults, the ratio is **30:2** irrespective of the number of rescuers.
- The depth of compression should be more than or equal to one-third of the anteroposterior diameter of the chest which is about 5 cm in children and 4 cm in infants.
- The compression rate should be 100-120/ minute.
- Allow complete chest recoil after each compression.
- Minimize interruptions in compressions (10 seconds or less).
- Rotate compressor every 2 minutes or earlier if fatigued.
- Avoid excessive ventilation.
- In 2010, American Heart Association changed CPR's long standing A-B-C (Airway, Breathing, Circulation) sequence to C-A-B (Circulation, Airway, Breathing).This was changed because there is not enough oxygen in the blood, to supply the heart and the brain for several minutes following cardiac arrest, chest compression are needed to circulate this oxygen.
- Asystole is a non-shockable rhythm-defibrillation is of no benefit.
- It involves a heterogeneous group of cardiac rhythms all without a pulse.
- The immediate treatment for this is giving chest compressions and 1 mg epinephrine at the earliest until more definitive therapy to the cause can be instituted.
- It is essential to rule out the reversible causes of cardiac arrest because the treatment for each of them is different and **Asystole** is likely to persist until the cause is treated.
- A non-shockable rhythm could be asystole or pulseless electrical activity

Reference: American Heart Association Basic/Advanced Cardiovascular Life Support Provider Manual- 2020 Guidelines

Q. A 45 year old male who was a case of polytrauma due to road traffic accident came to casuality. On examination, blood pressure was not recordable, carotid pulse was not felt and immediately cardiopulmonary resuscitation started according to ACLS guidelines. The monitor showed pulseless electrical activity. Which of the following is the least probable cause for pulseless electrical activity in this patient?

A. Pulseless ventricular tachycardia
B. Tension pneumothorax
C. Hypovolemia
D. Cardiac tamponade

Answer: A

Solution

Without a palpable pulse, the presence of organized electrical activity is called pulseless electrical activity (PEA)
To remember the reversible causes of PEA

- MAD (triple H) CAT

Mnemonic

- M - massive pulmonary/coronary embolism
- A - Acidosis
- D - Drug overdose (digitalis, beta blockers, calcium channel blockers, tricyclic antidepressants, toxins)
- H - Hypoxia/hypothermia
- H - hypovolaemia
- H - hypokalaemia/hyperkalaemia
- C - Cardiac tamponade
- A - Acute myocardial infarction
- T - Tension pneumothorax

Prompt initiation of chest compressions and administration of 1mg epinephrine are recommended as temporary measures until the definitive therapy can be provided once the cause for PEA is identified. Asystoloe or ventricular fibrillation can develop if PEA untreated

Reference: Miller's Anaesthesia, 9th edition, page 2719

20 BRAIN DEATH

- In natural deaths, only a few organs like cornea can be transplanted
- By living donor as well, only a few organs like kidneys can be transplanted
- But after brain death/ brain stem death, all organs can be transplanted if perfusion is maintained

History 00:01:28

- **1994**: Transplantation of Human Organ Act (THO Act)
- **1995**: Transplantation of Human Organ Rules (THO Rules)
- **2011**: Transplantation of Human Organ & Tissue Act
- **2014**: Transplantation of Human Organ & Tissues Rule

BRAINSTEM 00:03:32

- Includes Midbrain, Pons & Medulla
- Situated between Aqueduct of Sylvius & 4th ventricle
- Responsible for consciousness & respiration
  - Thus, if a person is pronounced brain dead, it means he can never regain consciousness & can never breathe spontaneously (legally & medically dead)

LEGAL ASPECTS 00:05:14

- Panel of following 4 Doctors are required to certify someone as brain dead

I. Treating Medical Officer
II. Medical Administrator of the hospital
III. Doctor (Surgeon/ Anesthetist etc.) from panel authorized by the hospital
IV. Neurologist / Neurosurgeon

- Doctors III & IV has to perform all the test to diagnose brainstem death
- Doctors I & II have to witness everything
- All four Doctors should sign the document

BRAINSTEM DEATH CERTIFICATION 00:07:23

- The format for brainstem death certification is laid out in Form -10 (brain stem death certification)
- Two different certifications are required to be carried out at least 6 hrs apart
- All tests have to be documented
- All four doctors will check & sign
- Legal time of death in these circumstances is taken as the time when 2nd set of brainstem death test results are certified

ESTABLISHING BRAINSTEM DEATH 00:10:08

- Patient must be in an irreversible coma from a known cause (Intra-ventricular haemorrhage / diffuse brain injury etc.)
- No responses should be there on stimulation
- All brainstem reflexes should be absent
- Apnea test should be positive

PREREQUISITES TO FULFILL BEFORE PERFORMING BRAINSTEM DEATH TESTS

- Functional reversible causes of coma must be ruled out like
  - Acute alcohol/drug intoxication
  - Neuromuscular blockade effect
  - Intake of CNS depressant drugs (patient should not have any circulating therapeutic levels of the drug that would cause coma)
  - Hypovolemic shock
  - An endocrine / electrolyte abnormality
  - Primary hypothermia
- Patient should be in coma due to some known cause
- Gap between coma & performance of brainstem death establishing test should be minimum 4hrs
- If hypoxia is the cause of coma then the gap should be 12hrs

TESTS FOR DIAGNOSIS OF BRAINSTEM DEATH 00:15:58

1. Brain stem reflexes are tested
2. Apnea test

1. Brainstem reflexes 00:16:52

- Absent pupillary reflexes
  - In a darkroom, move the torch from the corner of the eye towards the nasal bridge
  - If there is no movement in the pupil – the test is negative
- Absent corneal reflexes
  - Touch cornea with wet cotton wisp & check for the blinking of the eye
  - If no blinking - corneal reflex is absent
- Absent vestibulo-ocular reflexes
  - Put 40-50 ml of cold saline in one ear, followed by in another ear after 5 mins and look for any movement of the eyeball
  - If no movement, the reflex is absent

- Absent cranial nerve response to pain
  - Give pain stimulus and look for a response in a patient like grimace /posturing
  - If nothing is seen, the reflex is absent
- Absent gag & cough reflex
  - when the posterior pharyngeal wall is touched with a suction catheter, no cough/ gag response is seen

DOLL'S EYE PHENOMENON

00:21:16

- Pre-requisite is stable spine
- Head is moved from side to side from neutral position

Positive DOLL'S Eye	Negative DOLL'S Eye
• Eyes move in the opposite direction of head movement • Represents intact brain stem	• Eyes move in the same direction of head • Represents brainstem death

- Doll's eye phenomenon establishes the brainstem integrity

2. Apnea test

00:24:15

- Pre-requisites to fulfil before starting apnea test are
  - The patient should have normothermia (i.e. temperature >35°C-36°C)
  - Systolic BP > 90mm Hg
  - Euvolemia
- First apnea test should be performed only after 4 hours of coma associated with the absence of brain stem reflexes
- In case of Anoxic brain damage, the period should be extended to 12 hours

Steps and Interpretation of apnea test

I. The patient should be hyper-oxygenated with 100% oxygen
II. An ABG sample should be done & sent prior to apnea test
III. Patient is disconnected from the ventilator
IV. A catheter giving O_2 at a flow of 6L/min is placed from the endotracheal tube to reach the carina
V. The patient should be kept out of the ventilator for about 3-8 mins to allow $PaCO_2$ to rise above 55-60 mm of Hg (or) above 15mm of Hg from baseline

Interpretation

Positive test	No breathing/ No respiratory effort despite raise in $EtCO_2$
Negative test	Respiratory effort is present during the test
Indeterminate test	$PaCO_2$ < 55mm Hg; but no visible respiratory effort

- If apnea test is indeterminate, repeat it after sometime
- If still indeterminate, then do definitive tests

Definitive tests

- EEG
- Cerebral Angiography

Abandon/Abort the test

00:33:25

- If systolic Blood pressure decreases to 90mm Hg
- If O_2 saturation measure is <85% for 30 sec
- If cardiac Arrhythmia starts

Clinically diagnose brainstem death

00:34:32

- Brainstem reflexes should be -ve
- Doll's Eye reflex should be -ve
- Apnea test should be +ve

CLINICAL QUESTIONS

Q. A 60 year old male who was a known case of systemic hypertension admitted with the history of unconsciousness since 2 hours. The patient was intubated and connected to mechanical ventilator in view of poor GCS(3/15).On examination, blood pressure-130/70 mmHg; pulse rate-120/minute; SpO_2-98%. CT brain showed massive intracranial hemorrhage due to hypertensive bleed. After clinical examination, the neurosurgeon declared that the patient was brain dead. The clinical criteria which do not include to declare brain death in this patient would be?

A. Coma
B. Absent brainstem reflex
C. Absent spinal reflex
D. Apnea

Answer: C

Solution

Brain Death is defined as the irreversible cessation of all brain functions and the criteria will be applicable only in the absence of hypothermia, hypotension, metabolic or endocrine abnormalities, neuromuscular blockers and drugs known to depress the brain function.

Clinical Criteria

- Coma
- Absent motor activity including no decorticate or decerebrate posturing, respiratory effort (apnea).Spinal reflexes may be preserved in some patients
- Absent brainstem reflexes
  - Fixed, mid - dilated pupil
  - Absent corneal reflex
  - Absent oculovestibular reflex (Cold caloric)
  - Absent oculocephalic reflex (Doll's eye movement)
  - Absent gag and cough reflex
- Apnea testing **(positive)**-no respiratory effort (apnea) with the arterial CO_2 tension atleast 60 mmHg or 20 mmHg above the pretest level

Reference: Morgan and Mikhail's clinical Anaesthesiology, 5th edition, page 1280

PREP NUGGETS

Prep Nuggets

Cannulas

Colour code	Size	Flow rate ml/min
1. Orange	.....	250 – 300
2. Grey	.....	.....
3. Pink	.....	55 – 80
4. Blue	.....	22 – 50
5.	24 G	
6. Green	.....	.....
7	26 G	.....

Prep Nuggets

Asystole and pulseless electrical Activity

Compression 100 – 120/min
Ventilation.....
↓ 2 min
.....
↓
Resume C:V
↓
.....
↓ 2 min
.....
↓
Resume C:V
↓
.....
↓
C:V
↓
.....

Prep Nuggets

Pipeline supply

Color	Supply
1. Blue	.....
2. white	.....
3.	Air
4.	Vacuum

Prep Nuggets

D/D of flat capnogram

1. Accidental extubation
2. .....
3. .....
4. .....
5. .....

Prep Nuggets

Tubes	Indication
1. Flexometallic tube	.....
2. Double Lumen tube	.....
3. RAE Tube	.....
4. Calcified tube	.....
5.	Used in Laser Sx.

Prep Nuggets

Value of BIS Monitor

0	.....
40 – 60	.....
60 – 80	.....
.....	**Fully a ware**

Prep Nuggets

For classic LMA and Proseal LMA

Wt. in Kg	Size of LMA
- < 5 Kg	.....
- 5 – 10 kg	.....
-10 – 20 kg	.....
- > 100 kg	.....

Prep Nuggets

Bupivacaine

1. Action .....
2. Chemistry .....
3. Metabolism .....
4. Safety .....
5. IVRA/ Bier's Block .....

Prep Nuggets

Drug	Dose
1. Lignocaine	.....
2. NTG	.....
3. Sodium nitroprusside	.....
4.	3-5 µg/ Kg/ IV

Prep Nuggets

Stages of Anesthesia

Stage 1	.....
Stage 2	.....
Stage 3	.....
Stage 4	.....

Prep Nuggets

Atracurium	Cis – Atracurium
1. CVS unstable	CVS .....
2. Histamine	Minimal histamine release
3. Dose	Dose.....
4. Mixture of ..... Isomers	Pure

Prep Nuggets

Agents	S/E
1. Succinylcholine	.....
2. Morphine	.....
3. Thiopentone	.....
4.	.....

Prep Nuggets

Inhalational agents

Agents	Uses
1. Halothane	.....
2. Isoflurane	.....
3. Sevoflurane	.....
4. Desflurane	.....

Prep Nuggets

Agents	Induction time
1. Thiopentone	.....
2. Propofol	.....
3. Ketamine	.....
4. Etomidate	.....

Prep Nuggets

Non depolarising neuromuscular blocker

1. Pancuronium	.....
2. Rapacuronium	Short acting
3.	Long acting
4. Rocuronium	.....