

INTRODUCTION AND HISTORY OF ANAESTHESIA

Anaesthesia means loss of **pain** sensation.

Effects of pain

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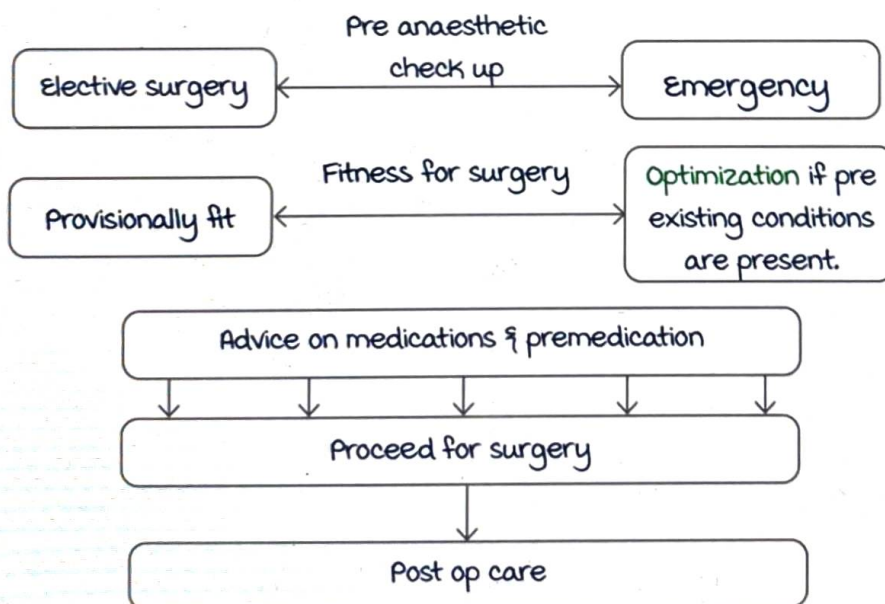
Pain causes release of sympathomimetic/ fight, flight, fright hormones (**adrenaline, noradrenaline**).

It increases HR, BP, RR, CO, oxygen consumption, renal and muscle blood flow thereby **increasing workload** on the body. In case, the body fails to deal with the pain, patient can present with failure (CVA/ CAD/ RF).

Sequence of events

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Work of an anaesthetic is to optimize patient's condition in order to tolerate the stress of surgery/ anaesthesia.



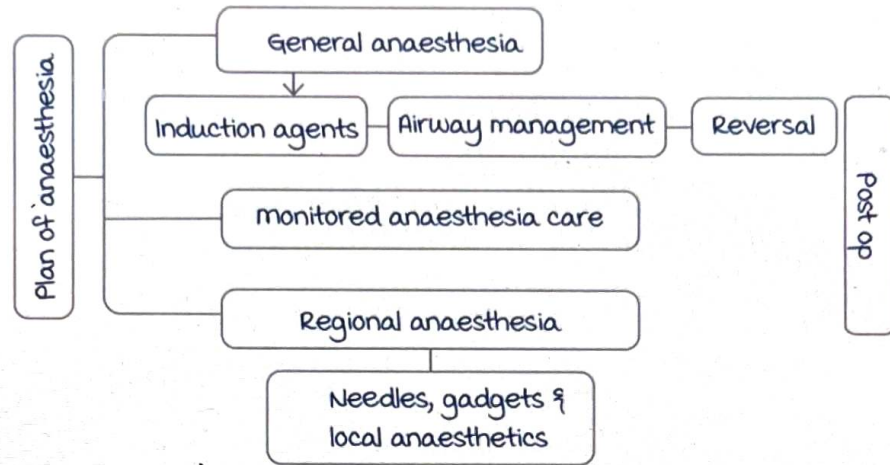
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Types of anaesthesia

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1. General anaesthesia.
2. Regional anaesthesia.
3. monitored anaesthesia care.

Active space



As soon as patient comes into the operation theatre, all monitors would be connected to the patient and IV cannula inserted.

Induction agents : They put the patient to sleep.

Intravenous agents :

- Thiopentone sodium.
- Propofol.
- Etomidate.
- Ketamine.

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Inhalational agents :

- Halothane.
- Isoflurane.
- Sevoflurane.
- Desflurane.
- Ether (obsolete).
- Chloroform (obsolete).

most anaesthetic agents are depressants. They decrease HR, BP, intra cranial pressure, respiratory stimulus as opposed to pain.

Airway management :

Induction agents cause respiratory depression which may lead to apnoea. This in turn, will cause hypoxia and complete hypoxic brain damage.

management involves administration of O_2 and removal of CO_2 .

Done using :

- ETT (Endotracheal tube).
- LMA (Laryngeal mask airway).

use of muscle relaxants :

Facilitates intubation for airway management by suppressing gag reflex (brainstem reflex) from anaesthetist's point of view and will also provide adequate time of exposure to surgeons for dissection as the muscles are relaxed.

Types :

Depolarizing muscle relaxants
Succinylcholine

NDMR (Non Depolarizing
muscle Relaxants)

Pancuronium

Vecuronium

Atracurium

After administration of muscle relaxants, patient is intubated followed by the initiation of dissection by the surgeon.

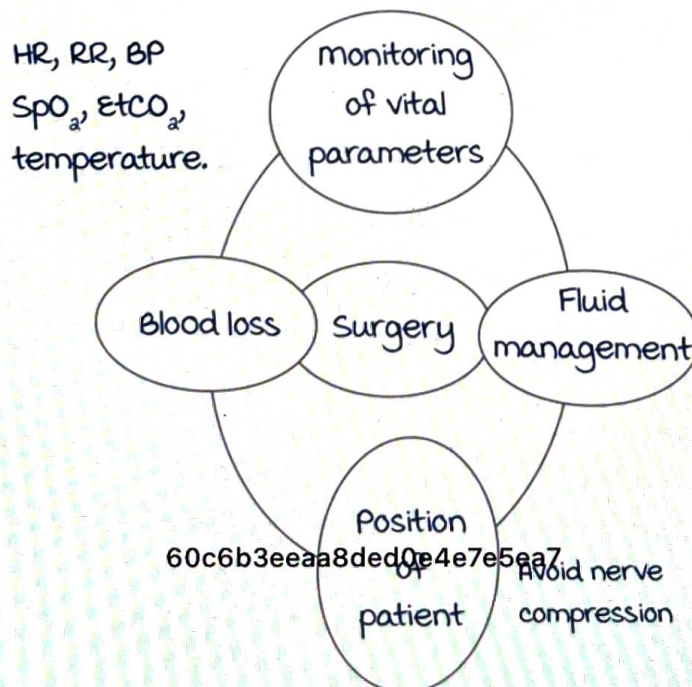
Reversal :

The effect of muscle relaxant is reversed.

E.g. Neostigmine (AChE inhibitor) is used. Patient's muscles return to normal tone.

Extubate the patient & shift to post op care for monitoring.

Post op monitoring :



Regional anaesthesia

00:26:48

As soon as patients enter the operation theatre, monitors will be attached and i.v line will be secured.

Central neuraxial blockade :

- Spinal anaesthesia
- Epidural anaesthesia.
- Caudal anaesthesia.

Needle is introduced very close to the nerves and local anaesthesia (LA) is injected. The area supplied by those nerves are blocked.

Peripheral neuraxial blockade :

Put a needle close to a peripheral nerve and inject local anaesthesia.

E.g. Brachial plexus block, femoral nerve block, intercostal nerve block.

Use of regional anaesthesia : Provides anaesthesia as well as analgesia during post op period.

monitored Anaesthesia Care (MAC) :

Anaesthesia given with monitoring of BP, HR, RR under the anaesthetist's supervision.

Drugs used are same as for sedation.

Uses :

Small diagnostic/ therapeutic procedures like,

- MRI.
- Radiotherapy .
- Small surgeries like MTP etc.

History

00:34:54

Who	Historical importance
Oliver Wendell Holmes	Coined the term 'Anaesthesia'.
Joseph Priestly	Discovered O_2 , CO_2 , N_2O .
Horrace wells	First demonstration (unsuccessful) of anaesthesia using N_2O .
W.T.G morton	First successful demonstration using ether on 16/10/1846. Branch of anaesthesia was born on this day.
John Snow kumarankitindia1@gmail.com	Father of epidemiology. Popularized the concept of obstetric anaesthesia after administering chloroform to Queen Victoria on her 8th delivery. Father of anaesthesia (if asked in exams), but not recognized in standard textbooks.
August Bier	1 st spinal anaesthesia.
Harold Griffith	1 st muscle relaxant used → d - tubocurare (arrow poison).
Carl Koller	1 st local anaesthetic → cocaine used in ophthalmic surgeries.

Active space

PRE ANAESTHESIA CHECKUP : PART - 1

Goal of pre anaesthetic checkup/ pre op evaluation

00:05:30

- Ensure patient tolerates surgery and anaesthesia.
- Optimize patient's general health condition (Hence, anaesthetists are called pre operative physicians).

Components of pre anaesthetic checkup :

1. Complete history taking includes demographic data (name, age, sex, address), chief complaint, H/O present and past illness, personal, family and allergic histories, H/O previous surgeries, H/O immunization (paediatric patient) and menstrual history (female patient).
2. General examination of the patient with height, weight and recording vitals.
3. Systemic examination of the patient (inspect, palpate, percuss and auscultate CVS, RS, GIT, CNS).
4. Airway examination.

Past history

00:13:59

Hypertension :

Scenario 1 :

Patient posted for elective surgery.

In pre - anaesthetic checkup, BP is 180/130mm Hg.

Can the patient be posted for surgery?

Solution : No.

Physiological concept :

Surgical concern : Severe hemorrhage.

Anaesthetic concern : most of the anaesthetic agents are

depressants i.e., decreases blood pressure causing poor perfusion of autoregulatory organs (brain, heart, kidneys).

Autoregulation :

Perfusion of vital organs remains the same with fluctuation in BP within the physiological limits.

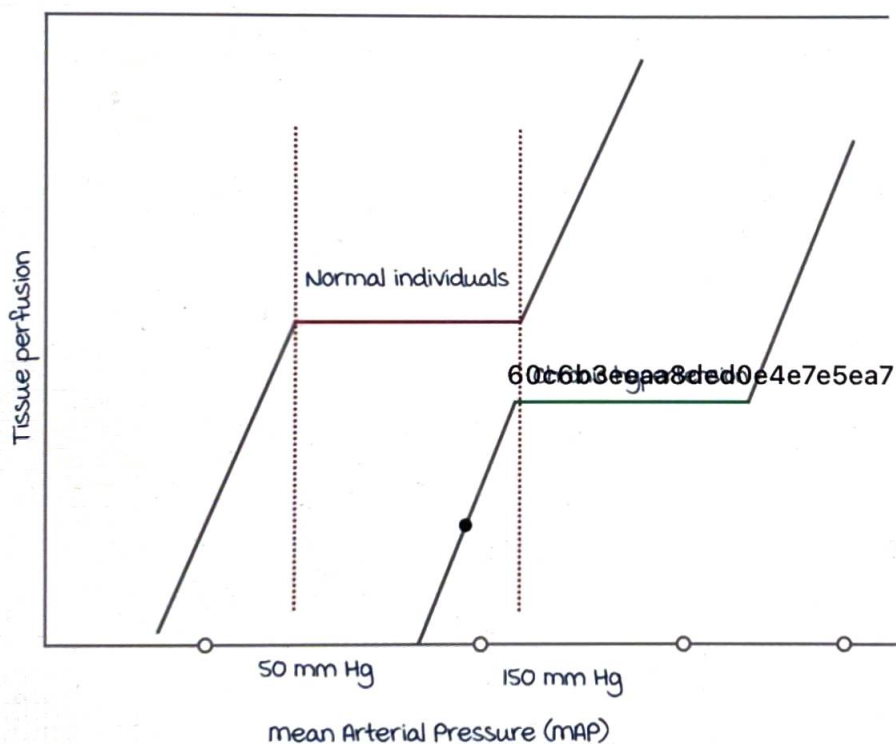
Perfusion of organ - mean Arterial Pressure (MAP) curve shows constant perfusion in normal individuals even with sudden fall in BP.

In chronic hypertensive patients, the curve moves to the right.

A sudden fall in BP results in MAP falling below normal perfusion levels.

Leads to organ damage (hypoperfusion) like renal impairment, coronary artery disease, stroke (CVA).

High BP should not be reduced drastically in a chronic hypertensive patient.



Fall in MAP below normal perfusion level in chronic hypertensive patients during anaesthesia.

Pharmacological optimization of the patient

00:22:02

use anti - hypertensive medications.

Continue anti - hypertensives till the day of surgery except ACE inhibitors and ARBs depending on the nature of surgery.

Active space

- a. **minor surgeries** (not much blood loss, no fluid shifts) :
Continue ACE inhibitors and ARBs.
- b. **major surgeries** : Stop ACE inhibitors and ARBs because of severe intractable hypotension under anaesthesia.

Scenario 2 : A patient posted for cataract surgery is on Telmisartan 40 mg. Should it be continued till the day of surgery?

Solution : Yes. Because cataract is a minor surgery.

Diabetes mellitus

00:30:43

Scenario 3 : A patient posted for elective surgery has 450 mg/dl blood sugar during pre anaesthesia checkup. Can the patient be posted for surgery?

Solution : No.

Physiological concept :

Surgical concern : Poor wound healing, longer hospital stay.

Anaesthetic concern : Acute complications of DM are :

- Diabetic ketoacidosis (DKA).
- Hyperglycemic hyperosmolar coma.
- Hypoglycemia (very dangerous complication under anaesthesia).

Signs and symptoms of hypoglycemia like light-headedness, tremors, confusion are **masked** under general anaesthesia.

If not identified within 3 minutes, leads to permanent neurological deficit.

Pharmacological optimization

00:36:25

Reduce blood sugar levels using oral hypoglycemic agents (OHA), Insulin and maintain between 120 - 200 mg/dl.

Can OHAs and Insulin be continued peri operatively : No.

OHAS	Insulin
All OHAs except SGLT - 2 inhibitors should be stopped on the day of surgery. SGLT - 2 inhibitors are stopped 24 hours before surgery (euglycemic ketoacidosis).	Reduce the dose of long acting Insulin in type 1 diabetics by $1/3^{\text{rd}}$. Reduce the dose of long acting Insulin in type 2 diabetics by half ($1/2$). Stop other forms of Insulin.

surgery be posted for an elective surgery?

Solution : No. Patient with immediate/ first onset of seizure before an elective surgery should be evaluated further for congenital, iatrogenic, idiopathic, traumatic, neoplastic causes.

Seizures are due to sudden activation of neurons & can present as Generalized Tonic Clonic Seizures (GTCS). This hyperexcitability can be due to multiple aetiologies. During a seizure episode, the tongue falls back causing airway obstruction leading to hypoxia, hypercarbia & acidosis. This in turn triggers subsequent multiple episodes & is called status epilepticus.

Scenario 5 : Can a patient with known seizure disorder on regular medications be posted for an elective surgery?

Solution : Yes, in case of only 1 episode of seizure and if hypoxia, hypercarbia and acidosis are ruled out (permanent neurological deficit).

Optimization : Turn the patient to left lateral position.

In obese patients, jaw thrust manoeuvre (tensile strength of muscles will increase). Prevents tongue fall back and airway obstruction.

Pharmacological intervention

00:51:16

Secure IV line. Give IV short acting benzodiazepine (midazolam).

monitor for respiratory depression.

Followed by Phenytoin sodium infusion 15 - 20 mg/kg diluted in 100 ml NS over 45 min or Levetiracetam 20 mg/kg.

All anti epileptic drugs should be continued till the day of surgery.

Anaesthetic agents like **enflurane/methohexital** are contraindicated in a patient with seizure episodes (**precipitates seizure**).

Liver Function Tests (LFT) to be done along with routine investigations like CBC, serum electrolytes in an epileptic patient (all anti epileptics are enzyme inducers) during pre operative evaluation.

Patients on anti epileptic drugs : One of the strongest risk factors for post operative mortality is acute fulminant liver failure.

Thyroid disorders

00:57:45

Scenario 6 : A patient with TSH of 25 (hypothyroidism). Can the patient be taken for surgery?

Solution : No.

Physiological concept : Thyroid hormones maintain Basal metabolic Rate (BMR).

↓
In hypothyroid patients, BMR decreased.

↓
metabolism of anaesthetic drugs decreased.

↓
Delay in recovery from anaesthesia.

↓
Pharmacological optimization : By supplementing thyroxine. Thyroxine supplementation should be continued till the day of surgery.

Scenario 7 : Can a patient with TSH of 0.01 (hyperthyroidism) be taken for surgery?

Solution : No.

Physiological concept : **Hyperthyroidism** can lead to palpitations (**atrial arrhythmias/ fibrillation**) during surgery under anaesthesia.

Pharmacological optimization : Anti thyroid drugs like Propylthiouracil, Carbimazole etc.

Continue anti thyroid medications till the day of surgery.

Scenario 8 : Hypothyroid patient posted for an emergency surgery.

Ketamine (stimulant) used as induction agent.

Prefer regional anaesthesia in a hypothyroid patient posted for amputation. GA avoided as much as possible.

Scenario 9 : Hyperthyroid patient posted for an emergency surgery.

Thiopentone sodium (anti thyroid properties) used as induction agent.

Other drugs to control hyperthyroid manifestations should be kept ready.

Psychiatry problems

01:05:59

Scenario 10 : Which of the following psychiatry medications should be stopped prior to elective surgery?

- MAO inhibitors.
- SSRI.
- TCA.
- Phenothiazines.

All anti psychotic medications should be continued till the day of surgery except older MAO inhibitors (interact with synthetic opioids like meperidine/ Pethidine).

Catecholamine surge causes a cheese like reaction leading to increase in heart rate and BP.
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Older MAO inhibitors are stopped 2 - 3 weeks prior to surgery.

Lithium (bipolar disorder) and magnesium (as $MgSO_4$ in eclampsia)



Interact with muscle relaxants



Prolong the duration of muscle relaxants

magnesium should never be stopped in a patient with eclampsia.

Lithium can be continued and newer short acting muscle relaxants (Atracurium, Cis atracurium, mivacurium) are used.

Previous guideline : Stop Lithium before 24 - 48 hours before surgery.

PRE ANAESTHESIA CHECKUP : PART - 2

H/o Myocardial infarction/prosthetic valve

00:00:08

Physiological concept : With past h/o MI or prosthetic valve, patient will be on,

- Aspirin.
- Clopidogrel.
- At least 1 drug each from the classes of beta blockers, ACE inhibitors and statins.

Surgeon's perspective : **uncontrolled bleeding** during surgery because of blood thinners (aspirin and clopidogrel).

Cardiologist's perspective : Stopping blood thinners increases the risk of **reinfarction**.

Pharmacological optimization : Stop blood thinners 5 - 7 days before surgery.

Replace them with Inj. LMWH sc BD dosing.

This process is called bridging. 60c6b3eaaa8ded0e4e7e5ea7

Purpose behind bridging therapy

00:07:13

Regional anaesthesia like spinal/ epidural/ peribulbar block carries risk of accidental injury to blood vessels (**blind procedure**).

Patients on blood thinners (including warfarin) can bleed into closed cavity spaces and form an **organised clot**.

Hematoma leads to permanent paraplegia (spinal cord compression)/permanent blindness (optic nerve compression).

Rest all antianginal/antiarrhythmic medications should be continued like beta blockers, statins, ACE inhibitors (unless ACE inhibitors cause maximum fluid shift).

Last dose of LMWH should be stopped **12 hours prior** to a regional anaesthetic procedure.

Epidural catheter should be removed only after 12 hours of the last dose of LMWH.

Start LMWH atleast 2 hours after removal of epidural catheter.

Case scenarios

00:16:20

A 70 year old on clopidogrel posted for cataract surgery under topical anaesthesia. Should the drug be stopped?

Answer : No. Continue the drug (topical anaesthesia, no blind needle insertion).

Emergency below knee amputation in a patient on clopidogrel. Which anaesthesia can be given?

Answer : General anaesthesia.

minimum duration for discontinuation of drugs prior to a regional anaesthesia procedure :

Low dose aspirin	Try to continue. Stop 3 days before a vascular surgery/ major risk of bleeding
Clopidogrel/ warfarin	7 days
Ticagrelor	5 - 7 days
Prasugrel	7 - 10 days
Ticlopidine	10 days
Cangrelor	3 hours
Extended release dipyridamole	24 hours
Abciximab	24 - 48 hours
Eptifibatide & tirofiban	4 - 8 hours

Oral contraceptive pills :

Scenario 12 : A 30 year old female posted for epigastric hernia repair is on OCPs. What are the anaesthetic implications ?

OCPs are of 3 types :

- Combined pills.

- Progesterone only pills.
- mini pills.

Estrogen containing pills : Increases venous stasis leading to Deep Vein Thrombosis (DVT).

Risk factors for DVT :

1. Old aged patient.
2. Prolonged bedridden patients.
3. Chemo/radiotherapy.
4. Oncological surgeries.
5. Long bone fractures.
6. Past H/O DVT.

Estrogen containing pills are avoided in presence of any risk factor.

In the absence of any risk factor, OCPs with/ without estrogen can be continued. kumarankitindia1@gmail.com

Scenario 13 : A 24yr old known case of TB on anti tubercular therapy is posted for cervical lymph node biopsy. What are the anaesthetic implications?

Continue ATT (to avoid multi drug resistance).

ATT medications are enzyme inducers (pre operative LFT essential).

Scenario 14 : Patient on steroid replacement therapy posted for an elective surgery.

Physiological concept : Abrupt stoppage of steroids will cause HPA suppression.

Steroids should be continued till the day of surgery.

If patient takes > 5 mg of steroid within past 3 months of surgery, supplemental dosage of hydrocortisone (quick onset) should be given intraoperatively (as surgery itself is a stressful factor).

Scenario 15 :

A patient is on herbal medicine. What are the anaesthetic implications?

Herbal medicines affect the functions of liver.

Ideally, stop herbal medicines before 2 weeks.

Practically, stop before 1 week.

Check LFT values. If normal, proceed with the surgery.

Scenario 16 : A patient on NSAIDs. What are the anaesthetic implications?

NSAIDs should be stopped 48 hours before surgery
(aggravates renal injury).

COX 2 inhibitors can be continued till the day of surgery.

If the surgeon feels it will affect wound healing, then stop 24 hours prior (Continue > stop for 24 hours).

Scenario 17 : A patient is on sildenafil for pulmonary artery hypertension (PAH).

Sildenafil is a phosphodiesterase inhibitor. Causes vasodilation
(intractable hypotension). Stopped 24 hrs before surgery.

Scenario 18 : A patient is on diuretics.

All diuretics except thiazide diuretics should be stopped
24 hours before surgery.

Check **serum electrolytes** pre operatively.

Scenario 19 :

A patient on Anti Retroviral Therapy (ART).

ARTs affects liver, derange electrolytes and clotting cascade,
depresses bone marrow function etc.

Continue ARTs and do all necessary investigations with
complete knowledge about ART's adverse effects.

Scenario 20 : Avoid topical ointments pre operatively (skin
color under anaesthesia may not be appreciated eg : during
cyanosis).

most of the eye drops can be continued except during ocular
surgeries.

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Personal history

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Evaluate personal habits of the patient.

Smoking :

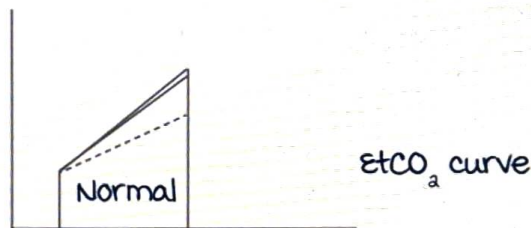
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Stop smoking 6 - 8 weeks before surgery.

Under GA, upon intubation **laryngospasm/bronchospasm** risk increases (smokers airway are irritable as smoke is an irritant).

Intraoperative bronchospasm :

1. Sudden unexplained tachycardia, hypertension.
2. Increased airway resistance (P_{aw} on ventilator).
3. Decreased expiratory tidal volume.
4. B/L wheeze on auscultation.
5. Increased upstroke on $EtCO_2$ curve.



Treatment for bronchospasm :

Inhaled beta-2 agonists (salbutamol). Steroids can be added.

Laryngospasm

00:49:39

Sudden forceful closure of glottis leads to stridor and desaturation.

Seen when patient is not in adequate planes of anaesthesia. Occurs before intubation/end of extubation (more common).

mechanism : ET tube secretions trickle into the airway. Reflex constriction of laryngeal muscles that leads to, Desaturation, hypoxia & bradycardia.

Treatment of laryngospasm :

100% O_2 and perform Larsons manoeuvre/jaw thrust (apply pressure behind the angle of mandible/in front of mastoid). Very painful.

Administer Inj. Propofol 10-20 mg IV (blunts reflex constriction).

If nothing works and patient is still desaturating, give Inj. Succinylcholine (depolarising muscle relaxant). Additional care of airway be taken while giving Succinylcholine.

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Alcohol :

Stop alcohol consumption 24 - 48 hours before surgery (both anaesthetics & alcohol are depressants).

Alcohol is an enzyme inducer. Increases SGPT/SGOT (post op acute fulminant hepatic failure).

Tobacco chewing :

Leads to submucosal fibrosis.

Difficult intubation due to restricted mouth opening.

- Drug addiction : most of the drugs are stimulants (sympathomimetics). Causes myocardial ischemia.

medications against drug abuse	Anaesthetic implication
methadone	Supplementary doses can be continued till the day of surgery.
Disulfiram (alcohol addiction)	Stop 10 days before surgery (disulfiram like reaction).
Naltrexone (long acting opioid antagonist)	Stop 3 days before surgery (to avoid interference with intra op opioids).

Family history of malignant hyperthermia should be ruled out to prevent massive cardiac arrest.

Allergic history :

Severe form of allergy is anaphylactic shock.

Anaphylactic shock

01:09:28

Etiology : most common precipitating factors of anaphylactic shock are antibiotics > latex > muscle relaxant > local anaesthetics (according to a study in France).

Pathophysiology :

Antigen - antibody reaction causes Histamine release.

Active space

Clinical features :

- Sudden unexplained tachycardia.
- Hypotension.
- Increased airway resistance (difficulty in bagging).
- Edema of face, neck, lips.

Treatment :

- Inj. Adrenaline (drug of choice).

1ml = 1mg in 1 : 1000 dilution.

IV route is preferred.

1ml of 1 : 10,000 dilution is given (1 ml of 1 : 1000 diluted with 9ml NS).

S/C route : 0.5 ml of 1 : 1000. 60c6b3eaa8ded0e4e7e5ea7

- Push IV fluids.
- Steroids : Hydrocortisone 1 - 2 mg/kg (quick onset).
Stabilizes mast cell membrane and prevents anaphylaxis.
2nd drug of choice.
- IM injection is not preferred as it causes local tissue necrosis.

Risk stratification of the patient by ASA grading

01:19:21

ASA : American Society of Anaesthesiologist.

Grades according to the physical status of the patient to understand post-operative prognosis.

- I. Normal healthy patient (no comorbidities).
- II. mild systemic disease without functional limitation (controlled asthmatic, hypertension, diabetes mellitus).
- III. moderate systemic disease with functional limitation (chronic kidney disease, chronic liver disease).
- IV. Severe systemic disease that is life threatening (myocardial ischemia, unstable angina).
- V. moribund patient (life expectancy < 24hours).
- VI. Brain dead patient.

Disadvantages :

Cannot assess the mortality/morbidity of a surgical procedure.

Cannot quantify expected blood loss, post op ICU stay.

Cannot specify the type of monitoring required for a particular patient.

John Hopkins surgical risk stratification

01:27:28

Graded according to the risk of surgical procedure.

- I. minimal risk : minimally invasive.
- II. mild to moderate risk : < 500 ml blood loss.
- III. moderate risk : 500 to 1500 ml blood loss.
- IV. High risk : > 1500 ml blood loss.
- V. Critically ill patient requiring ICU care.

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Active space

PRE OPERATIVE PREPARATIONS

Pre op preparations

00:01:19

Pre op preparations include :

1. Investigations.
2. Optimization and risk stratification.
3. Pre - medications.
4. Consent.

Investigations and purpose :

Investigations sent : Surgical profile (CBP + CUE (complete urine examination) + LFT + RFT + PT, aPTT, PT INR + ECG.

Inv.	Tests	Purpose (To rule out)	Target	Notes
CBP	Hb (RBC).	Anemia. Infections. Bleeding disorders.	Healthy : $>8g/dL$ even with mild blood loss. Patient with any comorbidities/ surgery involving mild/moderate bleeding : $>10 g/dL$. In ICU or surgery involving high risk of bleeding (vascular surgery) : $>12g/dL$.	Anemia causes delayed wound healing (since oxygen carried by blood is decreased).
	TLC (WBC).		Normal levels (WBC) : 4000 to 11000 cells/mm ³ .	
	Platelets.		Normal : 1.5 - 4 lakh/mm ³ (1 lakh).	Platelet count should not be lower than 1 lakh/mm ³ for any regional anesthesia.

Active space

Inv.	Tests	Purpose (To rule out)	Notes
RFT	Blood urea. Serum creatinine. Serum electrolytes.	Ongoing renal damage. Notes	Ordered according to the patient's clinical history : Example : 1. CKD patient : Check serum potassium. 2. Patient clinically very ill : Check serum sodium.
LFT	Serum bilirubin. Liver enzymes.	Ongoing liver damage.	mandatory to be done in people on herbal medications, ATT or any chronic treatment.
Coagulation studies	BT, CT. PT with INR and aPTT.	Bleeding disorders.	Done in all, but less significant. Only done if history indicates bleeding issues (hemophilia, missed abortions, massive blood transfusions).
CUE	urine protein levels.	Any ongoing renal issues. (proteinuria)	Hyaline casts indicate CKD. Proteinuria + DM indicates diabetic nephropathy.
UPT	urine pregnancy test.	Pregnancy.	mandatory in all females of reproductive age.
ECG	ST-T changes. Arrhythmias.	Left ventricular hypertrophy. Ectopic arrhythmias. Any heart issues.	Indicated in patients > 40 years or any comorbidities DM, HTN ; Past h/o CVA, CAD etc. (Always compare previous ECGs for rhythms).
Chest X-ray.		Ongoing LRTI.	Only done in pts with suspected LRTI (Lower Respiratory Tract Infection).

Guidelines for these investigations

00:11:48

All these investigations are valid for **2 months**, provided patient is hemodynamically stable, always correlate with the patient's condition.

Example : Always recheck in female patients who had menorrhagia (Hb may drop due to severe bleeding, regardless of the time).

Optimization and risk stratification :

most important organ systems with higher risk of intra op and post op mortality : CVS, respiratory system & CNS.

Cardiovascular system (CVS) :

Step guidelines given by ACC (American College of Cardiology)/ AHA (American Heart Association) to assess risk in a cardiac patient for non-cardiac surgery :

Steps : (ACC/AHA guidelines for cardiac patients)		Procedure to be followed
Step 1 : Assess the need of surgery	Emergency surgery : < 6 hours. Urgent surgery : 6 to 24 hours. Time sensitive (onco surgeries/ ortho surgeries) : 1 - 6 weeks.	Proceed with high risk consent + careful monitoring + necessary postoperative interventions.
Step 2 : Rule out active cardiac issues.	Acute coronary syndrome. Decompensated heart failure. Significant ventricular arrhythmias. Valvular heart diseases.	Always postpone elective surgeries. First evaluate, treat, and then continue.

Active space

<p>Step 3 : Assess the risk of peri - operative ml/ death.</p>	<ol style="list-style-type: none"> 1. High risk surgery (intraperitoneal/ intra thoracic/ vascular surgeries). 2. History of Is-chemic heart disease (IHD). 3. H/O Congestive Heart Failure (CHF) 4. H/O Cerebrovascular accident (CVA). 5. C/O DM requiring insulin treatment. 6. S. Creatinine >2.0. 	<p>One point given to each of these conditions.</p> <table border="1" data-bbox="836 271 1107 521"> <thead> <tr> <th>Score</th> <th>% of risk</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0-0.4%</td> </tr> <tr> <td>1</td> <td>1.0%</td> </tr> <tr> <td>2</td> <td>2.4%</td> </tr> <tr> <td>>/= 3</td> <td>5.4%</td> </tr> </tbody> </table> <p>Proceed with the elective surgery if risk <4%.</p>	Score	% of risk	0	0-0.4%	1	1.0%	2	2.4%	>/= 3	5.4%
Score	% of risk											
0	0-0.4%											
1	1.0%											
2	2.4%											
>/= 3	5.4%											
<p>Step 4 : Assess the functional capacity.</p>	<p>Functional capacity = metabolic equivalent (met) = Normal amount of O₂ consumed at rest. 1 met = 3.5 ml of O₂/ Kg/ minute (normal). Example : Walking slowly - 2 mets. Can run for 10 km - 10 mets.</p>	<p>Proceed for surgery if > 4 mets (patient should approximately be able to climb 2 floors comfortably). If patient fails, step 5.</p>										
<p>Step 5 : Stress testing.</p>	<p>Dobutamine stress testing → to evaluate if pt can tolerate surgery stress.</p>	<p>If stress tolerance is good, proceed with the surgery If not, Step 6.</p>										
<p>Step 6 : Either proceed to surgery (or) alternate plan.</p>	<p>Identifying the risk from the above steps, either proceed or drop (talk to the surgeon in charge and plan for an alternative).</p>											

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Canadian society guidelines

00:21:52

5 step guidelines given by **CSG** (Canadian Society Guidelines) for CVS risk :

- **Step 1 to Step 3** same as ACC/ AHA guidelines.
- **Step 4** : Brain Natriuretic Peptide (BNP) <90 or pro BNP <300 ng/L \rightarrow Proceed to surgery.
- **Step 5** : Proceed to surgery. measure Troponin levels daily for 48 to 72 hours post op. and obtain ECG in PICU. BNP is the most sensitive indicator of cardiac function.

When to proceed for surgery after

- i. **Coronary stenting** :
 - Bare metal stent \rightarrow No elective surgery within 1 month.
 - Drug eluting stent (DES) \rightarrow No elective surgery <6 months \rightarrow 3 to 6 months if time sensitive surgery.
- ii. **Heart failure** \rightarrow Apply the same strategy as in the guidelines given above.
- iii. **murmurs** \rightarrow Apply the same strategy as in the guidelines given above.
- iv. **Pacemaker/ICD** (any implantable cardiac device) :
Apply the same strategy as in the guidelines given above.

Any implantable cardiac device \rightarrow monopolar cautery should not used (Electro surgical unit (ESU).

Device sends electrical signals/ impulses to the heart, when used simultaneously with cautery, it might interfere, leading to dangerous arrhythmias. Cautery can be used by the following ways :

1. magnet can be kept on heart, all impulses will be nullified.
2. Bipolar cautery can be used.

Guidelines to administer **Infective Endocarditis prophylaxis**.

Previously it was given to all cardiac patients. It is not recommended anymore as it might lead to antimicrobial resistance.

According to new guidelines, patient should have :

1. Past H/O Infective endocarditis.
2. Prosthetic valve.

3. unrepaired cyanotic congenital heart disease (CHD).
4. Repaired CHD with residual disease.
5. Undergone cardiac transplant.

Respiratory system

00:27:56

1. **Upper Respiratory Tract Infection (URTI)** (cough/cold) :
Increased chances of bronchospasm/ laryngospasm
wait for 4 to 6 weeks.
2. **Chronic Obstructive lung diseases (COPD)** :
 - Chest radiograph → if any lung infection suspected.
 - Arterial blood gas → only when patient is in ICU with acute exacerbation.
 - Regional anaesthesia preferred (to avoid irritation to the airway).
 - Continue all his other medications.
3. **Restrictive lung diseases (Pulmonary fibrosis)**.
 - kumarankitindia1@gmail.com PFT (pulmonary function test) → reserved only for lobectomy/pneumonectomy.
 - Always rule out RHF (Right Heart Failure).

Highest risk factors of post operative respiratory complication :

- i. Patient with low levels of albumin concentration (< 3.5 g/L).
- ii. Patient posted for upper abdominal surgery.
- iii. Patient is a known case of COPD.
- iv. Patient getting general anaesthesia.
- v. Patient who is a chronic smoker.

Patient related risk factors :

- Advanced age.
- ASA - PS class 2 or more.
- Congestive heart failure.
- Functionally dependent.
- Chronic obstructive pulmonary disease.
- Weight loss.
- Impaired sensorium.
- Cigarette use.
- Alcohol use.
- Abnormal findings on chest.

Active space

Potential procedure related risk :

- Aortic aneurysm repair.
- Thoracic surgery.
- Abdominal surgery.
- Neurosurgery.
- Head & neck surgery.
- Emergency surgery.
- Vascular surgery.
- General anaesthesia.
- Peri operative transfusion.

Potential laboratory test risk factor :

- Albumin concentration < 35 g/L.
- Chest radiograph abnormalities.
- BUN concentration > 7.5 mmol/L (> 21 mg/dL).

Central Nervous System risk stratification :

Any patient with a H/O CVA :

- Defer elective surgery for 9 months.
- Continue Aspirin throughout the perioperative period.

Anaesthetic pre medication

00:33:50

To make the patient feel comfortable during surgery :

1. Relieve anxiety + induce sedation.
 - Rx : Short acting Benzodiazepines (midazolam/
Alprazolam)
 - Talk and explain the procedure to the patient, in order to increase his confidence.
2. Reduce secretions (especially in children) → may lead to laryngospasm or aspiration pneumonia (salivary hypersecretion).
 - Rx : Anti cholinergic (Glycopyrrolate/ Atropine).
3. Reduce the chances of aspiration of food material.
 - Rx : Adults → 6 to 8 hours of fasting in adults.
 - Children :
 - up to 2 hours : Clear liquids (water).
 - up to 4 hours : Semi solids (breast milk).
 - up to 6 hours : Solid food (non human milk).
 - up to 8 hours : Heavy fatty meal.

Emergency surgery : procedure to be followed 00:41:58

- i. Before proceeding to emergency surgery, pass a nasogastric tube & aspirate all the gastric contents.
- ii. Inject metoclopramide slowly (pro kinetic agent → increases gastric motility → pushes food into intestine from stomach).
Rapid administration of metoclopramide may precipitate extra pyramidal symptoms.
- iii. Inject with PPI/ H₂ blockers (Pantoprazole/ Ranitidine) to stop the acid secretions (decrease gastric acidity).
- iv. Antacid (for the acid already secreted by the previous food intake) : 0.3 molar Sodium citrate (non particulate) 30 ml, 30 minutes prior.

To reduce infections :

1. Operate in sterile conditions.
2. Pre op antibiotics (30 mins prior to skin incision).

To reduce post operative nausea/ vomiting :

1. Inject slowly with Ondansetron (5 HT₃ receptor blockers) : Adverse effects of rapid infusion are prolonged QT intervals/ ventricular arrhythmias.

Group of patients at risk for post operative nausea/vomiting :

- i. Female.
- ii. H/O motion sickness.
- iii. Non smoker.
- iv. General anaesthesia with opioids.
- v. Schedules for ocular(squint)/ ENT/ laparoscopic surgery.

Rx : Ondansetron + Dexamethasone is a very powerful anti emetic. Recently Ondansetron has been given black box warning by the FDA as it is found to cause QT prolongation. So, it should be given very slowly.

Analgesia (Pre emptive analgesia) :

Giving analgesic before surgical incision, as studies have shown that analgesia given before the surgical incision leads to less pain post op.

Rx: Short acting opioids (Fentanyl) under strict monitoring.
Adverse effect: Respiratory depression.

Consent

00:51:08

Take the consent after all the previous steps are done →
Proceed to the operation theatre.

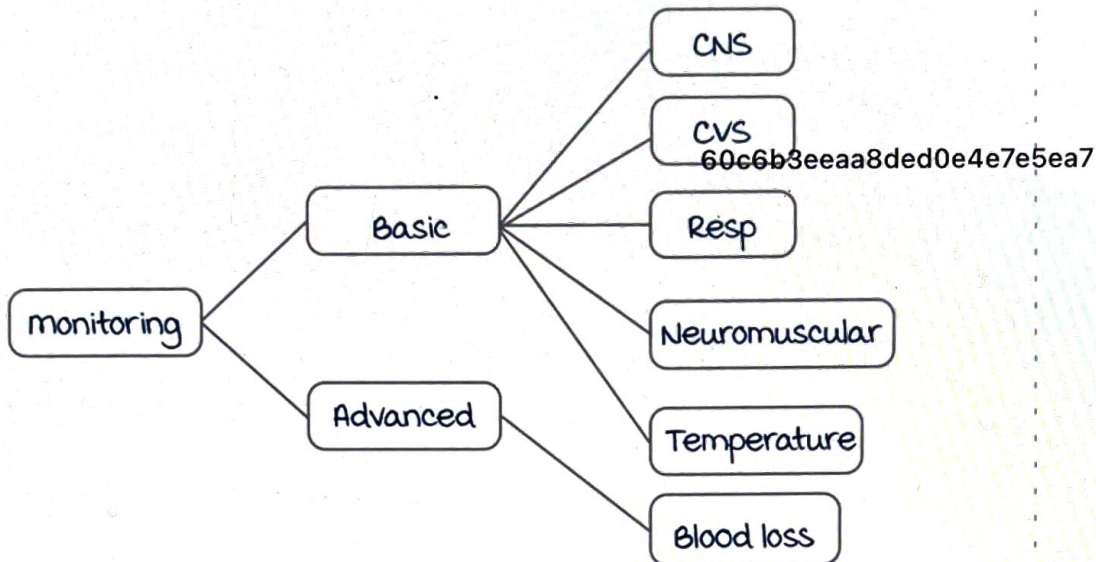
Active space

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MONITORING IN ANAESTHESIA

PART - 1

monitoring under anaesthesia can be divided into :



CNS monitors :

Depth of anaesthesia : Relates to the awareness of the patient during anaesthesia.

- **Balanced anaesthesia** : Introduced by John Lundy. He states that anaesthetized patient should have 4 A's :

1. **Amnesia**.
2. **Analgesia**.
3. **Adequate muscle relaxation**.
4. **Abolition of reflex activity**.

- To maintain the depth of anaesthesia : we use
 - midazolam.
 - Any inhalational anaesthetic.

Signs of lighter planes of anaesthesia :

Since factors such as amnesia and analgesia are **subjective**, signs of lighter planes of anaesthesia is used.

Signs of inadequate/ lighter planes of anaesthesia :

1. **Lacrimation**.
2. **Reflex movements**.
3. **Tachycardia**.
4. **Increased BP**.
5. **Sweating**.

Bispectral index :
monitors/ analyzes EEG rhythms and gives out numerical values that helps anaesthetists to evaluate the patient's depth of anaesthesia.



Bispectral leads attached to a female patient.

Entropy is a newer monitor used to detect depth of anaesthesia.

BIS monitoring :

Bispectral index system value	Depth of sedation
0	Flat line EEG (patient in deep anaesthesia)
0 - 40	Deep hypnotic state, memory function lost, increasing burst suppression
40 - 60	Recommended range for general anaesthesia.
60 - 90	Recommended range for sedation
100	Awake, memory intact

Cardiovascular system

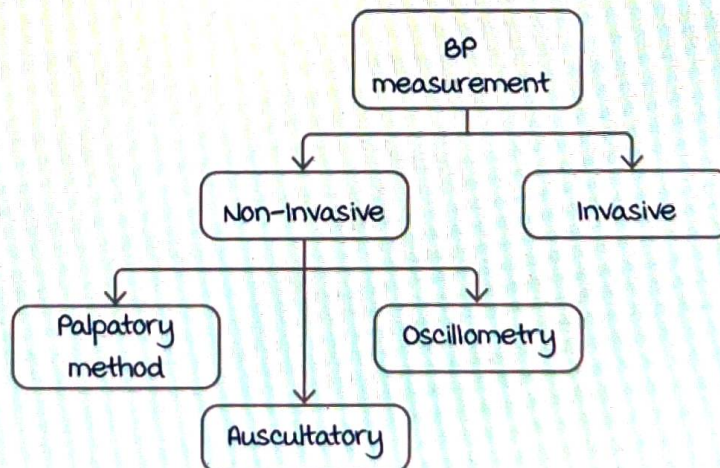
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Pulse rate/ heart rate :

Pulse rate is the first thing checked in the patient.

If the patient has pain, tachycardia is observed and if on beta blockers, then bradycardia is seen.

Blood pressure : Measurements can be done via 2 methods :



Active space

Non invasive BP monitoring :

Palpatory method is always done prior to auscultatory method. This is because identification of systolic blood pressure by **palpatory method** helps one to avoid a lower systolic reading by auscultatory method (auscultatory gap).

Automatic BP measuring device works via **oscillometry** method based on the **vibration** in the vessels.

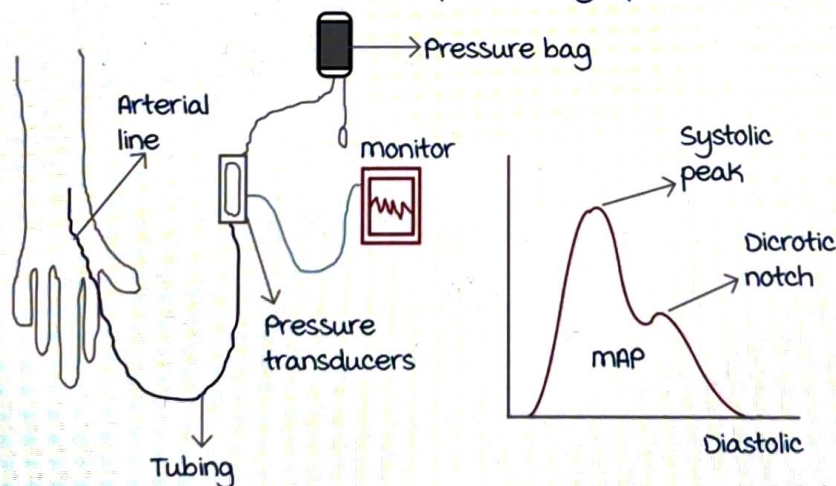
During the return of flow of blood once the BP cuff deflates, the systolic and diastolic BP is identified by the machine's sensor on the basis of **average value of the vibrations**.

The size of the cuff should be $1.5 \times$ diameter of the limb and should occupy $2/3^{\text{rd}}$ of the arm. If a small sized cuff is used, the BP will be **falsely elevated**.

Do not tie the cuff in limbs where **Arteries** are present (example AV fistula for dialysis).

Invasive BP monitoring :

A cannula is inserted into an artery and connected to a pressure transducer to attain a pressure graph.



Invasive BP monitoring is used when patient has severe comorbid conditions or major vascular surgeries (like transplants) to get a beat to beat BP monitoring.

A modified Allen's test is done prior to inserting cannula into artery to check for adequate collateral circulation.

modified Allen's Test :

The ulnar and radial side of the hand is compressed and

then when the ulnar side is released, within 5 - 15 secs the colour in the hand should return.

Positive Allen's test : Inadequate collateral circulation.

Negative Allen's test : Good collateral circulation.

Complications of arterial cannulation :

Arterial injuries.

Vessels can undergo spasm, ischemia, gangrene.

Thrombosis.

Sepsis.

Fistula/aneurysm formation.

Dicrotic notch : Represents the **elastic recoil** of the vessels.

Sites for inserting cannula :

Radial artery	most commonly used, easily accessible
Ulnar artery	used if good collaterals are available
Brachial artery	Has good collaterals, but uncomfortable for patient
Axillary artery	It mimics central arterial pressure
Femoral artery	Commonly used to measure the central arterial pressure values
Dorsalis pedis art. Posterior tibial art. Superficial temporal art.	Used in children

ECG monitoring :

used to detect ischemia, arrhythmias, HR.

Lead II : Very sensitive to arrhythmias as it coincides with axis of the heart; V_5/V_6 detects ischemia.

Central venous catheter

00:25:42

Internal jugular cannulation is usually not an emergency procedure and is done prior to major surgeries. All monitors are attached to the patient before initiating this procedure.

Positioning : Towel roll kept under shoulder, sternocleidomastoid muscle becomes prominent.



Procedure : Ask the patient to turn to the opposite side of catheter insertion. The area is cleaned with 2% chlorhexidine.

Feel the carotid artery pulsations with your left hand.

Administer subcutaneous local anaesthetic. Use a finder

needle to locate the IJV. Then use a larger needle and

direct it in the same direction as the finder needle and

slowly aspirate. Aspiration of dark colored blood indicates

that the needle is in IJV. Now, insert the guide wire through

the needle. Remove the needle. Now, hold on to the guide

wire and insert the triple lumen catheter. This is called the

Seldinger technique.

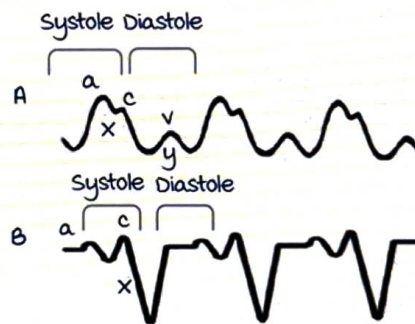
The catheter is 7Fr 20 cm triple lumen catheter.

16 G cannula is used for rapid resuscitation. Central venous catheter can be used for :

- Long term fluid therapy.
- Delivery of inotropes.

Waves obtained from central venous catheter are :

a, c, v positive waves and x, y negative waves.



A numerical value of 0 - 5 cm is obtained when the central venous catheter is attached to pressure transducer.

CVP values (0 - 5 cm) indicate the functioning of the right side of heart and the fluid status.

Various sites for central venous catheterization :

Right IJV	most commonly done.
Left IJV	Not usually used because the left pleural cupola is at higher level, therefore increased risk of pneumothorax and injury to thoracic duct. Increased risk of injury to vessels.
Subclavian v	most commonly used by surgeons, increased risk for pneumothorax and thoracic duct injury.
Ext jugular v	J tipped guide wires used.
Femoral v	Can cause infections and thromboembolism.

Axillary v	mimics the central venous pressure, but uncomfortable for the patient.
PICC	Peripherally Inserted Central Catheters, used for long term chemotherapy and nutrition.

CV catheter :

Indications	Complications
<ul style="list-style-type: none"> To monitor CVP For pacing and dialysis Injection of drugs For major surgeries where fluids are given based on CVP Repeated blood samplings 	<ul style="list-style-type: none"> Injury to arteries Pneumothorax Cardiac tamponade Thromboembolism Infections

CVP increased in	CVP decreased in
<ul style="list-style-type: none"> Right heart failure Congestive cardiac failure Positive pressure ventilation Fluid overload Cardiac tamponade Pleural effusion Constrictive pericarditis Pneumothorax 	<ul style="list-style-type: none"> Hypovolemia Shock General anaesthesia (sometimes)

↑ CVP and ↓ BP indicates pump failure/ heart failure.

↓ CVP and ↓ BP indicates hypovolemia.

A chest X ray is recommended after inserting the catheter to rule out pneumothorax.



The catheter inserted should be parallel to the superior vena cava.

The tip should be below the clavicles above the 3rd rib or at the level of T₄-T₅ interface.

Pulmonary capillary wedge pressure (PCWP) 00:43:53

Also called as pulmonary capillary occlusion pressure.

7.0-9.0 Fr 110 cm catheters are used. These catheters are flow directed and the balloon dilates at the level of lung capillaries.



Active space

PCWP is an indirect/ surrogate method to measure functioning of left side of the heart.

The catheter travels as such :

LJV → RA → RV → PA → Wedges at pulmonary capillaries.

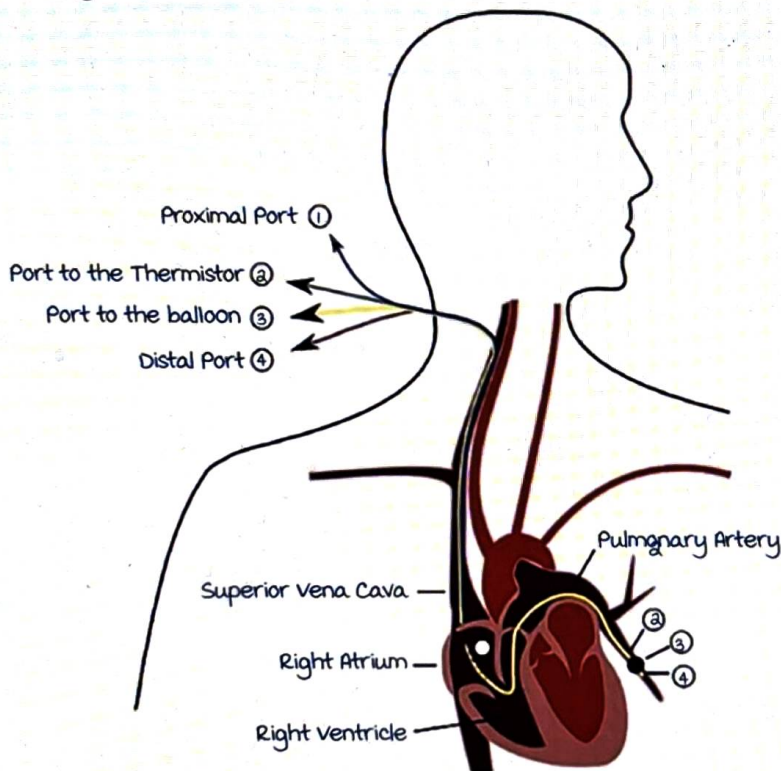
The pressures at various point are :

RA : 0 - 5/0 mmHg (SBP/DBP).

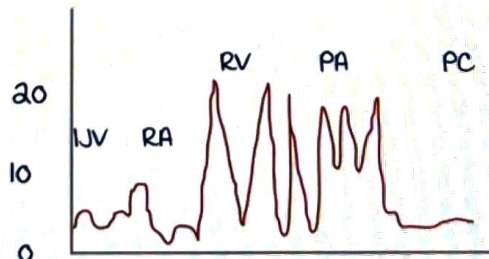
RV : 15 - 30/4 - 8 mmHg

Pulmonary artery : 15 - 30/4 - 8 mmHg.

Pulmonary capillaries : 12 - 16 cms.



The same is represented in graph when the catheter moves from each compartment.



Based on the distance the catheter has traveled, we can estimate the location of the catheter :

20 - 25 cm : RA.

30 - 35 cm : RV.

40 - 45 cm : PA.

At 55 cm : Wedging occurs.

For accurate values, the catheter tip should be placed at **west zone 3**.

Complications :

Arrhythmias.

mechanical knots from catheter entanglement.

Damage to pulmonary capillary leading to rupture and life threatening hemoptysis.

Uses :

To monitor functioning of left side of heart.

monitoring of **core body temperature**.

measure mixed venous oxygen saturation (best indicator of tissue oxygenation).

Calculate cardiac output or **cardiac index**.

Echocardiography :

Trans thoracic or trans esophageal echocardiography provides real time information regarding the functioning of the heart.

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MONITORING UNDER ANAESTHESIA : PART - 2

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Respiratory system

00:00:07

Function : Provide O_2 and remove CO_2 .

monitoring of :

- O_2 with pulse oximetry.
- CO_2 with capnography.
- Other respiratory functions by :
Spirometry (for lung volume).

ABG.

Airway pressure monitoring.

Normal SpO_2 : 98 - 100%.



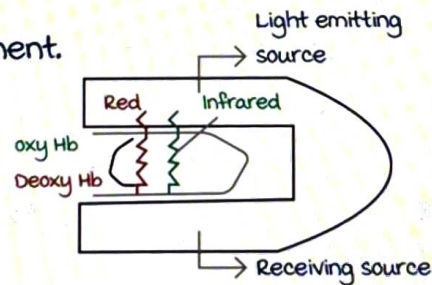
Pulse oximetry

00:01:35

Normal pulse oximeter value indicate amount of O_2 that is saturated to Hb.

It measures the **pulsatile** component.

Wave form is seen.



Working principle : Beer Lambert's law.

Pulse oximeter emits red and infra red light.

Reduced/deoxygenated Hb absorbs **red light** (660 nm).

Oxygenated Hb absorbs **infrared light** (940 nm).

$$R = \frac{\text{Red light falling/ red light receiving.}}{\text{Infrared light falling/ infrared light receiving.}}$$

Abnormal hemoglobins that can alter pulse oximeter value :

Carboxyhemoglobin and methemoglobin.

Carboxyhemoglobin (CO poisoning) :

It is seen in patients rescued from burns, fire accidents.

Carbon monoxide has 200 times more affinity to Hb molecule. Avidly binds to Hb and absorbs red and infrared light causing false high value of O_a saturation.

CO competes with O_a and binds avidly with Hb molecule. Pulse oximeter will not differentiate CO from O_a .

In a patient of burns on the body, SpO₂ is high but symptoms like low GCS, hemodynamic instability, unconsciousness is present, it indicates of intubation.

Treatment : 100 % oxygen in hyperbaric environment.

meth hemoglobinemia :

Condition where Fe^{2+} (ferrous) in Hb is converted to Fe^{3+} (ferric) causing decrease in affinity to O_a .

Pulse oximeter : False low value.

Typically seen in prilocaine toxicity (produces orthotoluidine and it causes methemoglobinemia).

Treatment : methylene blue ($Fe^{2+}-Fe^{3+}$).

Fetal Hb/Other Hb forms : No effect on O_a saturation .

Other conditions with false low value pulse oximeter :

Severe hypotension, methylene dye, cold, shivering, anemia (severe), nail polish, mehendi, hyperpigmentation, shock.

Co-oximeter : Indicates the accurate value of saturation even in carboxy Hb, meth Hb, and foetal Hb.

Capnography/EtCO₂

00:17:08

Presence of exhaled CO_a reflects fundamental physiological process.

Indicates :

Ventilation status of patients (movement of both O_a & CO_a).

Working principle :

For research :

- mass spectroscopy
- Raman spectroscopy
- Gas chromatography.

Day to day life :

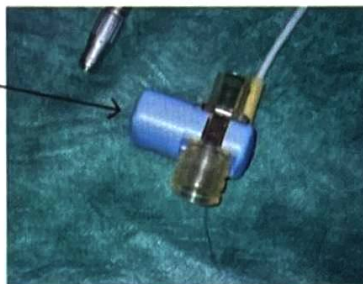
- Infra red spectroscopy (exhaled CO_a is sent to a monitor).

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Active space

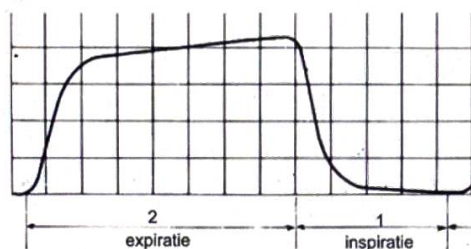
2 types of capnographic machines :

- Direct sampling (differential absorption of Infrared light).
- Indirect sampling.



Other terminologies :

- Capnometry : measurement of exhaled CO_2 .
- Capnometer : Is an equipment. 2 types : Direct (non diverting) and indirect (diverting). A slight time lag is seen in diverting but wave forms are equal for both.
- Capnography : Graphical representation of measured exhaled CO_2 vs time.



Normal capnography is **top hat shape** and normal value is

35 - 45 mmHg. kumarankitindia1@gmail.com

- Capnogram : Single wave form.

Phases in capnographic curve

00:22:24

Components/Phases of a normal capnography :

Phase I : **Inspiration baseline**

Completed inhalation,
about to begin expiration.
Exhalation of **dead space**
gases (contains no CO_2).

Phase 2 : Exhalation
predominantly from

upper alveoli rich in CO_2 concentration. **Expiratory upstroke.**

Phase 3 : Exhalation from middle and lower alveoli contains CO_2 but not rapid. So, **plateau phase** (slight upstroke as alveoli vary in sizes) seen.

Terminal portion of phase 3 represents **et CO_2** values.



Inspiration Expiration
Phase 0 : Inspiratory downstroke
Phase I : Inspiratory baseline : Dead space
Phase II : Expiratory upstroke : mixture
of dead space and alveolar gas
Phase III : Alveolar gas plateau
 α angle : Transition from phase II to phase III
 β angle : Transition from phase III to 0

Phase IV/ phase 0 : End of expiration and inspiration starts causing a drop. **Inspiratory downstroke.**

Alpha angle : Angle between phase 2 & 3.

Beta angle : Angle between phase 3 & 4.

Uses of capnography :

- **Surest sign of intubation.**
- To monitor chest compressions during CPR.
- Detect sudden dislodgement of ET tube or disconnections.
- To detect **venous air embolism (VAE)** (sudden fall of EtCO₂ value). usually VAE is seen in any surgery above heart level.
- To detect **malignant hyperthermia, bronchospasm.**

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Wave forms

00:31:16

- Normal (controlled mechanical ventilation) wave form.

Plateau shape (slight upstroke).



- Spontaneous breathing :

Normal wave form



- **Bronchospasm :**

Increase upstroke of phase 3.

Causes :

Obstructive lung diseases, Partial obstruction of ETT.



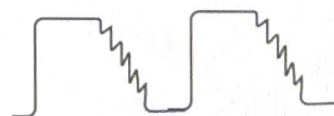
- **Cardiogenic oscillations :**

In phase 4 .

Normal phenomenon seen

in children because of heart beating against lungs.

Thin chest wall.



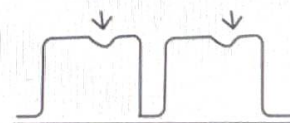
- **Curare cleft :**

Seen : During recovery from muscle relaxants.

1st muscle to recover : Diaphragm.

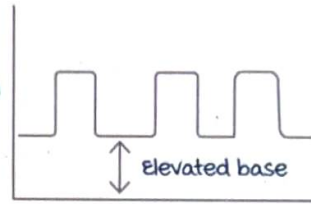
If surgery completed, administer **reversal.**

If surgery not completed, **muscle relaxant** supplemented.

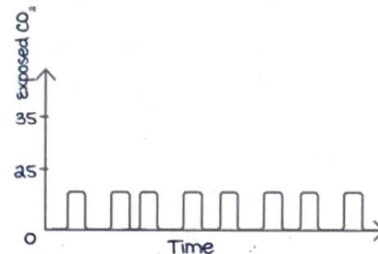


Active space

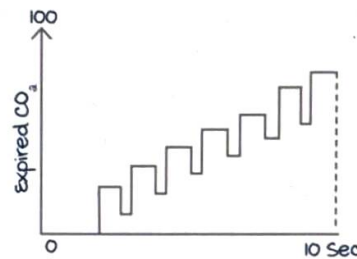
- **Rebreathing of CO_2 (faulty valve/ exhausted absorbent) :**
Rebreathed inspired or dead space gases contains some CO_2 , so elevation of baseline present.
Seen when **soda lime is exhausted.**



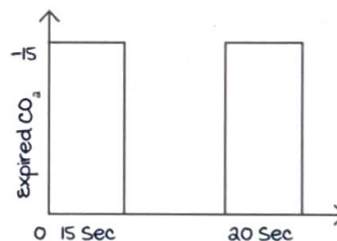
- **Hyperventilation :**
Repeated fast breathing causing repeated curves.



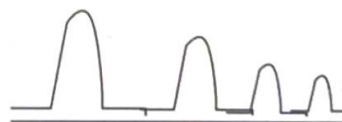
- **malignant hyperthermia (MH) :**
Inhalational anaesthetic in MH causes rapid rise in $EtCO_2$ levels reaching peak value in 10 secs.
Classical step ladder pattern :
Diagnostic of MH.



- **Hypo ventilation :**
Decreased RR.
Raised $EtCO_2$ levels
coming at very late phase.



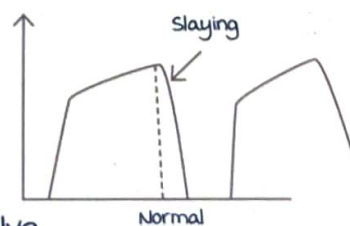
- **Oesophageal intubation :**
Initially saturation maintained because of good lung capacity.
Then remove ET tube and re intubate.



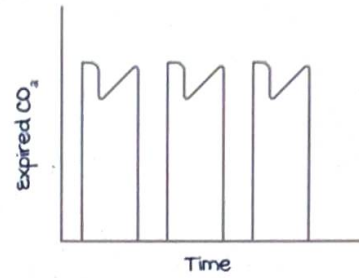
- **Dual plateau :**
Dual plateau sign
Cause : **Leaky sampling line.**



- **Incompetent inspiratory valve :**
Phase 0 is the inspiratory part.
Slaying (just dropping down) is seen.
Due to incompetent inspiratory valve.



- In single lung transplant :
2 peaks in phase 3.



- Abrupt onset of rupture of ETT/ leaking ETT.
Sudden shortening of phase.



ABG monitoring :

In ICU ABG is important in monitoring hypoxemia.

Neuro muscular monitoring

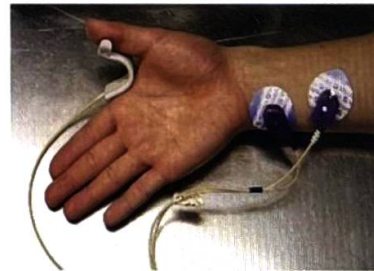
00:42:14

muscle relaxants administered as :

kumarankitindia1@gmail.com
At time of intubation, if muscles not relaxed, will lead to coughing and gag reflex. Increase in heart rate, BP and causes devastating complications.

At time of recovery, ensure all muscles return to function, if not patient will go into respiratory depression.

Neuromuscular relaxation assessment :



Equipment : Acceleromyography, mechanomyography.

Procedure : Electrodes attached to monitoring nerve and force of contraction occurs that is assessed by the equipment.

Mechanism :

A supra maximal stimulus (SS) of current provided to nerve. muscle will start to contract. value of it is measured. most commonly used nerve is ulnar nerve (UN).

most commonly used muscle is adductor Pollicis.

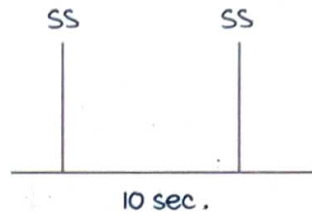
modality of application of SS :

Single twitch stimulation :

One SS given at every 10 seconds

If muscle contracts, MR have no effect.

If not contracting MR effect present.



Advantage : Easy to perform.

Disadvantages : Does not differentiate between Depolarizing muscle Relaxant (DMR) and non depolarizing muscle relaxant (NDMR).

Train of four (TOF) :

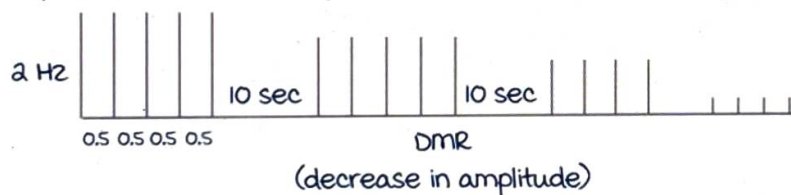
4 SS (2Hz) is given repeatedly every 0.5 seconds to assess the muscle movement.

In one SS, 2 hertz of current given .

TOF : $\frac{4\text{th amplitude response}}{1\text{st amplitude response}}$

TOF in various situations :

- In normal person without the effect of MR, TOF = 1.
- In DMR (succinyl choline) : There will be decrease in the amplitude but all 4 responses are equal. TOF is 1.



- In NDMR (pancuronium, vecuronium) : There is a gradual decrease in amplitude with each stimuli.

It is also called as fade.

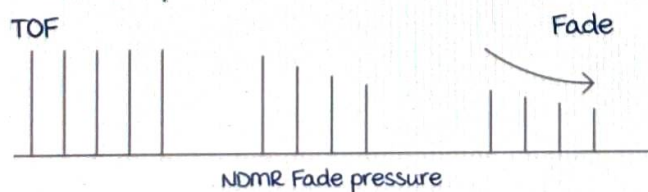
TOF > 0.9 is needed for successful extubation.

Same phenomenon is also seen in phase 2 block of succinyl choline.

When maximum dose of 5 mg/kg is exceeded : Receptors get damaged.

Previously neostigmine was administered but not suggested in recent studies.

Instead advised to gently wait as within 24 hours body will generate new receptors.



Advantage :

Differentiates between DMR (fade absent) & NDMR (fade present).

Indicates if extubation to be done or not.

Disadvantage :

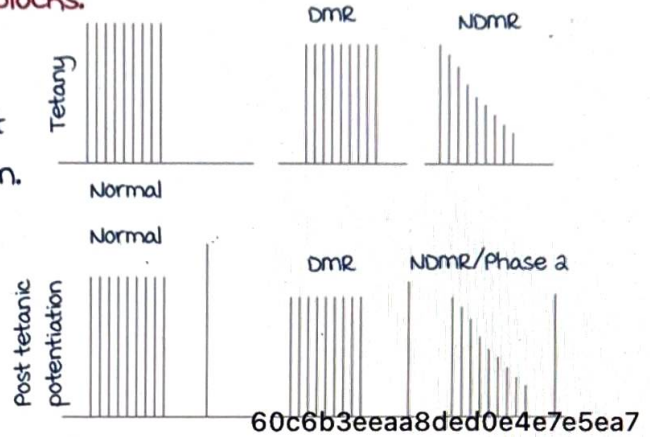
Will not indicate if muscle is adequately relaxed or not.

Not useful for deeper blocks.

Tetanic stimulation :

High frequency current applied in short duration.

50 - 100 hertz applied within 5 seconds.



In DMR :

Sustained contractions but decrease in amplitude seen.

In NDMR and Phase 2 Succinyl choline block :

Fade response is seen.

Fade : Pre synaptic event where acetyl choline in presynaptic area is completely utilised.

Post Tetanic Facilitation (PTF) :

5 - 10 secs after tetanic stimulation, again SS current is given which causes an increase in amplitude of contraction.

In NDMR, if muscle relaxation is not deep, PTF will be present.

For example if surgeon is working on vasculature and patient is not completely paralyzed, probability of surgeon injuring the vessels & causing bleeding increases.

Deep muscle relaxation obtained by continuous infusion of MR.

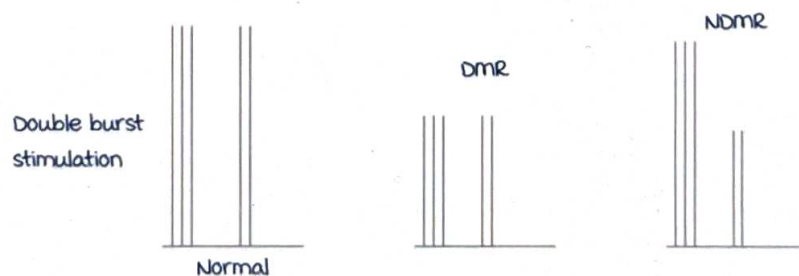
Advantage : PTF determines whether block is deep or not.

Disadvantage : Painful.

Double burst stimulation (DBS)

00:59:39

Active space



Procedure :

a short burst of tetanic stimulus given with each episode 750 millisecond apart & each burst with 0.2 millisecond duration.

DBS (3, 2) : 1st episode gives three stimulus & 2nd episode gives two stimulus. (most commonly used).

DBS (2, 2) is also present.

Advantage : Similar to tetanic stimulation but not painful.

For intubation on administering NDMR :

First muscle relaxed is diaphragm (due to high blood flow).

In ulnar nerve (UN) : First muscle relaxed is adductor pollicis (smaller muscle).

To assess if diaphragm relaxed or not during intubation :

monitoring of ulnar nerve is not preferred as adductor pollicis gets relaxed later than diaphragm.

Hence better to use central group of muscles like laryngeal adductors or corrugator supercilii.

It closely mimics diaphragm.

During maintenance :

If monitoring is done on smaller muscle or ulnar nerve, patient will buck without an adequate plane, hence corrugator supercilii preferred.

Order of recovery :

Diaphragm > large muscle > intermediate muscle > smaller muscle.

monitoring of ulnar nerve preferred for assessing adequacy of recovery.

If small muscle recovered, implies all other larger muscles and diaphragm will have recovered.

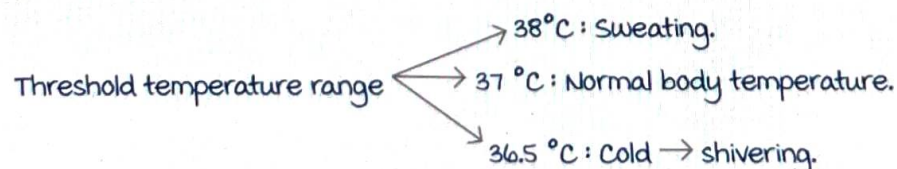
Temperature monitoring

01:06:16

most common abnormality : Hypothermia.

Hypothermia delays recovery especially in children in anaesthesia.

Range shown below is known as Inter-threshold range.



In a normal person : In between the above range, body shows no symptoms to change in temperature.

During anaesthesia, **threshold temperature range increases.**

Body reacts to hypothermia at 35°C & hyperthermia at 38.5°C .

Cause of hypothermia : **Hypothalamic depression.**

Anaesthetic drugs slightly increase sweating threshold and predominantly reduce vasoconstriction.

For example, in case of inhalational anaesthetics, $\text{O}_2 + \text{NO} + \text{Sevoflurane}$ administered.

Sevoflurane : **Body depressant** kumarankitindia1@gmail.com

Brain depressant.

Hypothalamic depressant.

Function of hypothalamus :

Body will react to hypothermia when temperature falls below 35°C .

Body reacts to hyperthermia when temperature reaches 38.5°C .

Mechanism of hypothermia :

It is **due to vasodilation.**

Vasodilation causes more amount of blood to reach body surface \rightarrow Increased heat loss (because of conduction).

Inter threshold range increases (cause for hypothermia).

Body cannot compensate for heat loss.

Anaesthetic agents causes : **Slight increase in sweating threshold.**

Predominantly **decreases vasoconstriction or response to cold.**

Causes of hypothermia :

1. Anaesthetics Agents : Due to vasodilation, hypothalamic depression increases the temperature threshold. No contraction of muscle, no heat production. Hence, causes hypothermia.
2. Cold environment in operation theatre.
3. Cold IV fluids.

Ideal humidity is 60 to 65% to prevent infection :

Because of wide exaggerated response and difficult to tolerate hypothermia, children : 28°C preferred,

In adults : 21°C is preferred.

Advantages of hypothermia :

- Decrease in oxygen consumption.
- Decrease in basal metabolic rate.

For every 1°C drop in temperature the BMR is reduced by 7%.
New guidelines of CPR : If the patient is in comatose state even after returning of spontaneous circulation, start on **institute therapeutic hypothermia for upto 24 to 48 hours** to protect brain from further injury and aid in recovery.
Therapeutic hypothermia is also used in cardiac surgeries.

Systemic effects of hypothermia :

- CVS : Decreased cardiac output .
Ventricular arrhythmia occur if temperature goes $<28^{\circ}\text{C}$.
- Respiratory system :
Shivering increases oxygen consumption.
If myocardial infarcted patient goes into cold area, body will start shivering \rightarrow Increased oxygen consumption \rightarrow High risk of precipitating angina.
- Blood in hypothermia :
Blood turns viscous \rightarrow Decrease tissue perfusion \rightarrow **metabolic acidosis**.

Hyperthermia (rare) and seen in sepsis, malignant hyperthermia.

Two types of body temperature

- Core.
- Surface (least preferred).

Monitoring of body temperature

01:16:18

Sites for core temperature assessment :

1. Pulmonary artery : For cardiac surgery.
2. Nasopharynx or tympanic membrane : Neurosurgery.
3. Lower oesophageal temperature : GIT or general surgery. Like passing Ryle's tube, probe is kept on the lower $1/3^{\text{rd}}$ region.
4. Rectal temperature : Easy technique but not so accurate. Should be less preferred.
5. Bladder : This is **not valid** if there is **urine flow**.

- 6. Bowel : Not preferred because of faeces contamination.
- 7. Axillary : Lesser preferred.
- 8. Oral.
- 9. Surface temperature (least preferred).

most common equipment to record temperature :
Thermometer.

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Active space

BOYLE'S MACHINE : PART - 1

main purpose of the machine :

1. Provide oxygen as most of the anaesthetics are depressants.

60c6b36a Provide anaesthesia

Boyle's machine inventor : Sir Henry Edmund Gaskin Boyle.



Anaesthesia machine : Classification	
Continuous flow	Intermittent flow
Gases flow throughout inspiration and expiration.	Patient has to draw the inspired anesthetic during inspiration.
Example : Boyle's machine.	Example : meckesson, used for labour analgesia.

Boyle's machine is divided into 3 categories :

High pressure	Intermediate pressure	Low pressure
<ul style="list-style-type: none"> • Cylinders • Hanger yoke • Cylinder pressure indicator (gauge) • Pressure regulators 	<ul style="list-style-type: none"> • master switch • Pipeline inlet connection • Pressure indicators • Gas power outlets • O₂ pressure failure devices • Gas selector switch • 2nd stage pressure regulator • O₂ flush • Flow adjustment control 	<ul style="list-style-type: none"> • Flow meter • Hypoxia prevention safety devices • Unidirectional (check) valves • Pressure relief device • Low pressure piping • Common (fresh) gas • Outlet

High pressure system :

Different sources of oxygen supply in hospital :

O_a cylinders.

Liquid oxygen tank.

O_a concentrator.



Classification of cylinder

00:13:15

Basis for classification : Critical temperature (CT) (The temperature above which a gas cannot be compressed to liquid no matter the pressure applied).	
Liquifiable gas cylinder	Non liquifiable gas cylinder
N ₂ O : CT : 36.5°C < 36.5°C = Liquid N ₂ O > 36.5°C = Gas N ₂ O	O ₂ : CT : -183°C < -183°C = Liquid O ₂ > -183°C = Gas O ₂

Identification of cylinder (colour coding)	
O ₂	Black body with white shoulder
N ₂ O	Blue cylinder
CO ₂	Grey cylinder
N ₂	Black cylinder
Helium	Brown cylinder
Air	White body with black shoulder
Entonox	Blue body with white shoulder
Cyclopropane	Orange

medical cylinders are made of an alloy of molybdenum steel.

MRI suit rooms : Special Aluminium made cylinders are to be used (since aluminium is not attracted to the magnetic field or else use an ambubag in case aluminum cylinders are unavailable).

Active space

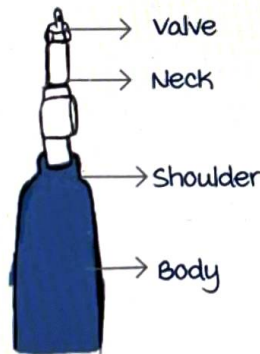
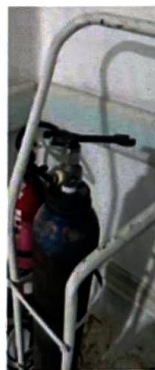
Safety features of cylinder

00:23:15

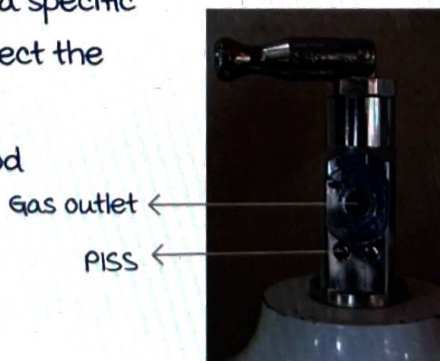
1. Color : Do not change the color of the cylinders.
2. Cylinder markings : Labels on the cylinder give information about :
 - **Service pressure** (max. pressure a cylinder can be refilled at 70 °F, applicable only to non - liquifiable gases (O₂)).
 - **manufacturer name.**
 - **Transportation number.**
 - **Cylinder number.**
 - **DOT specification number.**
 - **Testing date.**
 - **Filling ratio** : Instead of service pressure, liquifiable gases have filling ratio/ density.

Filling ratio = weight of empty cylinder / weight of water that it can hold.

3. Valve : The valve on a cylinder is usually made of brass or bronze and can be of 2 types : Packed type valve or diaphragm type valve. Inside the valve, there is also a pressure relief device.



4. Pin Index Safety System (PISS) :
For each type of cylinder, a specific pattern/ pin exists to connect the cylinder to the machine.
Creates a full proof method to eliminate crisscrossing of cylinders.

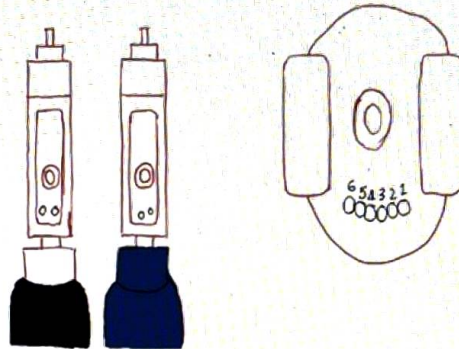


Active space

Air : 1,5
O _a : 2,5
N ₂ O : 3,5
CO ₂ : <7.5% : 2,6 > 7.5% : 1,6
Entonox : 7

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Entonox is 50% N₂O & 50% O₂, this gas is used for labour analgesia.



There are holes arranged in the valve in the form of an arc of a circle.

Each hole has a number.

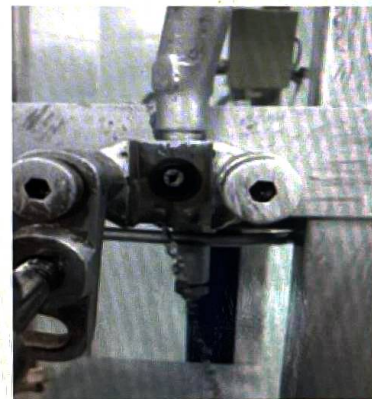
Correspondingly on the machine, there are pins.

Each cylinder has got a specific PISS number.

5. Bodock pressure seal :

To prevent leakage of gases when connected to Boyle's machine.

If more than 1 gasket seal/ pressure seal is used, the PISS will be void of function, as we can interchange the cylinders.



6. Sizes of cylinder : AA to H in increasing order of capacity.

AA : Smallest cylinder

H : Largest cylinder.

E type cylinder having capacity of 640 ltrs is generally used for Boyle's machine.

Measurement of contents of cylinder

00:41:38

Bourdon's pressure gauge is used to measure the contents of the cylinder. This gauge does not function for liquifiable gas cylinders (N_2O).

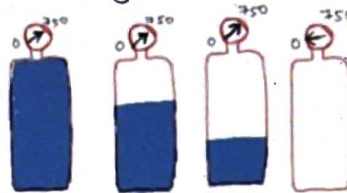
Pressure inside the O_2 cylinder is 2000 Psi.

Pressure inside N_2O cylinder is 760 Psi.

Pressure of cyclopropane cylinder (orange color) is 60 Psi.



Liquifiable gas cylinder



Liquid oxygen tank : 1 ml of O_2 = 840 ml of gas.

Q. What is the temperature of O_2 in liquid tanks ?

Ans : $-200^\circ C$, because oxygen has a critical temperature of $-183^\circ C$. The temperature is maintained by creating a vacuum around the storage tank. (Thermos flask principle)

Oxygen concentrators :

Works on the principal of Pressure swing adsorbent (PSA) technology. About 96% pure O_2 can be delivered by this machine.



Pressure relief device :

Consists of a spring and an opening to relieve pressure when pressure exceeds Oxygen concentrator in the cylinder.



Handle (handle wheel) : Rotate in anticlockwise direction to open.

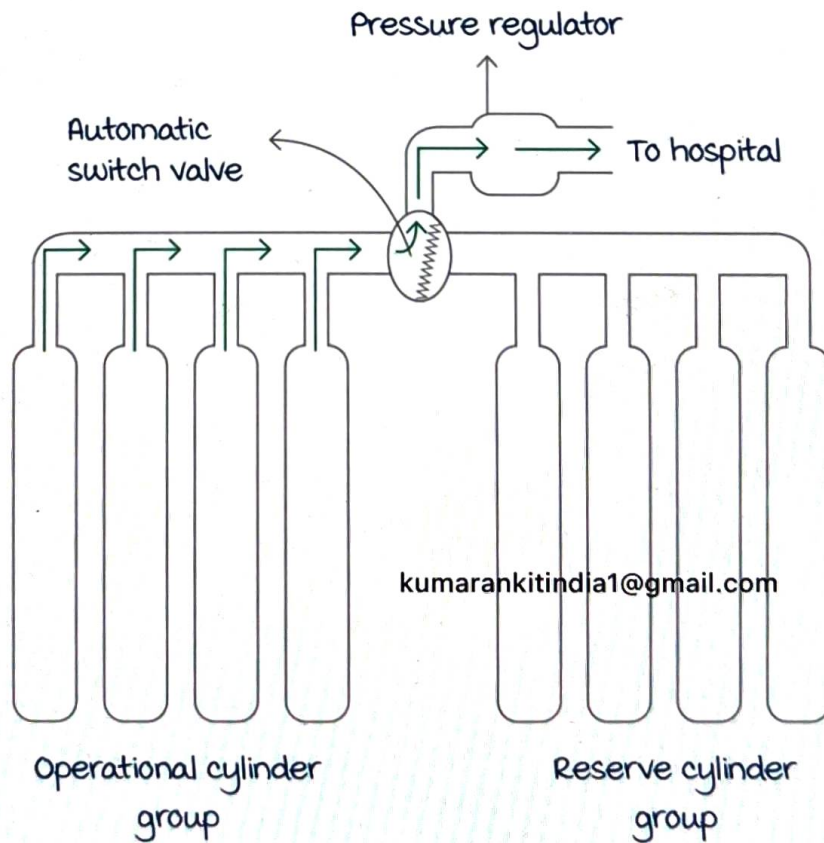
Active space

Yoke Assembly :

Is the point where the cylinder is attached to the Boyle's machine. Yoke assembly has a **unidirectional valve** so that gas travels to the yoke assembly than to another empty cylinder.



manifold : when **multiple cylinders** are linked to provide constant supply of gas.



Active space

BOYLE'S MACHINE : PART - 2

Intermediate pressure system

00:00:10

The pressure inside oxygen cylinder is 2000 psi, and the pressure inside nitrous oxide cylinder is 760 psi.

The pressure regulating/reducing valve will make the pressure for both gases uniform at around 50-55 psi.

Components of the intermediate pressure system :

- Piping.
- Pipeline pressure indicators.
- Pipeline inlet connection system/



Pipeline pressure indicators

Diameter Index Safety System (DISS) : It is a non-interchangeable system.

- master switch (gas power outlet) : Only present at work station, if switched on all electrical connection gets activated.



master switch

Oxygen flush valve

- Oxygen fail-safe devices : whenever the concentration of oxygen in the cylinders decreases, it automatically reduces the flow of nitrous oxide. This is to prevent nitrous oxide from reaching the patient as it would not allow the patient to recover from anaesthesia.

Active space

- **Oxygen supply failure alarm** : High priority alarm, that intimates when oxygen supply falls. Earlier called **Bowman's whistle**, these used to go off whenever the oxygen fail safe device is activated.
- **Second stage pressure regulator** : In some machines for precision, these pressure regulators decrease the pressure from **50-55 psi to 20-25 psi**.
- **Oxygen flush valve (O_2+)** : It will deliver **35-75 litres/min** of oxygen, i.e. high unmetered flow of oxygen from high pressure system to the patient. Can be used in cases where there is decreased oxygen in cylinder. Continuous O_2 flush can lead to **barotrauma**, dilution of the inhalational anaesthetic vapour and patient can have awareness.

Low pressure system

00:15:18

It starts from flow control valves to the common gas outlet.

The pressure is maintained around **10-15 psi**.

Components in the low pressure system :

- Flow meters/**Rotameters**.
- Hypoxia prevention safety devices.
- Unidirectional valve.
- Pressure relief devices.
- Common gas outlet.
- Vaporizers and their mounting devices.

Flow meters/rotameters

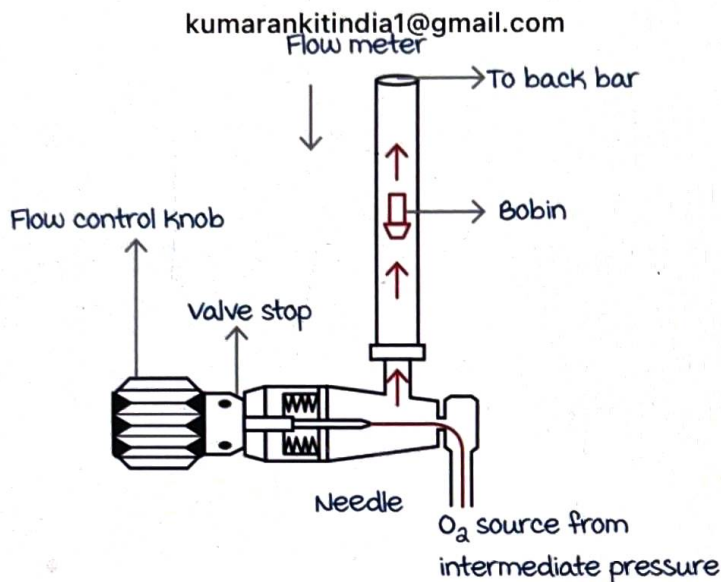
00:16:41

Parts of a flow meter are as follows :

- Small indicator called **bobin**.
- A small control knob which when turned in anti-clockwise direction will open and gases will flow while turning in clockwise direction will close the gasflow. These are **constant pressure variable orifice devices**.

Internally, the flow meters are slightly conical so that as gases flow in, the bobbin does not obstruct the meter and cause pressure build-up as would have been the case if the flow meters were cylindrical.

The oxygen flow meter and the nitrous oxide flow meter are colour coded and touch sensitive.



Based on the shape of bobbin the reading is taken differently as explained below :

- If the bobbin is circular the reading is taken at the middle.
- If it is hob shaped, the reading is taken at the bottom.
- If it is conical, the reading is taken at the top.

Flow meters are calibrated and gas specific.

Problem with flow control valves :

Flow meters are the most common site for gas leakage.

They are prone to damage, especially the control knob.

If the atmospheric pressure is reduced, the flows will be high such that we might be giving 2L but the patient gets 3L. The readings are erroneous, this is because these flow meters are calibrated at sea-level.

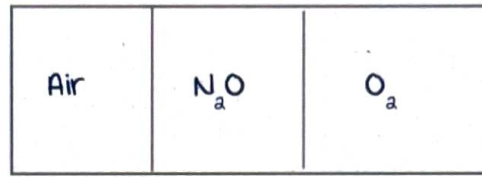
Flow meter assembly

00:24:06

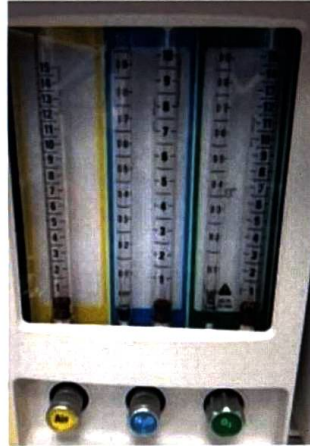
Older work stations, O_2 is on the left side and N_2O is on the right side.

Newer work stations, O_2 is on the right side and N_2O is on the left side.

To avoid confusion, O_a flowmeter should always be located downstream.



Flow adjustment controls :

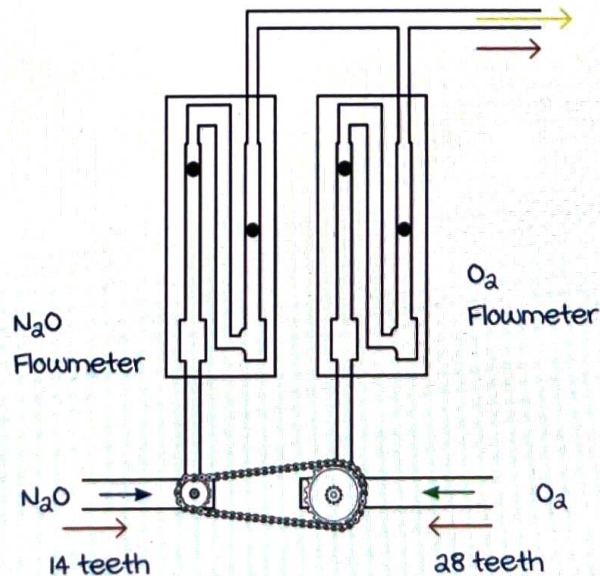


In the day to day practice, 'Low flow anaesthesia' is followed. Flow meter assembly is the usage of dual chambered flowmeter to have a precise control of gas flow during low flow anaesthesia.

In the first chamber they have 0-1 L only, whereas in the second chamber they have 1-10 L.

When the gas flows are very low it will be laminar flow, if the gas flows are very high it will be turbulent flow.

At the top of flow meter there is a stop that prevents the movement of bobbin into the system/patient's mouth.



Safety features of flow meter :

- **minimum mandatory oxygen flow** : Unless the flow meter is switched off, **minimum of 250 ml/min of oxygen** is always delivered.
- **Link system** where oxygen and nitrous oxide flow meters are interconnected by a chain like system. This means even **accidental closure of oxygen flow meter** will bring about an **automatic decrease** in the nitrous oxide flow.

Oxygen flowmeter has **28 spokes** whereas nitrous oxide flowmeter has **14 spokes**.

Thus, when the concentration of oxygen flowmeter is reduced it automatically reduces the concentration of nitrous oxide flow.

Back bar :

Back bar forms the frame work of the machine where the vaporizer is mounted.



Vaporizer is a specialised machine that holds the inhalational anaesthetic.

All inhalational anaesthetics are volatile liquids stored in the liquid form in a container, which is called vaporizer.

Yoke assembly :

Oxygen and nitrous oxide coming from the high pressure system moves into the intermediate pressure system and finally into the low pressure system.



The oxygen and nitrous oxide from respective flow meter goes into the back bar where it picks up the anaesthetic vapour from the vaporizer and goes into common/fresh gas outlet.

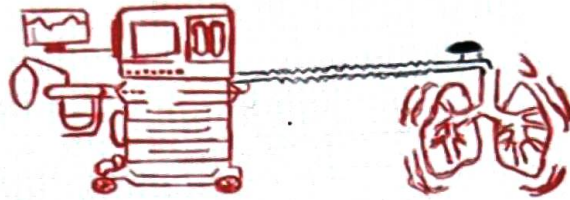
Common gas outlet receives the ^{kumarankitindia1@gmail.com} oxygen + nitrous oxide + anaesthetic vapour.

Active space

BREATHING SYSTEM

Breathing systems

00:00:11



Breathing system means circuit.

It is a connection between Boyle's machine and endotracheal tube.

Classification :

- Open.
- Semi open/ semi closed.
- Closed.



Schimmel Busch mask

Open circuit : Schimmel Busch mask.

Advantages :

- Simple device.
- Does not require much knowledge.

Disadvantages :

Lot of theatre pollution.

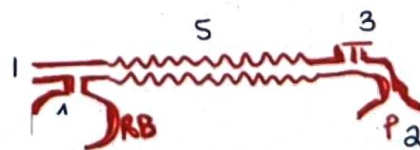
Semi open (or) semi closed :

Described by mapleson, hence aka mapleson circuit.



Has 5 components :

1. Machine end
2. Patient's end
3. Adjustable pressure limiting valve (APL valve).
4. Reservoir bag (represents lung compliance).
5. Corrugated tubing.



Active space

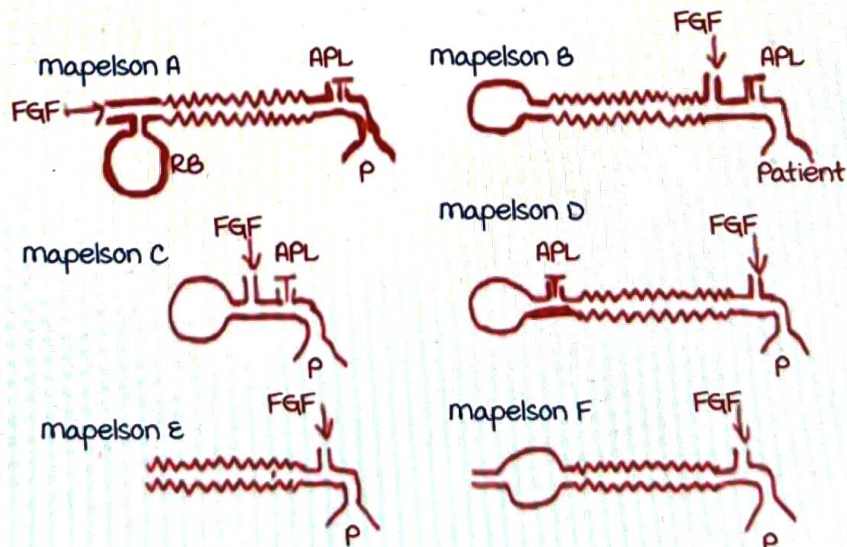
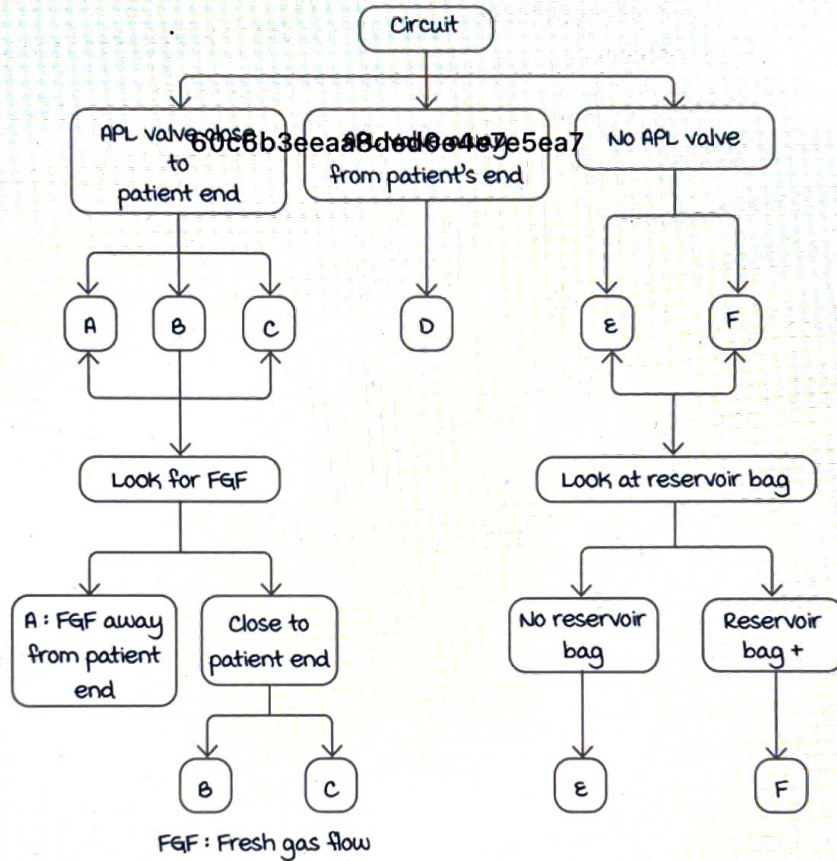
APL valve consists of a lid and spring.

If gases flow in one direction (unidirectional) → Lids closed.

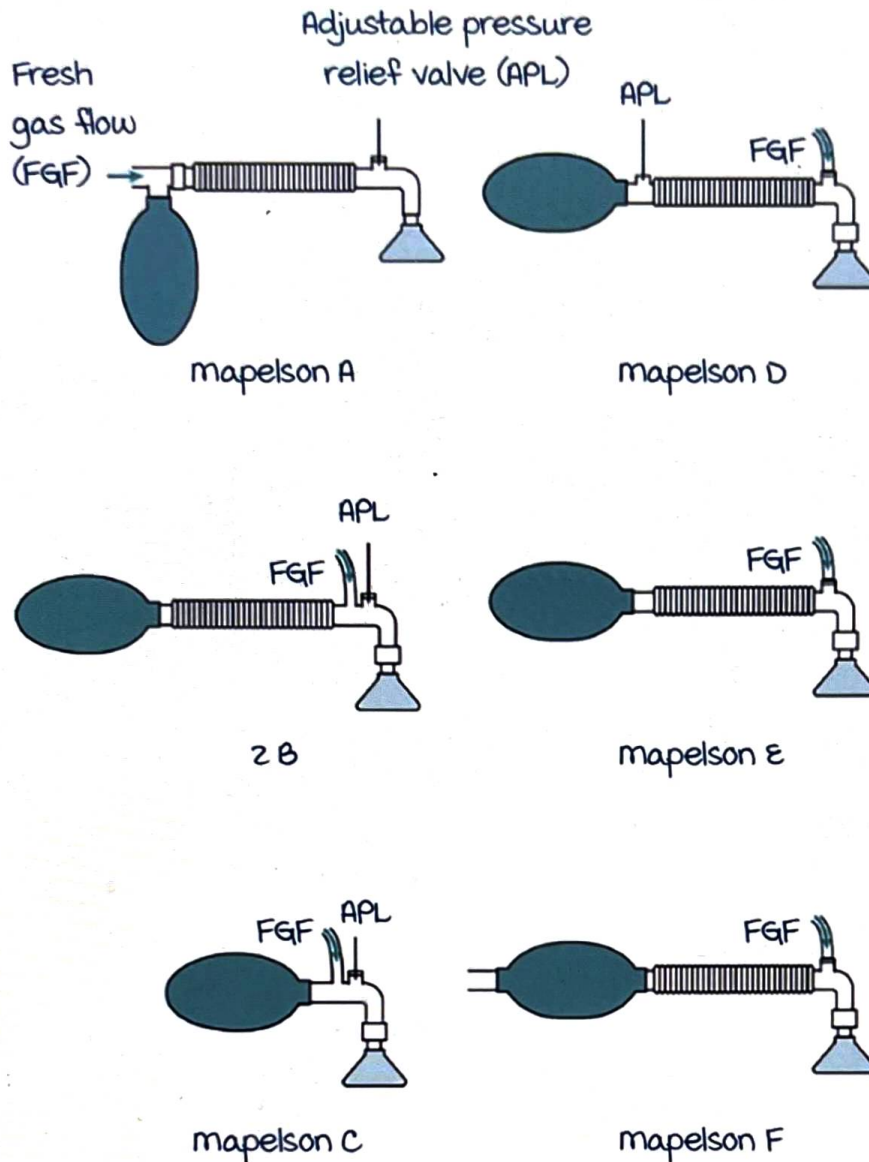
If a different gases flow in a different directions → Lids opened.

How to identify Mapelson circuit by looking at a diagram

00:08:05



Active space



kumarankitindia1@gmail.com

Type A is the circuit of choice for spontaneous respiration. It is also known as **magill circuit**.

Lack circuit: modification of Type A system.

- Co axial circuit (circuit within a circuit).
- Inner tubing is for expiration of gases.

Type B: Obsolete circuit, no more used.

Type C: Obsolete circuit, no more used (functionally B, C are equally effective for spontaneous and CV). Has no corrugated tubing. Also called as **to & fro circuit**.

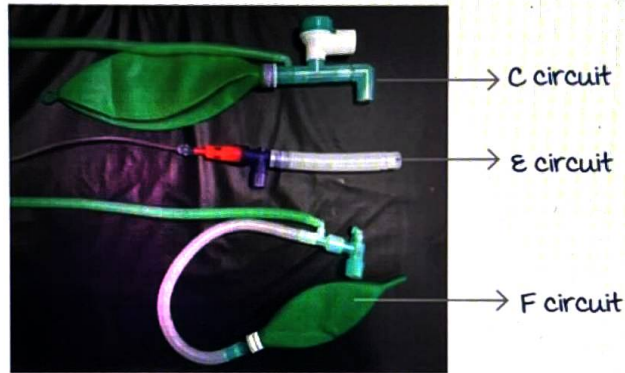
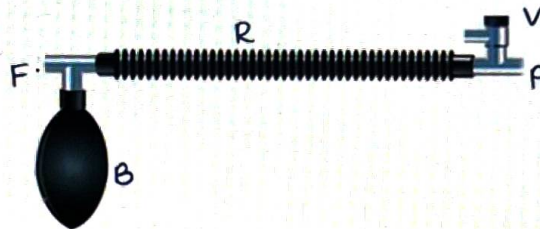
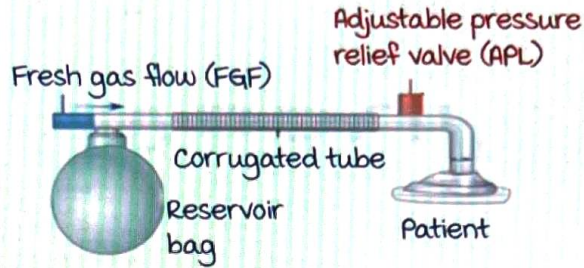
In type A circuit: For spontaneous respiration:

$$MV = 500 \times 12$$

$MV = 6000$ ml of gases \rightarrow 6L per minute is required.

Hence, type A circuit is called as circuit with least FGF requirement.

mapleson A (magill's circuit)



Type D:

Circuit of choice for controlled ventilation.

FGF required is very least in this circuit.

Circuit D = $1.6 \times 6 = 9.6 \text{ L/min} \rightarrow$ Approx 10 L/min.

Bain's circuit is a modification of D circuit, which is also a co axial circuit.

Difference between Lack's circuit and Bain's circuit :

In Lack's circuit (A), inner tubing is for **expiratory gases**.

In Bain's circuit (D), inner tubing is for **inspiratory gases**.

Circuit length is 1.6 mts.

mapleson E : Aka **Ayres T piece**.

mapleson F :

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It is a **Jackson Rees modification of Ayres T piece** (mapleson E) system.

usually used for children < 6 years of age and < 20 Kgs.

Circuit of choice for spontaneous ventilation : A > DFE > CB.

For controlled ventilation : DFE > BC > A.

Active space

Performance depends on :

- FGF.

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- mode of ventilation (spontaneous or controlled).
- I : E ratio expiratory pause duration peak inspiratory flow.
- volume of reservoir bag or tubing.
- ventilation through mask or ETT.
- Sampling site.

Circuit type	Spontaneous	Controlled
Type A	= mv	3xmv
Type B	2xmv	2.25xmv
Type C	2xmv	2.25xmv
Type D	2.5xmv	1.6xmv
Type E	2.5xmv	3xmv
Type F	2.5xmv	1.5-2xmv

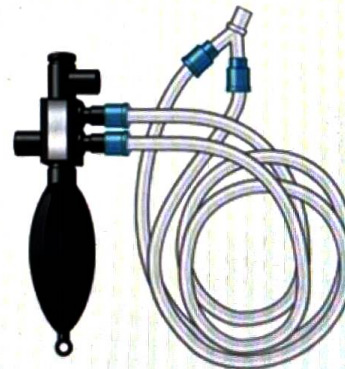
Newer circuits

00:23:55

Newer circuits : Humphrey ADE, PENLON, MERA-F, LACKS
(all these are co axial circuits).

Newer semi closed circuit

Humphrey ADE or
semi closed circuit



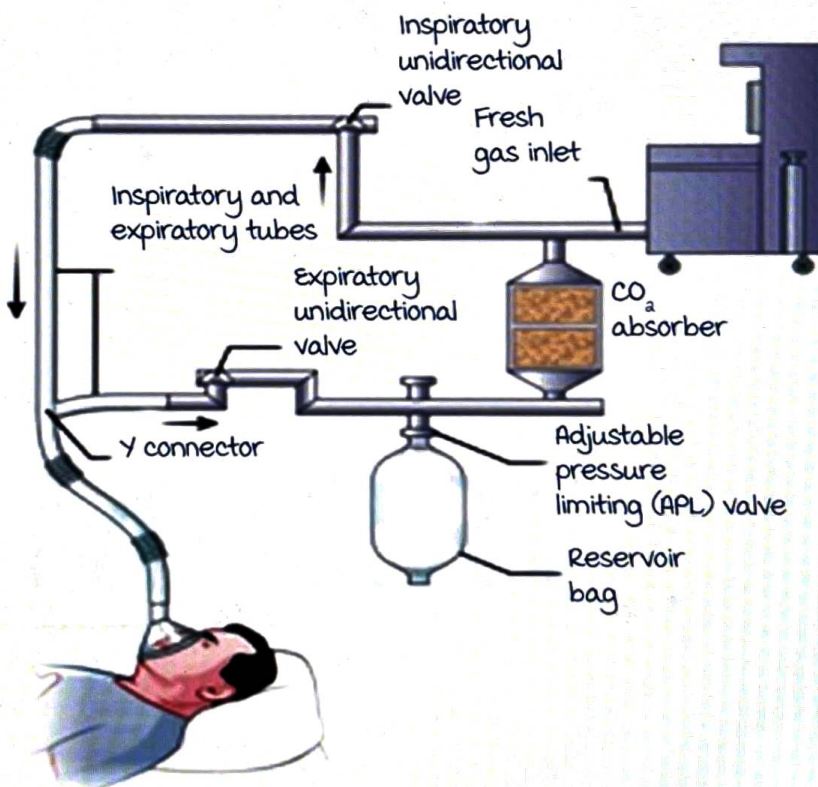
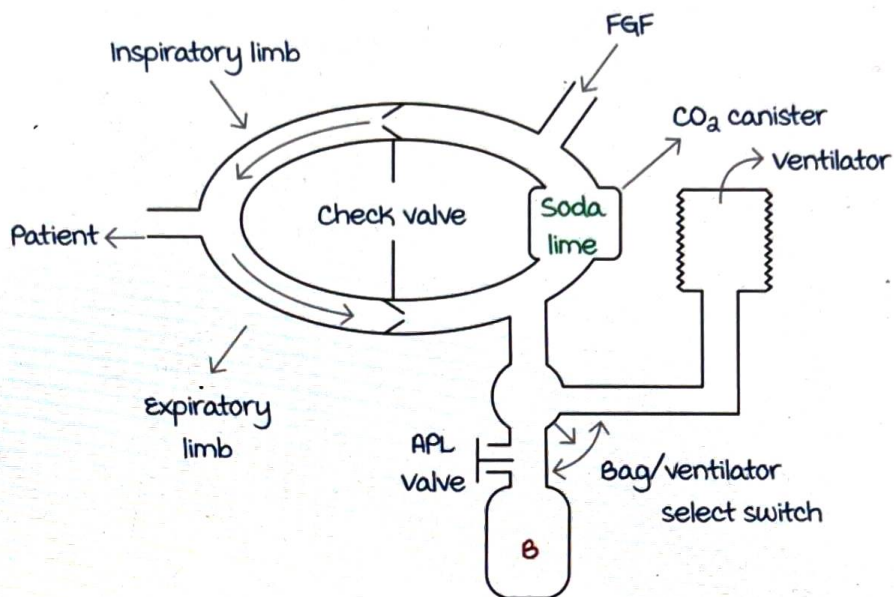
Humphrey ADE circuit



Active space

Closed circuits

00:25:14



If a person inhales 21% of O_2 → He exhales 16% of O_2 .

Duration exhalation, 16% of O_2 and 5% of CO_2 .

Recycling : If CO_2 can be re absorbed during expiration, 16% O_2 can be recycled. Brings down the number of flows, which will help in closed circuit. Patient will receive O_2 from FGF via unidirectional valves. The CO_2 produced flows through the expiratory limb via another unidirectional valve. The expired air containing both O_2 & CO_2 flows through an unit containing soda lime. All of CO_2 is re absorbed & O_2 is recycled.

Active space

main component in closed circuit is **sodalime**.



Sodalime cannister



APL valve



Parts of closed circuits :

- FGF.
- Corrugated tube.
- Patient's end.
- Presence of Soda lime.

Advantages : Recycle of gases and lesser number of flows.

Disadvantage : Adds lots of resistance.

Purpose of components

00:30:48

Absorbant	$Ca(OH)_a$	NaOH	KOH	H_aO	Others
Classic sodalime	80	3	2	16	
New sodalime	73	< 4	0	< 19	
Sodasorb	76.5	2.25	2.25	18.9	
Sodasorb LF	> 80	< 1	0	15 - 17	
Druggersorb	82	2	0.003	16	
medisorb	81	1 - 2	0.003	18	
Barylime	73	0	5	11 - 16	$Ba(OH)_a : 11 - 16$
Druggersorb free	74 - 82	0.5 - 2	0	14 - 18	$CaCl_a : 3 - 5$
Amsorb plus	> 75	0	0	14.5	< 1 $CaCl_a$, $CaSO_4$
Softnolime	> 75	< 3	0	12 - 19	
Litholime	> 75	0	0	12 - 19	< 3 $LiCl_a$
Spiralith	0	0	0	0	$LiOH - 95\%$, 5% polyethylene

Active space

main components of soda lime : Ca(OH)_2 : 80%.

NaOH : 3%, KOH : 2%, H_2O : 16%.

$\text{CO}_2 + \text{Ca(OH)}_2 \rightarrow \text{CaCO}_3 + (\text{Slow reaction})$.

Faster reaction :

$\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$

$\text{H}_2\text{CO}_3 + \text{NaOH (or) KOH} \rightarrow \text{Na}_2\text{CO}_3 \text{ (or) } \text{K}_2\text{CO}_3 + \text{H}_2\text{O}$.

$\text{Na}_2\text{CO}_3 \text{ (or) } \text{K}_2\text{CO}_3 + \text{Ca(OH)}_2 \rightarrow \text{CaCO}_3 + \text{NaOH or KOH} + \text{H}_2\text{O}$.

main component of the reaction : NaOH/ KOH (helps initiate).

CO_2 : Reabsorbed, NaOH/ KOH : Reproduced, H_2O : Reused.

Silica can also be added which is an hardening agent.

Spiralith : LiOH → Doesn't require NaOH to absorb CO_2 .

Concerns with soda lime (CO_2 absorbents)

00:35:41

Soda lime + Trilene → Phosgene + Dichloroacetylene.

Phosgene is a respiratory irritant and dichloroacetylene is neurotoxic.

Soda lime + Sevoflurane $\xrightarrow{\text{Prolonged period}}$ Compound A.

Compound A is proven nephrotoxic in lower group of animals.

Barylime : Ba(OH)_2 → more exothermic reaction & more compound A.

Li(OH)_2 → No compound A.

Carbon monoxide production :

Inhalational anaesthetics + Soda lime (strong alkali) → CO .

When CO binds with Hb → HbCO (carboxyhemoglobin).

CO production is even more in Barylime.

Factors responsible for CO production :

- Agent :
Barylime > Soda lime.
Desflurane (more CO).
Desflurane > Enflurane > Isoflurane >> Halothane > / =
Sevoflurane.
- Repeated usage → Dryness.
- High temperatures.
- Concentration of agent.
- Low FGF.
- Desiccated soda lime.

Identification of desiccation

00:41:14

Indicator : Changes it's colour.

Ethylene violet is most commonly used.

It changes from white to purple (during dessication).

In capnography, whenever there is re breathing or sodalime is desiccated → Elevation of baseline.

Indicator	Colour when fresh	Colour when exhausted
Phenolphthalein	White	Pink
Ethyl violet	White	Purple
Clayton yellow	Red	Yellow
Ethyl orange	Orange	Yellow
mimosa 2	Red	White

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Heat production :

Barylime : maximum heat production.

LiOH_a : minimal or no heat production.

Absorbing capacity :

Ca(OH)_a : 0.59 lb of CO_a .

LiOH_a : 0.91 lb of CO_a .

Factors deciding absorption :

Size of granules : 4 - 8 mesh size.

Too large size → Reduce absorption.

Too small size → Channelling effect of granules.

REGIONAL ANAESTHESIA : PART - 1

Classification :

Central neuraxial blockade	Peripheral neuraxial blockade.
<ul style="list-style-type: none"> • Spinal anaesthesia • Epidural anaesthesia • Caudal anaesthesia 	All blocks e.g. femoral, brachial, intercostal block etc.

Spinal anaesthesia

00:01:43

Also known as **subarachnoid block**.

Similar to lumbar puncture.

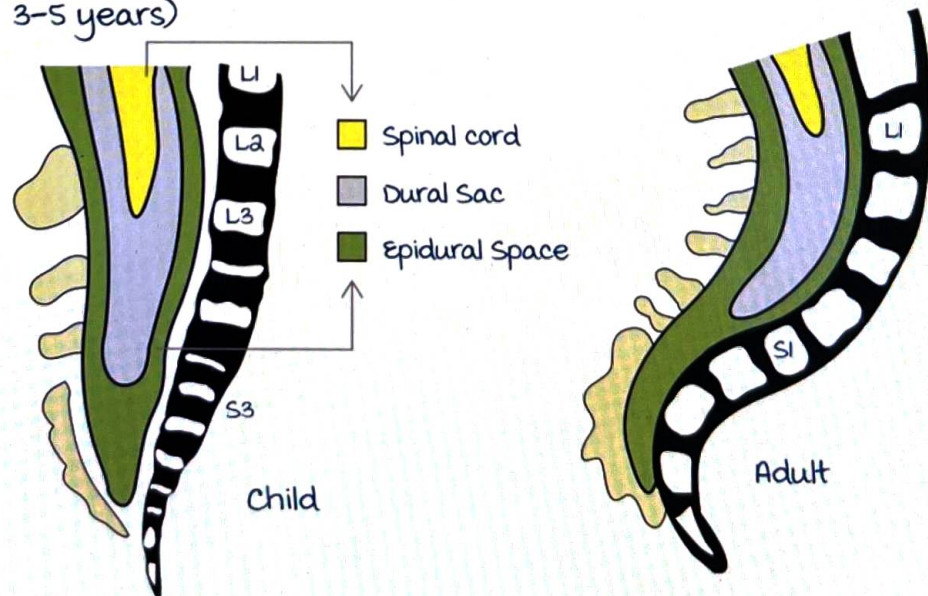
During intrauterine life : **Whole of vertebral column** is occupied by spinal cord.

During time of birth :

- Bony vertebral column grows at a faster pace.
- Spinal cord grows at a slower pace.
- Dura mater and pia mater grows at an intermediate pace.

Adult : Spinal cord ends at L1.

Infant : Spinal cord ends at L3 (reaches adult level at age 3-5 years)



Active space

Indications :

- Any surgery **below the level** of umbilicus.
- Surgeries **at the level** of umbilicus.

Contraindications :

Absolute	Relative (based on clinical judgement)
<ul style="list-style-type: none"> • Raised ICP (Projectile vomiting, papilledema, identified via imaging) : Sudden decompression leads to herniation/coning of brain contents. • Bleeding disorders : Clot formed after 5-10 min in bleeding disorders leads to compression of spinal cord that can lead to permanent paraplegia. • Infection at the site of injection : Can spread to brain. • Patient refusal. • Severe hypovolemia/ hypotension. • Severe hypertension : Spinal anaesthesia can cause hypotension. Sudden drop in BP can cause hypoperfusion of vital organs. • mitral stenosis/Aortic stenosis : Any fixed cardiac output lesion. • Allergy to the drug. 	<ul style="list-style-type: none"> • moderate hypertension/ hypovolemia. • Spinal deformities. • Previous history of spine surgery. • Chronic backache. • Progressive neurological disorders (spinal anaesthesia can worsen it). • Septicemia. • Heart blocks.

Active space

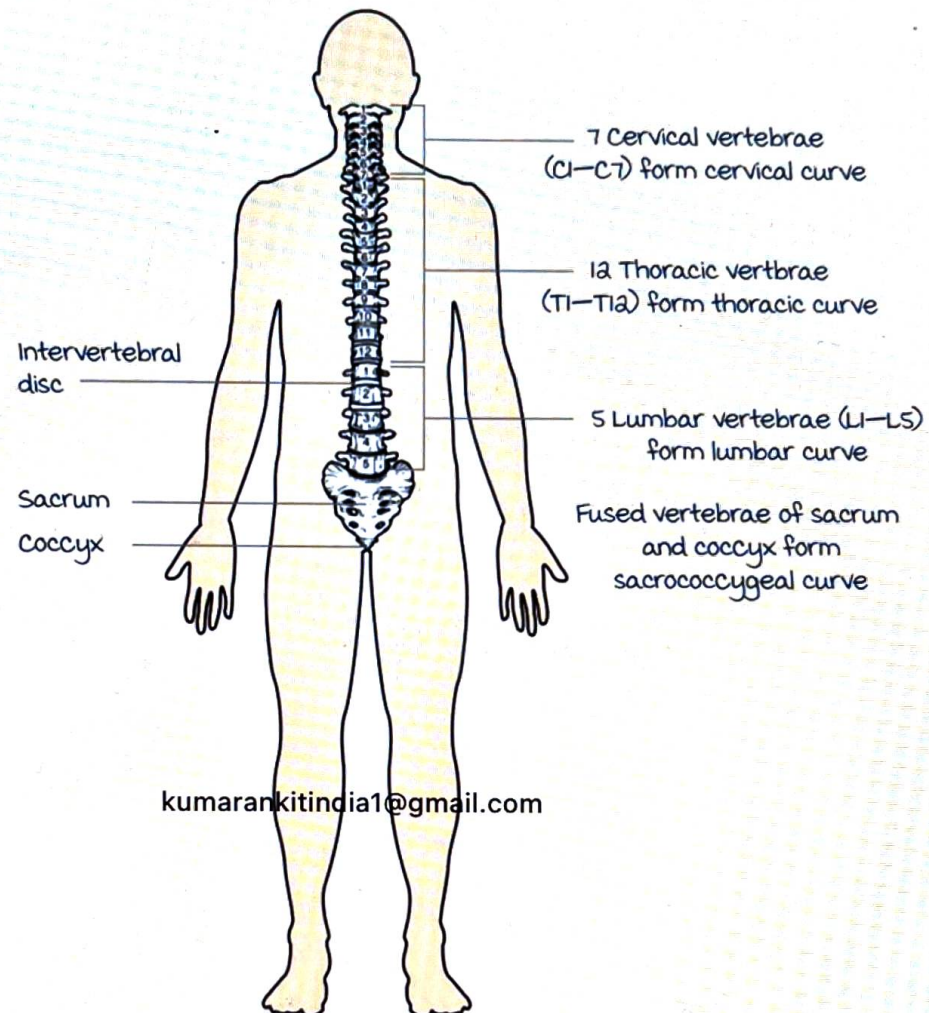
Procedure & approach

00:23:38

Adult (L1) : L3-L4.

Children (L2-L3) : L4-L5.

Tuffier's line : Imaginary line that passes through L4 spinous process or through L4-L5 interspace.



Steps to do procedure :

3P's :

- Preparation.
- Position.
- Projection.

Preparation :

- Precautions to prevent infection (e.g. 2% chlorhexidine)
- Keep an intravenous line active.
- Keep all resuscitation equipments ready.

Position :

- **Sitting** position.
- Left lateral position.
- Prone position.

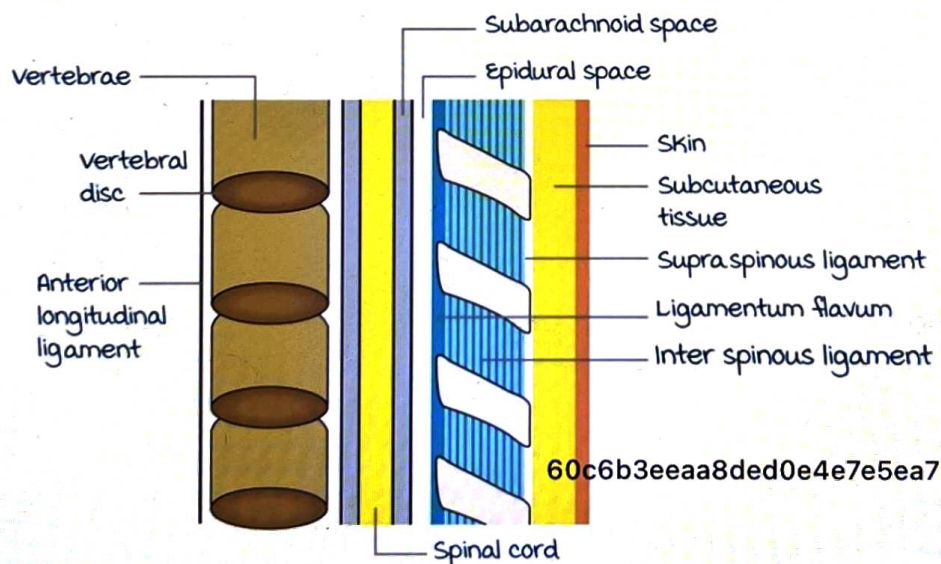
Approaches :

- **midline** approach (between spinous process).
- **Paramedian** approach (1 cm lateral to spinal process).

Projection :

Structures pierced while giving spinal anaesthesia :

1. Skin.
2. Subcutaneous tissue.
3. Supraspinous ligament.
4. Interspinous ligament.
5. Ligamentum flavum : **maximum resistance.**
6. Duramater.
7. Arachnoid : CSF.
8. Pia mater : Not to be pierced.



Spinal anaesthesia : Sub arachnoid block.

Epidural : Above duramater.

Active space

Classification of spinal needles

00:32:07

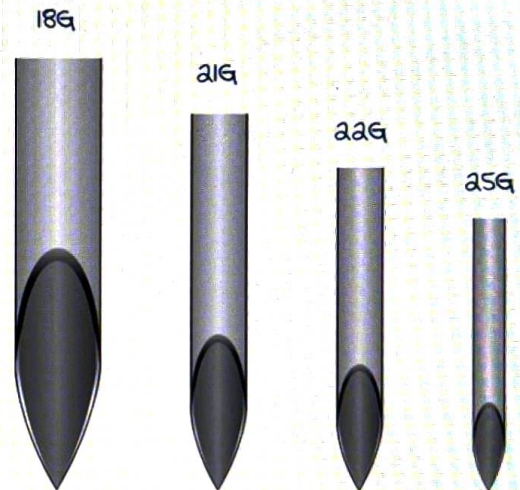
Dura cutting needles 60c6b3eeaa8ded0e4e7e5ea7	Dura splitting needles
makes a hole in the dura	makes a small vent.
more CSF loss. more headache.	Less CSF loss. Less headache.
Examples : Quincke Babcock	Examples : Whitacare, Sparte
Technically easier as layers can be appreciated better.	Technically difficult
Gauge of needles (size)	Drugs
more the number/i.e. Finer the needle.	Local anaesthetics or will add additives.

18G :

- Creates big hole.
- more CSF loss.
- more headache.

25G :

- Less CSF loss.
- Less headache.
- Smaller hole.



Identify the needle that has highest chance of causing PDPH :

- A) 23G Quincke.
- B) 23G Whitacare.
- C) 18G Quincke.
- D) 18G Whitacare.

Post Dural Puncture Headache (PDPH)

00:40:50

Complications of subarachnoid block/spinal anaesthesia.

Etiology : Spinal anaesthesia with dura cutting and thicker needles.

Incidence : Seen predominantly in females (after LSCS).

Pathophysiology : CSF leakage (reduced cushioning effect).

Clinical presentation :

- Onset : 24-48 hours after administering spinal anaesthesia. This is the time taken for significant amount of CSF to leak.

Active space

- Site : Occipital region & frontal region.
- Character: Dull boring kind of headache (mild to moderate intensity).
- Associated symptoms :
Nausea, vomiting, photophobia, 6th nerve palsy (rare)
Never associated with neck rigidity.
- Aggravating factors : Walking, talking, coughing, straining during defecation increases CSF leak.
- Relieving factors : Taking rest.

Treatment of PDPH :

Improving the CSF production :

- CSF is produced by ultrafiltration of plasma.
- Adequate bed rest.
- Good hydration (Oral or IV fluids).

Medical therapy :

Simple analgesics are enough to relieve headache.

Caffeine + Paracetamol combination tablets are preferred.

Caffeine helps in vasoconstriction and CSF production.

If not resolving : Epidural blood patches.

Injecting patients own blood (10-15 ml) into epidural space.

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The clot that is formed will help in healing.

Follow strict aseptic precautions.

Block monitoring :

Sensory level checking	Motor level Bromage scale :
By doing pin prick test, we can get level of anaesthesia (According to dermatome). Umbilicus (T10), xiphisternum (T6), nipple (T4) & manubrium sternum (T2) etc.	Assess motor block : 0 : Can freely move the leg and feet 1 : Able to flex knees. 2 : Able to move only feet. 3 : No movement at all.

Active space

Level of block required for common surgeries :

LSCS	Up to T4
Prostate	Up to T10
Upper abdominal surgery	T4
Hip Surgery	Up to T10
Foot and ankle surgery	La

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Active space

REGIONAL ANAESTHESIA : PART - 2

Factors affecting height of spinal anaesthesia 00:00:14

Drug factors	Patient factors	Procedure factors
Baricity. Dose.	CSF volume. Age. Pregnancy.	Position. Epidural injection: post spinal.
Less important	Less important	Less important
Volume. Concentration. Temperature. Viscosity.	Weight, height. Spinal anatomy. Intra-abdominal pressure.	Level of injection. Fluid currents. Needle type & direction.

Baricity of the drug :

Density of the drug when compared to density of CSF.

Density of CSF : 1.00059 g/L.

Hypobaric drug (less dense than CSF density) :

Drug floats in CSF → Higher level of anaesthesia.

Hyperbaric drug (density of drug > CSF density) :

Drug will settle down → Lower the level of anaesthesia.

Dose of drug = volume × concentration.

i.e., Dose \propto volume \propto level of anaesthesia.

So, higher the dose/volume of the drug, higher is the level of anaesthesia.

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Patient factors

00:07:50

CSF volume	Age	Pregnancy
<p>Children will have more volume of CSF per segment level.</p> <p>Old age : Low CSF volume. CSF volume is inversely proportional to the level of anaesthesia.</p>	<ul style="list-style-type: none"> As age increases, specific gravity increases. In old age, it becomes hypobaric resulting in higher level of anaesthesia. 	<ul style="list-style-type: none"> Due to gravid uterus compressing the epidural and sub arachnoid space, the drug will spread faster. Hence the dose of drug is reduced by 50% (30-40%). Because of the effect of progesterone, there will be increased sensitivity to local anaesthetics.

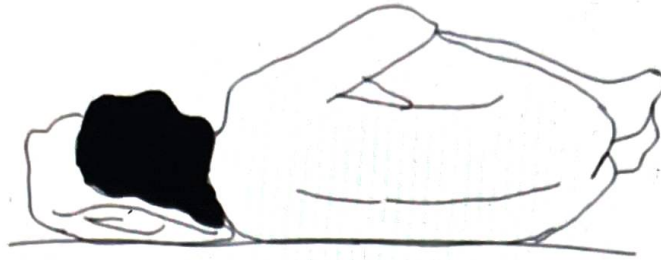
Other factors include :

Height	Gender	CSF density
<p>Height is inversely proportional to level of anaesthesia.</p>	<ul style="list-style-type: none"> In males, in left lateral position, spinal cord is curved. Hyperbaric drug goes down and level of anaesthesia affected. In females, pelvis size is broader. The hyperbaric drug goes up and level of anaesthesia is affected. 	

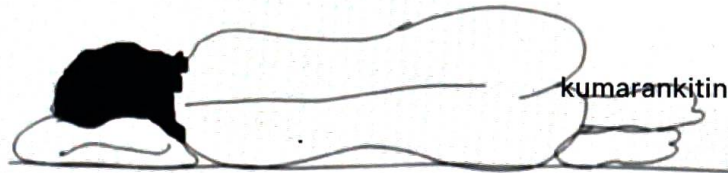
Active space

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male



Female



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Procedure factors

00:16:40

- Position of the patient :
Sitting position : Hyperbaric drug will settle down.
Trendelenburg position : Hyperbaric drug will move towards neck.
- Injection of **epidural drug post spinal anaesthesia** →
Compress the subarachnoid space and increases level of anaesthesia.

Side effects of spinal anaesthesia :

Spinal anaesthesia = Sympathetic blockade (LA blocks the thoracolumbar outflow apart from sensory & motor).

Cardiovascular system :

System	Effect	management
Cardiovascular system	Decreased heart rate : Bradycardia .	HR dropping >20% of baseline value : Atropine/glycopyrrolate.
	vasodilation leading to peripheral pooling of blood : Hypotension.	<ul style="list-style-type: none"> • Preloading : 15-20 ml/kg of RL/NS. • Inj. Phenyl epinephrine/ Inj. mephentramine/ Inj. Ephedrine.
	Systemic vascular resistance decreases.	

Active space

Agent of choice to treat hypotension after spinal anaesthesia :

- **Ephedrine** : Preferred for most of non pregnant, non cardiac patients.
- **Phenyl epinephrine** : Preferred for pregnant patients coming for LSCS.

Bradycardia occurs due to blockade of **cardio-accelerator fibers T1-T4**.

Respiratory system

00:28:55

Respiratory system	No effect of sympathetic blockade on bronchial tone (predominantly controlled by histaminic or non-adrenergic non cholinergic system).	
60c6b3eeaa8ded0e4e7e5ea7	<ul style="list-style-type: none"> • If the level of anaesthesia is low : No effect. • If the level of anaesthesia is high : Only intercostal muscles will be paralyzed leading to heaviness of chest/SOB. <p>This is known as high spinal anaesthesia.</p>	Treatment : Supplement oxygen & reassurance.

Other systems

00:33:14

Gastrointestinal system :

Sphincters are relaxed leading to defecation.

Genito urinary tract :

Will cause urinary retention (due to paralysis of detrusor muscle).

management by Foley's catheter.

most common complaint after spinal anaesthesia : **urinary retention**.

Active space

Central nervous system :

Level of anesthesia following spinal anesthesia:

1. Autonomic : Blocks highest level of impulses (T4).
2. Sensory : Blocks 2 segments below autonomic (T6).
3. Motor : Blocks 2 segments below sensory (T8).

It may cause urinary retention/bradycardia/hypotension.

Complications of spinal anesthesia :

- Anterior spinal artery syndrome.
- Cauda equina syndrome.
- Permanent paraplegia.
- Cord ischemia.
- Arachnoiditis.
- meningitis.

Drugs used in spinal anesthesia

00:39:20

Procaine : Not used in India.

Lignocaine : Not used now due to chances of **transient neurological symptoms**.

Bupivacaine : 0.5% Heavy (hyperbaric) is used.

Isobaric Levobupivacaine, Ropivacaine : Available in hyperbaric forms too.

Additives used in spinal anesthesia :

They are used along with local anesthetics to prolong the duration of blockade.

- **Opioids** : Prolongs the duration of action by acting on μ receptors present on dorsal horn of spinal cord.
- Fentanyl :
Lipid soluble.
Shorter duration of action.
200 times more potent than morphine.
most used.
Dose : 25 micrograms.
- morphine :
Long-acting drug.
Hydrophilic.
Dose: 0.1 milligram.
Side effect : **Respiratory depression**.

- Diamorphine.
- Hydromorphone.
- Sufentanyl :
Dose : 2-10 micrograms.

Other drugs include :

1. α_2 agonists : Clonidine (8-10 hours).
Dexmedetomidine (used lately).
2. Neostigmine :
Preservative free.
10-15 micrograms.
Increases nausea and vomiting.
3. Adrenaline : Not used nowadays due to risk of cord ischemia.
4. Dexamethasone : Prolongs the duration.

Other approaches/techniques

00:47:05

- Continuous spinal anaesthesia :
In the same spinal, a small catheter can be inserted to continuously increase the dose of anaesthetic.
Increased incidence of cauda equina syndrome.
Used in very sick patients.
Catheter used does not cause irritation to cord/related structures.
- Unilateral spinal anesthesia :
Patient is placed in lateral position & injected with a hyperbaric drug, only one side of the body is blocked.
- Saddle anesthesia :
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Patient made to sit after spinal anaesthesia is injected.
Only saddle area blocked, no systemic side effects.
E.g. For hemorrhoidectomy, anal sphincterotomy etc.
- Taylor's approach :
Done for severe fusion of spine (ankylosing spondylitis).
Reach sub arachnoid space from L5-S1, using long spinal needle.

EPIDURAL ANAESTHESIA

Epidural anaesthesia

00:00:11

Indications : Similar to spinal anaesthesia.

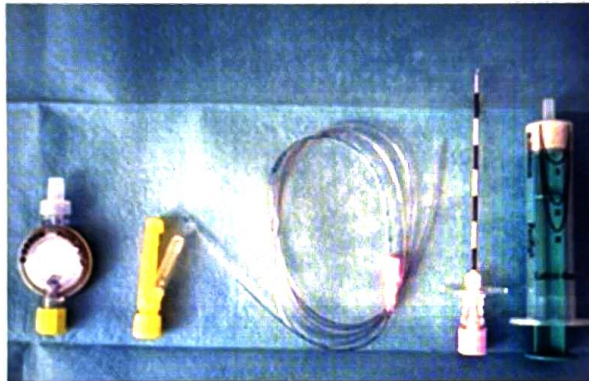
Contraindications : Similar to spinal anaesthesia.

Level : Can be done at thoracic, lumbar and cervical levels.

Associated things :

Epidural catheter set :

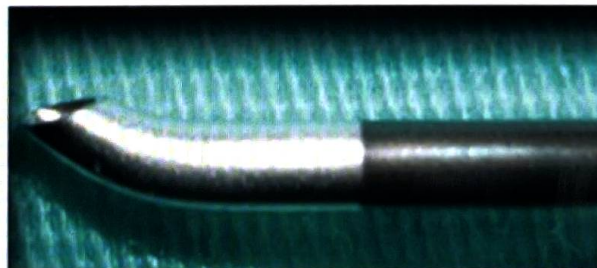
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Tuohy needle : Special needle used to locate epidural space.

Slightly curved in the anterior and has a lumen.

Size : 18G / 16G is used.



Epidural space is a potentially empty space filled with negative pressure.

Technique : Special technique called loss of resistance technique is adopted. As the needle moves layer by layer, on reaching the epidural space, the drug is sucked in.

Factors affecting epidural anaesthesia :

Active space

Drug factors	Patient factors	Procedure factors
Volume of drug injected. (minimum 10-15 ml is injected). more volume injected, more the block will be produced.	Position, weight, height of patient or baricity of drug doesn't have an effect. Elderly patients and pregnancy : Require less volume as epidural space is narrow.	Position/site of needle insertion. (Level of anaesthesia for the same volume of drug is higher at cervical level compared to thoracic level)

Advantages of epidural anaesthesia :

- After identifying epidural space, a fine catheter is passed gently into epidural space through Tuohy needle.
- By inserting the catheter into empty space, drugs can be injected continuously → Any duration of surgery can be performed. Can also be used for post op analgesia.
- No chance of Post Dural Puncture Headache (PDPH).
- By altering the volume of the drug injected, level of anaesthesia can be changed.
- Less variation in hemodynamics as drug is injected in an empty space.



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Disadvantages of epidural anaesthesia

00:12:08

- Technically difficult → Chances of patchy block.
- Accidental migration of catheter into subarachnoid space gives rise to total spinal anaesthesia (intracranial spread of anaesthetic) → Patient becomes unresponsive, with profound bradycardia and hypotension.
Treatment → Intubate/positive pressure ventilation/continue 100% oxygen/raise BP as quickly as possible.
In high spinal anaesthesia (paralysis of intercostal

Active space

muscles), patient complains of difficulty in breathing → Reassure the patient, supportive treatment to be given.

- Accidental migration of catheter into any blood vessel leads to local anaesthesia toxicity.
- Accidental dural puncture while identifying epidural space → Patient will have worst kind of headache (PDPH).
- Onset of action is very slow → Cannot be used for emergencies.

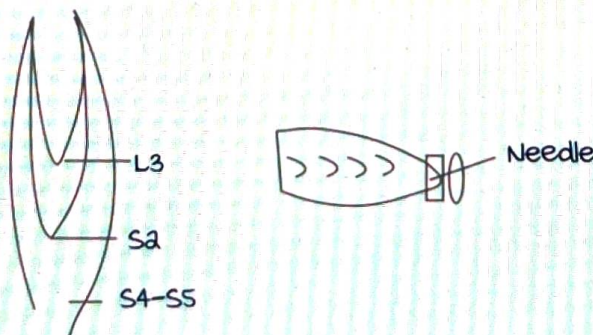
Epidural injection (local anaesthetic + dexamethasone) under fluoroscopic guidance is done for back pain patients.

Side effects, treatment of side effects and complications of epidural anaesthesia are same as subarachnoid block. kumarankitindia1@gmail.com

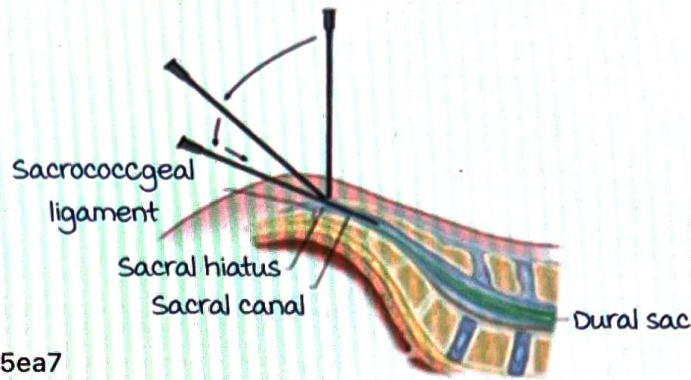
Caudal block

00:23:18

- Preferably done in children.
- In children sacral vertebra is formed by fusion of S1-S2-S3-S4 and S5 segment is unfused. This gives rise to a dip above the natal cleft. Spinal cord ends at L3, and dural sac extends up to S2 and there is an unfused segment between S4 and S5.
- Child is kept at left lateral position → Identify the S4 and S5 segment → Pass the needle between S4-S5 segment and reach to S2 region → Caudal block.
- Caudal anaesthesia is equal to epidural anaesthesia where we approach epidural space from S4-S5 (unfused sacral vertebra).



Active space



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Advantage of caudal anaesthesia : No chance of spinal cord injury. In children ligaments are very thin and its difficult to appreciate layers and so increased chances of spinal cord damage doing it by loss of resistance technique at S2-S3 level.

Disadvantages of caudal anaesthesia :

- Children are uncooperative. Caudal anaesthesia is used mostly as a supplement for general anaesthesia to provide analgesia.
- Strict aseptic precautions should be taken as children do not have control over bowel and bladder movements, hence the site may always not be clean.
- Injury to bony structures (as bone is cartilaginous) or growth centers leading to permanent damage.

Q. Which of the following type of anaesthesia is contraindicated in a pregnant female coming for elective caesarean section ?

- Spinal anaesthesia.
- Epidural anaesthesia.
- Caudal anaesthesia.
- General anaesthesia.

Answer : C. Caudal anaesthesia.

Volume of drug injected in caudal epidural anaesthesia :

Armitage formula :

Lower limb surgery : 0.5 ml/kg of local anaesthetic.

Lower abdominal surgery : 0.75 ml/kg of local anaesthetic.

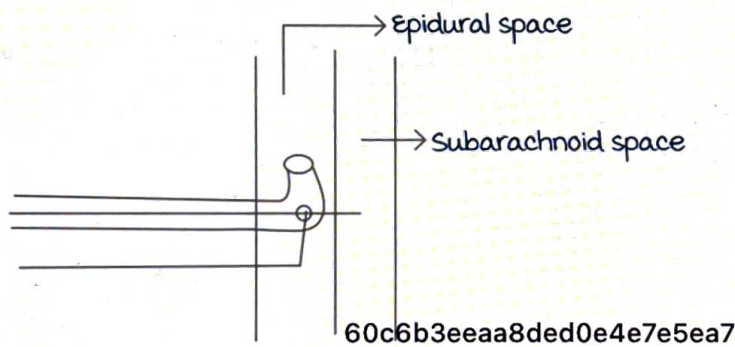
Upper abdominal surgery : 1 to 1.5 ml/kg of local anaesthetic.

Combined spinal epidural anaesthesia :

In order to provide post operative anaesthesia, subarachnoid space is identified using a single needle. Using another needle, loss of resistance is identified, and a catheter is passed (two needle technique).

Advantage : Effect is quick with spinal anaesthesia and anaesthesia can be prolonged / post op analgesia can be provided with epidural anaesthesia.

Now a days, **one needle technique** is used. Needle is similar to Tuohy needle except there is a small hole at the base. On reaching the epidural space, a needle is passed through the first needle to reach the subarachnoid space. Drug can be injected into subarachnoid space and catheter can be passed into epidural space.



PERIPHERAL NERVE BLOCKS

Goal

00:01:37

The main goal is to deposit the local anesthetic near the nerve, and not inject it into the nerve.

Techniques to locate peripheral nerve :

- Surface anatomy guided
- Paresthesia's technique : Shock like response when the needle nears the nerve.
- Electrical stimulator guided (peripheral nerve stimulator).
- ultrasound guided

The other goal is to provide analgesia and anaesthesia

Blocks of face :

main nerve supply of face is through trigeminal nerve. It has 3 superficial divisions :

- Ophthalmic division :
Exits through superior orbital fissure.
Supplies forehead, eyebrow, upper part of scalp.
Has 3 branches : Frontal, nasociliary and lacrimal nerve.
- maxillary division :
Exits through inferior orbital fissure.
Purely sensory nerve. Supplies lower part of eyelid, upper part of lip, lateral part of cheek.
- mandibular division :

Exits through mental foramen.

Mixed nerve.

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Supplies muscles of mastication, tongue.

Anesthesia at :

Suprazygomatic region blocks maxillary nerve completely.

In front of Tragus blocks mandibular nerve completely.

Cervical plexus block

00:12:44

Cervical plexus is derived from anterior divisions of C1, C2, C3, C4.

Present in posterior triangle of neck.

Superficial cervical plexus innervates front of head, anterior part of neck and small areas of shoulder.

main landmark : SCM

Sternocleidomastoid muscle.



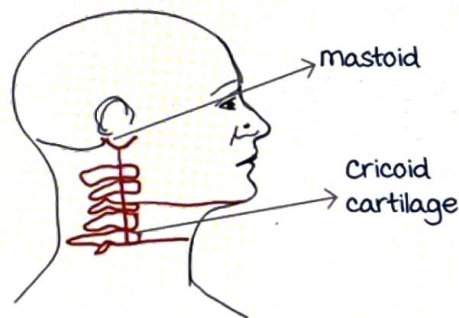
Superficial cervical plexus block :

Insert needle into lateral border of clavicular head of sternocleidomastoid muscle.

Inject anesthetic in a fan shaped fashion.

Deep cervical plexus :

Innervates deeper structures of neck including muscles of anterior neck and diaphragm, which is supplied by phrenic nerve.



Landmark : **mastoid process.**

Draw an imaginary line along cricoid cartilage and other one along mastoid. The line connecting both these serves as point for injection.

Indications of cervical plexus block :

Superficial surgeries of neck :

- Lymph node biopsy.
- Small thyroid surgery.
- Carotid endarterectomy.
- Cervical lymph node biopsy.

Complications of cervical plexus block :

- Injury to nerve or vascular structures.
- Spread of drug into epidural or intrathecal space making the patient unresponsive : **most important complication.**

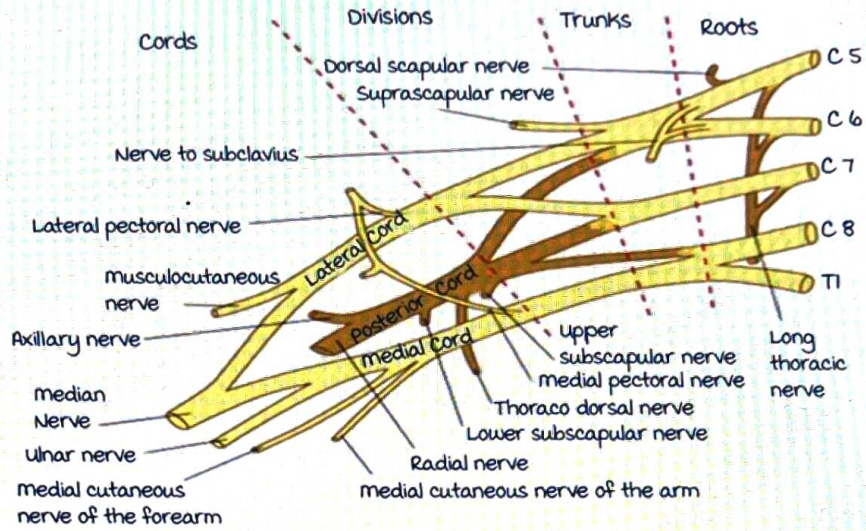
Active space

Blocks of upper limb

00:19:26

Nerve supply : **Brachial plexus block.**

Brachial plexus is formed by the anterior primary rami of C5 to T1 vertebrae.



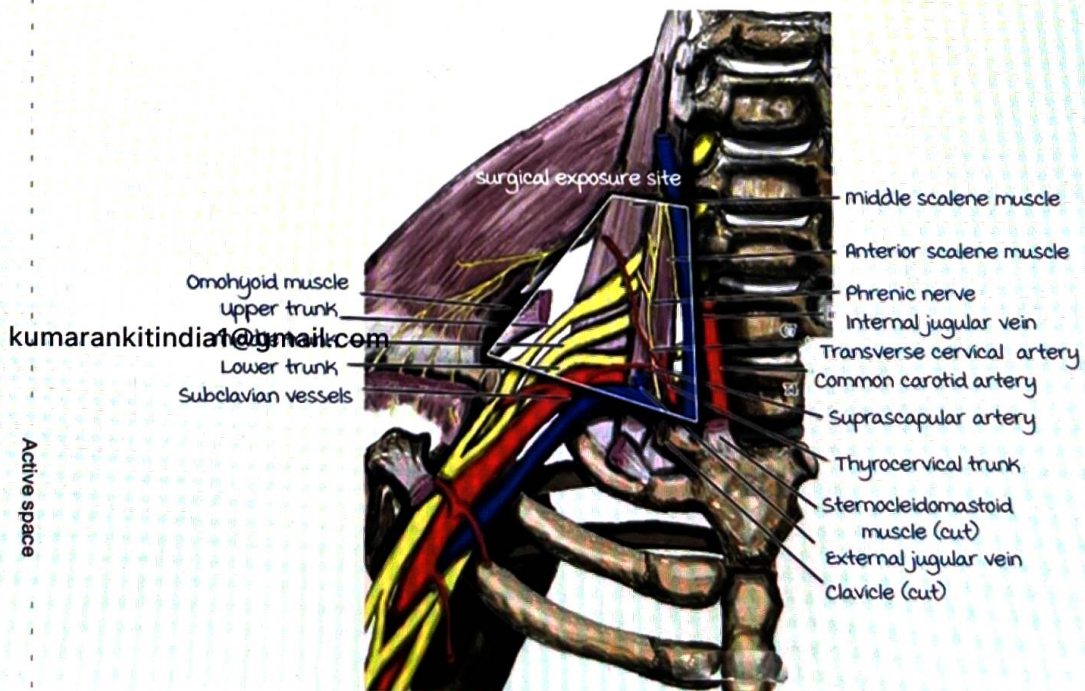
Pathway :

Courses between anterior and middle scalene muscles.

They unite to form 3 trunks.

The trunks travel cephalo-posteriorly to the subclavian artery, above the first rib.

On the lateral edge of rib, divides into anterior and posterior division. Enters axilla, and near axillary artery divides into peripheral nerves.



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Active space

3 approaches which include :

Interscalene approach :

Identify SCM, move laterally, a groove will be felt between anterior and middle scalene.

Indications :

- Surgeries on upper limb especially shoulder, upper third of humerus.

Complications :

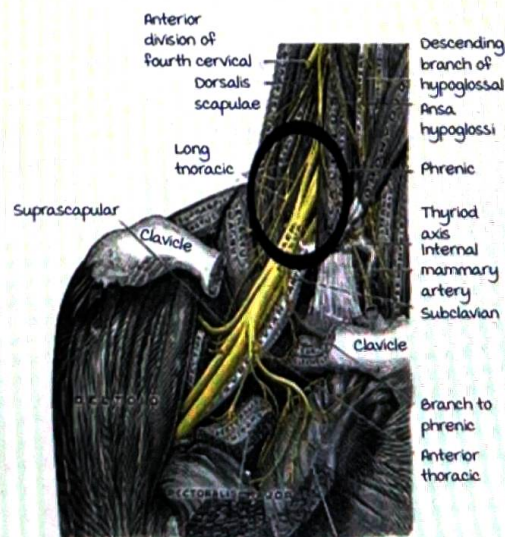
- Phrenic nerve block/ palsy (100%) : Have to be cautious in COPD patients.
- Spread into epidural space/ intrathecal space.
- Horner's syndrome (cervical sympathetic plexus very close by).
- Chances of sparing of ulnar nerve.



Supraclavicular approach :

Insert needle lateral to subclavian artery pulsation.

Directed towards downwards, inward, backward.



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Active space

Indications :

- Lower one third of arm, elbow, forearm.

Complications :

- Pneumothorax (0.5 - 6% risk).
- Phrenic nerve blockade (40 - 60%).
- Horner's syndrome.

Axillary approach :

Important landmark : Identifying the axillary artery pulsation.
median nerve above pulsation.

Ulnar nerve below pulsation. 60c6b3eaa8ded0e4e7e5ea7

Radial nerve behind the pulsation.

Advantage :

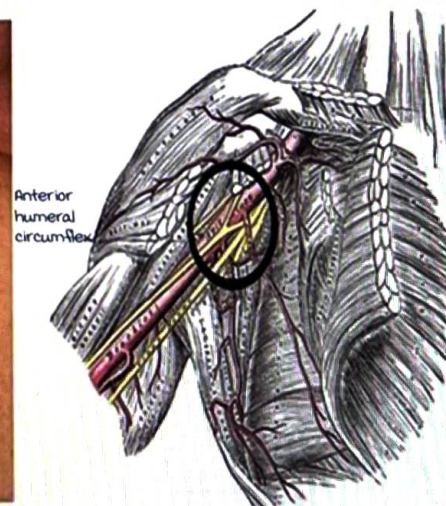
- No chance of pneumothorax/ phrenic nerve palsy/ Horner's syndrome.

Disadvantage :

- musculocutaneous nerve and intercosto brachial nerve (T₂) are spared.

Complications :

- Axillary artery injury.



Infraclavicular approach

00:34:28

Recently developed.

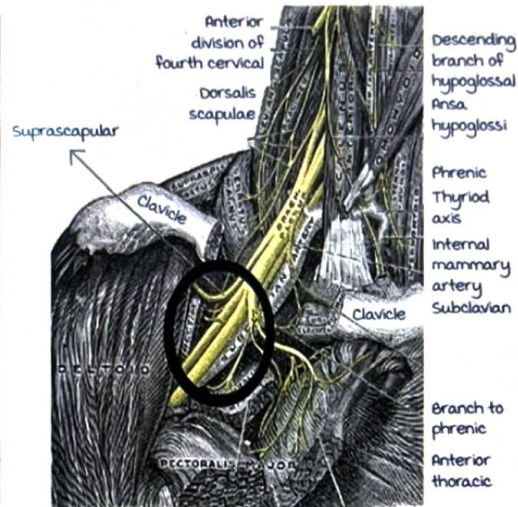
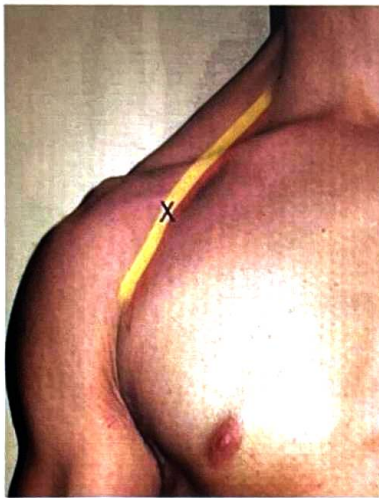
Block coming at the level of cords.

Procedure : Identify the coracoid process, go in 2 cm medially & 2 cm downwards or mid point of clavicle, inferior border then direct needle towards coracoid process.

Advantage : Theoretically, it covers musculocutaneous nerve.

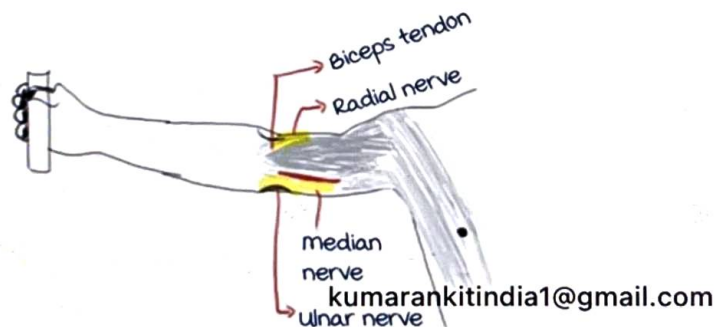
Disadvantage : might injure lung structures.

Hence done using ultrasound/ peripheral nerve stimulator.



Blocks at elbow :

Nerve	Elbow
median nerve.	medial to brachial artery.
Ulnar nerve	Subcutaneously at medial epicondyle : high incidence of nerve injury .
Radial nerve.	Lateral to biceps tendon.



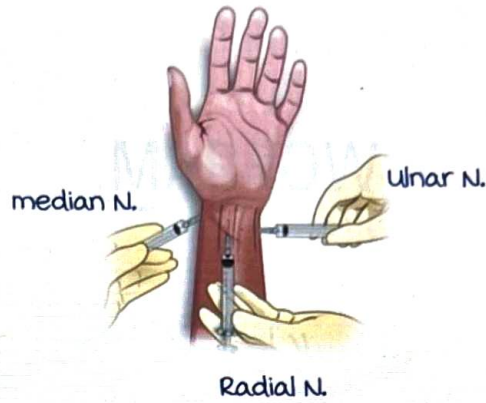
Blocks at wrist joint :

median nerve : Insert needle between palmaris longus and flexor carpi radialis.

ulnar nerve : Identify flexor carpi ulnaris (FCU) tendon and inject medial to the tendon of FCU.

Radial nerve : Essentially a field block. Given near anatomical snuff box.

Wrist : Nerve block



Block of thorax

00:40:35

Intercostal nerve block :

Procedure :

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Patient in prone position.

From the midline, draw a 6 - 8 cm line.

mid axillary line if patient is in sitting position.

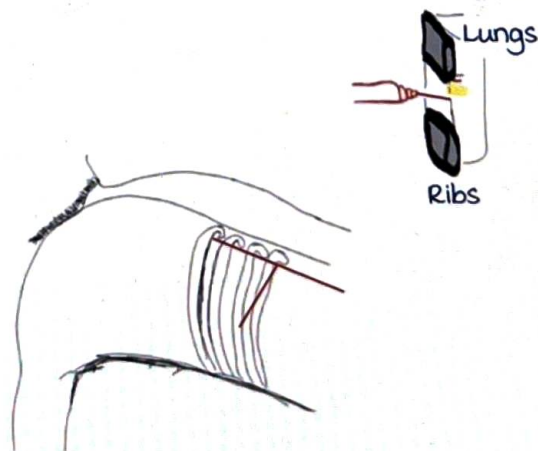
The anesthetic is injected into subcostal groove.

mnemonic : VAN.

The intercostal Nerve is inferior to the posterior intercostal Artery, which is inferior to the intercostal Vein.

In sitting position, mid axillary line is taken.

Caution : maximum systemic absorption of local anesthetic takes place here.



Transversus abdominis plane blocks :

Also called as TAP block.

Active space

Abdomen supplied by :

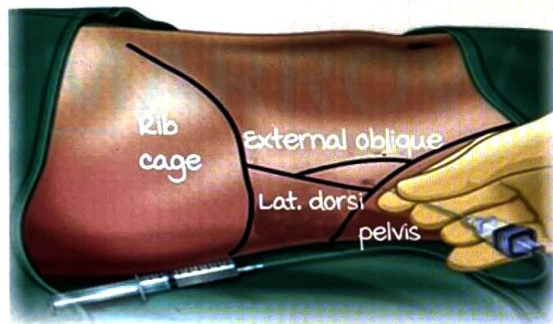
- Sub costal nerve.
- Ilio inguinal nerve.
- Ilio hypogastric nerve.
- Genito femoral nerve.

These nerves are present between internal oblique and transverse abdominis muscles.

Identify iliac crest. Needle inserted just above it. Once needle reaches between muscles, block is given.

Indications : All abdominal surgeries like cesarean section, feeding jejunostomy etc.

Transverse abdominis plane block



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Lower extremity blocks

00:45:28

Not commonly done.

Generally used for analgesic purpose.

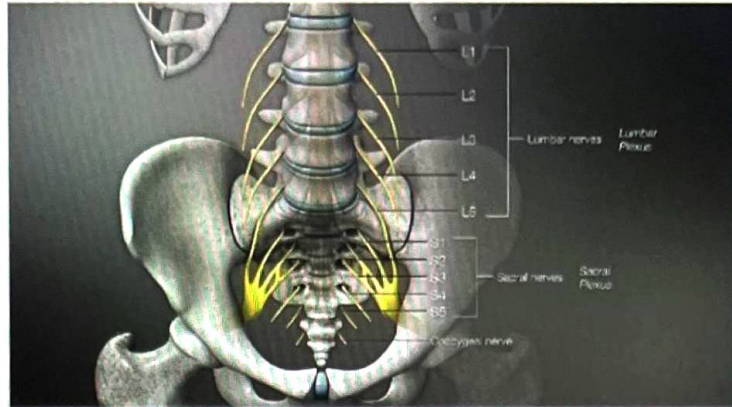
Lower extremity is supplied by lumbo sacral plexus.

Nerves include :

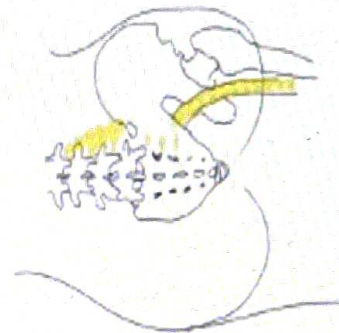
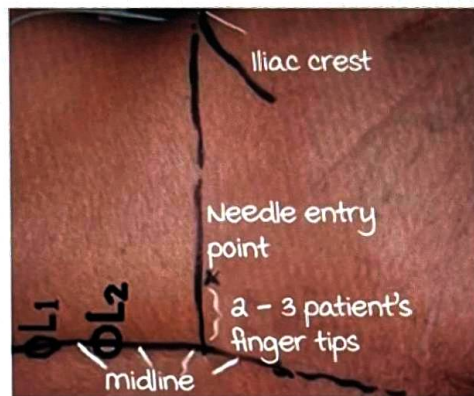
1. Lateral cutaneous nerve of thigh.
2. Lumbar region :
 - Femoral nerve.
 - Obturator nerve.
3. Sacral region :

Sciatic nerve divides into 2 branches in the popliteal fossa :

- Tibial nerve.
- Common peroneal nerve.



Lumbar plexus block :



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Also called as **psoas compartment block.**

Lumbar plexus is located between psoas and quadratus lumborum.

Draw an imaginary line from iliac crest to spinous process.

Go 5 cm laterally and 3 cm down.

Done under ultrasound guidance only.

Highest risk block : Chances of injury to renal vessels and kidney.

Advantage : Could directly block femoral and obturator nerve, if psoas block given.

Femoral nerve block :

Palpate femoral artery.

medially : Femoral vein; Laterally : Femoral nerve.

Insert the needle 1 cm lateral to the femoral artery & block given.

Indications :

All lower limb surgeries like TKR, skin graft from thigh etc.

Active space



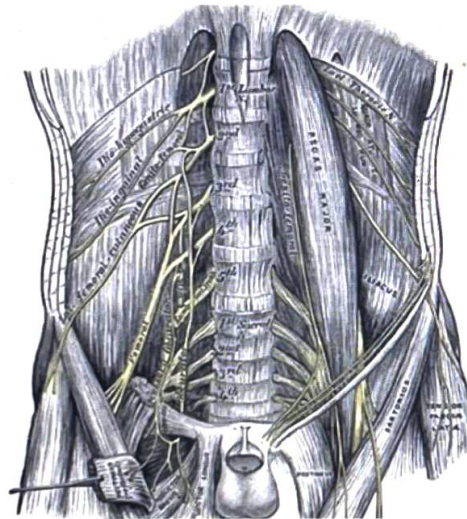
Lateral femoral cutaneous nerve block :

Identify anterior superior iliac spine.

Insert a needle 2 cm medially and caudally.

Inject in a fan shaped fashion.

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Obturator nerve block

00:51:17

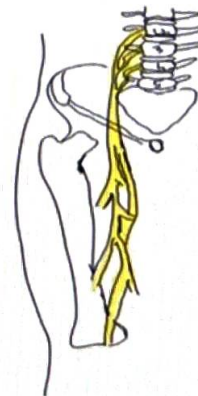
main landmark : **Pubic tubercle.**

Procedure :

Identify pubic tubercle.

Insert needle 2 cm laterally & 2 cm caudally
and block given.

Indication : Painful neurological spasms.



Active space

Sciatic nerve block :

Biggest nerve from sacral plexus.

Procedure :

Keep patient in left lateral position.

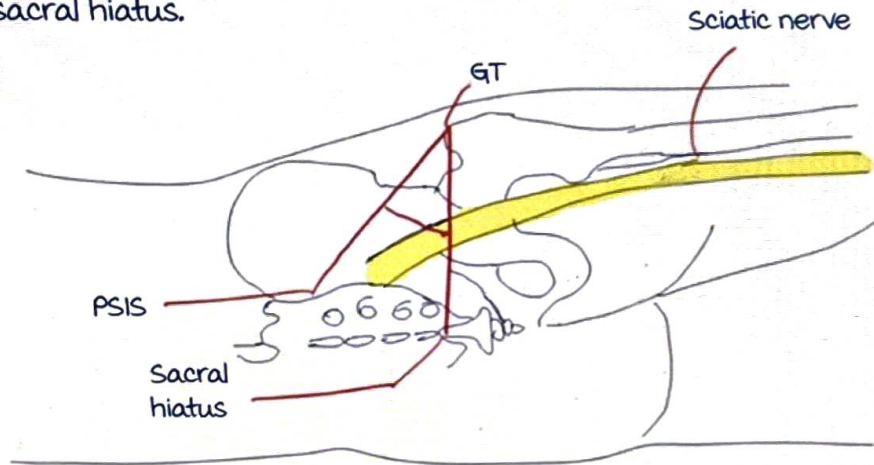
Identify greater trochanter of femur, posterior superior iliac spine.

Draw an imaginary line connecting both points.

Draw another imaginary line connecting greater trochanter to sacral hiatus.

Connect both imaginary lines.

Sciatic nerve block is given at the point where the line touches the imaginary line between greater trochanter and sacral hiatus.



Popliteal fossa block :

Procedure :

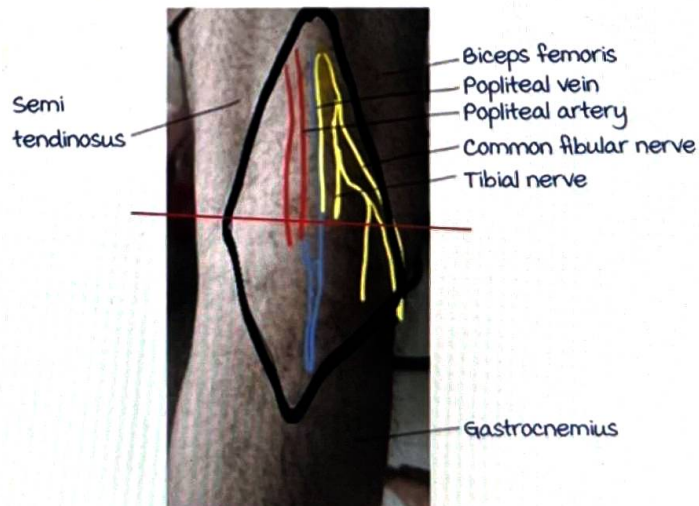
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Identify femoral artery pulsations in popliteal fossa.

Draw an imaginary line from popliteal crease.

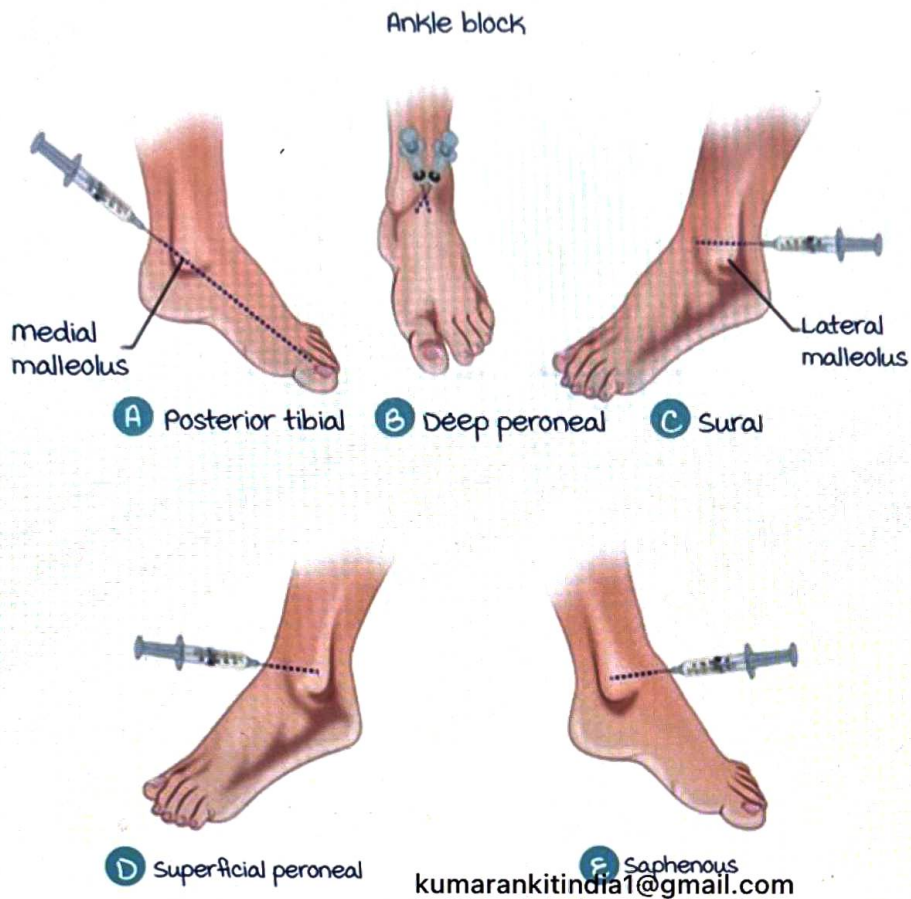
Palpate the popliteal artery in the triangle formed.

Block given by inserting needle medial to it.



Active space

Blocks of foot :



Ankle block :

- Terminal branches of sciatic nerve.
- Posterior tibial nerve.
- Sural nerve.
- Superficial peroneal nerve.
- Deep peroneal nerve.

Posterior tibial nerve block :

Palpate posterior tibial artery and inject laterally.

Sural nerve block :

Between lateral malleolus and Achilles tendon.

Identify Achilles tendon and insert needle laterally directing towards malleolus.

Peroneal (both deep and superficial) nerve block :

Procedure :

Draw imaginary line between 2 malleoli.

Identify **External hallucis longus** : Seen prominently when toe is dorsiflexed.

Active space

Identify anterior tibial artery pulsation .

Inject deep for deep peroneal nerve block and superficially for superficial peroneal nerve block in relation to the pulsation.

Saphenous nerve :

Present superficially between medial malleolus and Achilles tendon.

Inject medially to the anterior tibial artery pulsation for saphenous nerve block.

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INTRAVENOUS ANAESTHETICS

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Commonly used induction agents

00:00:54

Commonly used IV induction agents :

- Barbiturates.
- Propofol.
- Imidazoline derivatives (Etomidate).
- Phencyclidine derivatives (ketamine : Not a CNS depressant).

Other agents used :

- Benzodiazepines : Induce sleep
- Droperidol and Haloperidol : Butyrophenone derivatives.
- Dexmedetomidine (α_2 agonist) : mimics natural sleep, no respiratory depression.

most of IV induction agents are **depressants** :

Decreases (heart rate, respiratory rate, BP, ICP, IOP, liver blood flow, renal blood flow, etc.).

They act on **GABA receptors** : Increases chloride conductance.

Barbiturates

00:05:25

- Introduced around 1930 by **Ralph Waters** & **John Lundy**.
- The cause of more fatal casualties among the servicemen at Pearl harbour than the enemy bombs.
- Chemical structure and composition :
Urea + malonic acid : **Barbituric acid**
Barbituric acid is condensed and made it to powder form barbiturates.
- Classification : Oxybarbiturates (Oxygen at C_4).
Thiobarbiturates (Sulphur at C_4).
- Hypnotic activity depends on C_5 : Presence of **alkyl/aryl groups** at C_5 .
- more potent if **length** of alkyl group is more.
- Eg : **Thiopentone sodium**, **Thiamylal**, **methohexitone**.

Active space

Thiopentone sodium (TPS)

00:11:24

- Thiopentone sodium contains 6% of sodium carbonate. It is in powder form (yellow).
- Mechanism of action: Acts on GABA receptors and increases chloride conductance.

Availability	Yellow powder (amorphous in nature).
pH	Highly alkaline: 10.5 (due to sodium carbonate) Never mix/dilute it with RL as it precipitates with calcium.
Odour	Garlic/onion like.



Properties:

Onset	15 seconds (Arm brain circulation time).
Dose	Concentration of 2.5%, 3-5 mg/kg dose.
Duration	The mechanism of termination of action of TPS is by redistribution between the brain and fat cells. TPS: Highly lipophilic. $T_{1/2\alpha}$: 10 hrs 30 mins.
metabolism and excretion	Hydroxylated in Liver & excreted in Kidneys. It is majorly bound by albumin.

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Systemic effects of TPS

00:20:19

- Decreases heart rate, respiratory rate, BP.
- maximum decrease in ICP. Good anti-convulsant property. Decreases cerebral metabolic rate (decreases oxygen consumption of brain).
Hence used as agent of choice for neurosurgery.
- At high doses: Prolongation of QT interval so use with caution in Arrhythmia patients.
- Prevents peripheral conversion of T_4 to T_3 (anti thyroid property).
Hence agent of choice for hyperthyroid patients.

Complications :

- Accidental intra-arterial administration of TPS leads to severe pain, pallor, cyanosis, edema, gangrene.

mechanism :

Arteries : Difference in the pH between TPS (10.5) & the blood (7.35). Causes crystal formation that obstructs the artery as there is decrease in calibre of the artery along the blood flow.



Veins : Crystal forms but no obstruction since calibre increases along the blood flow and the crystals dissolve.

management :

- Do not remove the needle.
Removing the needle : Noxious stimuli leads to vessel spasm that aggravates the gangrene.
- Flush with NS/Heparin to prevent thrombus formation.
- Stellate ganglion block :** Lowest cervical sympathetic ganglion block : Causes sympathetic blockade in the hand, leading to vasodilation, thereby reducing gangrene formation.
- Concentration is kept as low as **2.5%**.
Gangrene formation is directly proportional to the concentration used.
If given IM : Gangrene & necrosis occurs (due to high alkaline nature).

Contraindications of TPS

00:32:18

Absolute	Relative
Porphyria	Unable to secure airway. Hypotension. Heart blocks. Uncontrolled hypertension. Asthma.

Active space

In porphyrias, barbiturates/TPS stimulate gamma amino levulinic acid. It also leads to LMN paralysis and death.

Methohexitone

00:34:47

- All barbiturates are anticonvulsants except methohexitone (pro convulsant).
- On the structure, at C₁: methyl group is present.
- This causes excitatory symptoms which leads to convulsions.
- more potent than TPS.
- Dose : 1-1.5 mg/kg. 60c6b3eaa8ded0e4e7e5ea7
- **Quicker recovery profile** : 4 hours.
- Contraindicated in neurosurgery.
- Indicated in ECT.

Propofol

00:37:58

Chemical structure, availability & composition



- Introduced in 1970.
- Has alkyl phenol group.
- White colour (as it has 1.2% egg phospholipid).
Should be used within 6 hours.
Egg : Good emulsifier.
- Oily preparation (has 10% soybean oil).
Painful on i.v. injection.
Pain can be controlled by mini Bier's block (iv regional anaesthesia ex. Prilocaine is given. Tourniquet is applied distal and proximally for 5 minutes and Propofol is given).
- Also contains glycerol (2.25%) to maintain tonicity.

Alternative preparation

Fos propofol :

- Prodrug of propofol.
- Not much pain.
- Causes perianal itching.
- EDTA & sodium metabisulphate are added as bacteriostatic agents.
- **Aqueous** (trade name : Aquaman)

mechanism of action	Acts on GABA receptors & increases chloride conductance.
---------------------	--

Properties of propofol :

Onset	15 seconds (Arm-brain circulation time).
Dose	1-2.5 mg/kg. (Induction : 1-1.5 mg/kg, maintenance : 50-150 μ g/kg/min).
Duration	<p>2-8 mins.</p> <ul style="list-style-type: none"> • Agent of choice for day care anaesthesia (quicker recovery profile). • Agent of choice for any procedure sedation. <p>(monitored Anaesthesia Care or MAC) : As context sensitive half life is small.</p> <ul style="list-style-type: none"> • used for endoscopy, sedation.
metabolism & excretion	metabolised in liver. Excreted through kidney.

Context sensitive half life : The time taken for a drug to decline to half its concentration when it is stopped after prolonged infusion.

Systemic effects of Propofol :

- Decreases heart rate, respiratory rate, BP.
- Decreases ICP.

Although on infusion some epileptic spikes noted on EEG, are not convulsant. Hence can be safely used in neuro surgery.

- Attenuates/abolishes laryngeal reflexes effectively. Hence can be used for **LMA insertion**.

That is why used in treatment of **laryngospasm**.

- Decreases IOP. Hence used as agent of choice for **ocular surgeries**.
- Good antiemetic, antipruritic. (But Fospropofol : Pruritic).
- Used in treatment of **emergence** (recovery profile is very pleasant). It may cause sexual hallucinations.

Prolonged infusion of propofol

00:56:11

On prolonged infusion of propofol ($> 4 \text{ mg/kg/hr}$ for $> 48 \text{ hrs}$), patient goes into :

- Refractory bradycardia.
- Asystole.
- Severe metabolic acidosis.
- Green coloured urine (due to phenol groups).
- This is because of reductive metabolism of lipids. Propofol contains soyabean oil (lipids).
- It is called **prolonged propofol infusion syndrome**.
- Risk factors : Poor oxygen delivery, sepsis, cerebral injury.
- First sign to detect prolonged propofol infusion syndrome : Increased lipid levels.
- Sedation holiday or change of drugs can prevent this condition.

Etomidate

01:00:45

Chemical structure & availability	Imidazoline derivative. Concentration : 0.2%. Contains propylene glycol (35%). Oily preparation : Very painful on injection.
Mechanism of action	Acts on GABA receptors : Increases chloride conductance.
Unique property	most cardiostable agent.

Properties of Etomidate :

Onset	kumarankitindia1@gmail.com 15 seconds (Arm brain circulation time).
Dose	0.2-0.4 mg/kg.
Duration	Shorter recovery profile. One of the preferred agents for DC cardioversion. Not to be used for continuous infusion.
Metabolism and excretion	Metabolised in liver by ester hydrolysis Excreted through kidney.

Active space

Systemic effects of Etomidate :

- Decreases heart rate, respiratory rate, BP.
- Decreases ICP.
- most cardiostable agent.

Agent of choice for cardiac surgeries, neurosurgeries (like aneurysm clipping).

- minimal respiratory depression.

Uses of Etomidate :

- For cardiac surgeries.
- For neuro surgeries.

Side effects of Etomidate :

- It should not be used for continuous infusion because it suppresses adrenocortical hormone (suppresses the enzyme β hydroxylase) : Causes severe hypotension.
- Painful on injection.
- maximum emetogenic property.
- myoclonic activity on limbs is noted.

Novel varieties of Etomidate :

- Carbo etomidate.
- Cyclo propyl methoxy carbonyl Etomidate.

These novel agents decrease the emetogenic property, decrease the suppression of adrenocortical hormone.

Ketamine

01:08:04

Chemical structure & availability	<ul style="list-style-type: none"> • Phencyclidine derivative. • Available in racemic mixture formation (S+) : Less amount of psychotropic actions.
Mechanism of action	Acts on NMDA receptors (excitatory receptors) : Suppresses the excitatory symptoms.
Unique property	Dissociative anaesthesia (patient is wide awake but doesn't react to pain). Dissociation occurs at thalamocortical junction.

Properties of Ketamine :

Route of administration	IV/IM/epidural/spinal/nasally. (Nasally : In treatment of depression)
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Active space

Dose	IV: 1 - 2 mg/kg IM: 4 - 6 mg/kg
metabolism & excretion	metabolised to norketamine in liver. Excreted through kidney.

Systemic effects of ketamine

01:14:57

- Increases heart rate, BP.
 1. Contraindicated in hypertensives, past history of MI.
 2. Indicated/agent of choice for **any hypotensives**, (most commonly in hemorrhagic shock).
- **Respiratory stimulant**
Hence used in **low resource setting** like warfare.
For short procedures like **incision and drainage**. For **burns dressing**.
- Bronchodilator.
Hence used as agent of choice for **asthmatic**.
- Increases ICP.
Hence contraindicated for neurosurgery.
- Increases IOP.
Hence contraindicated for ocular surgeries.
- Good analgesic agent.
- Causes nystagmus.
- Causes unpleasant hallucinations.
midazolam should be added to reduce unpleasant hallucinations.
- Increases secretions.
Atropine/Glycopyrrolate should be added to decrease secretions.
- **Stimulant**: Increases catecholamine levels when inside the body & causes increase in BP. But, if injected to heart ex situ, it acts as a depressant.
- **Depressant**: If a patient is bleeding profusely for many hours, ketamine may not increase BP as much, since it is inherently a depressant.

Uses of Ketamine :

Agent of choice for **R-L shunt (tetralogy of Fallot)**.

Ketamine tries to maintain shunting fraction as it causes **vasoconstriction**.

INHALATIONAL ANAESTHETICS :

PART - 1

Route of administration : Oral cavity (respiratory tract).

Pathway of drug : Oral cavity (nose) → Trachea →

Lungs → Alveoli → Pulmonary circulation → Brain.

Gas remains in gaseous form at room temperature.

Vapour attains liquid form at room temperature.

Volatile agents : These substances upon exposure to atmosphere, get converted to vapour. Stored in specialised containers called vaporisers and delivered in calculated doses.

Vapour pressure : Pressure exerted by molecules escaping from the surface of liquid.

Dalton's law of partial pressure : $P = P_1 + P_2 + P_3$.

Total pressure in alveoli is equal to the sum of all individual components of gases.

Diffusion :

- movement of molecules from higher concentration to lower concentration.
- Gas molecules from alveoli diffuse into pulmonary circulation.

Classification :

Newer agents (Non flammable)	Older agents (Flammable)
Halothane Isoflurane Desflurane Sevoflurane	ether Chloroform Trielene Cyclopropane methoxyflurane

use of cautery in surgery when flammable anaesthetic is used poses a risk of fire in the theatre.

Purpose of inhalational anaesthetic agents :

- To induce anaesthesia in children.
- To maintain anaesthesia in adults (IV induction agents used for induction).
- Given as a mixture of $O_2 + N_2O +$ Inhalational agent for maintenance.

First anaesthesia demonstration was done by W.T.G. Morton using ether on 16th Oct 1846.

Mechanism of action of inhalational agents is still unknown.

Theories proposed to explain mechanism include :

- Critical volume hypothesis.
- Fluidization theory.
- Glycine receptor theory.
- Unitary hypothesis.

Meyer-Overton rule

00:14:07

The first attempt made to explain mechanism of action / pharmacology of inhalational anaesthetics.

If an agent is more lipid soluble, that means it is more potent.

Potency : minimum drug \rightarrow maximum effect

Minimum Alveolar Concentration (MAC) :

- Denotes potency.
- The minimum amount of drug required to produce immobility to painful stimulus (effect) in 50% of subjects.

$$\text{Potency} \propto \frac{1}{\text{MAC}}$$

Inhalational agents	Minimum Alveolar Concentration	
Methoxyflurane	0.16	Least MAC; more potent.
Trielene	0.2	
Halothane	0.74	
Isoflurane	1.15	
Enflurane	1.68	
Sevoflurane	2.05	

Desflurane	6	
Cyclopropane	9.2	
Ether	1.92	
Chloroform	0.8	
N_2O	104	more MAC; Least potent.

Commonly used agents :

Agent	molecular weight	Boiling point	B/G	MAC	Vapour pressure
N_2O	44	-88.5	0.47	104	43880
Halothane	197	40	2.5	0.75	243
Isoflurane	184	48	1.4	1.28	238
Desflurane	168	22	0.45	6.0	666
Sevoflurane	200	58	0.65	2.05	157
methoxyflurane	165	104	12	0.2	22.5
Enflurane	184	56	1.9	1.58	174

Factors affecting MAC

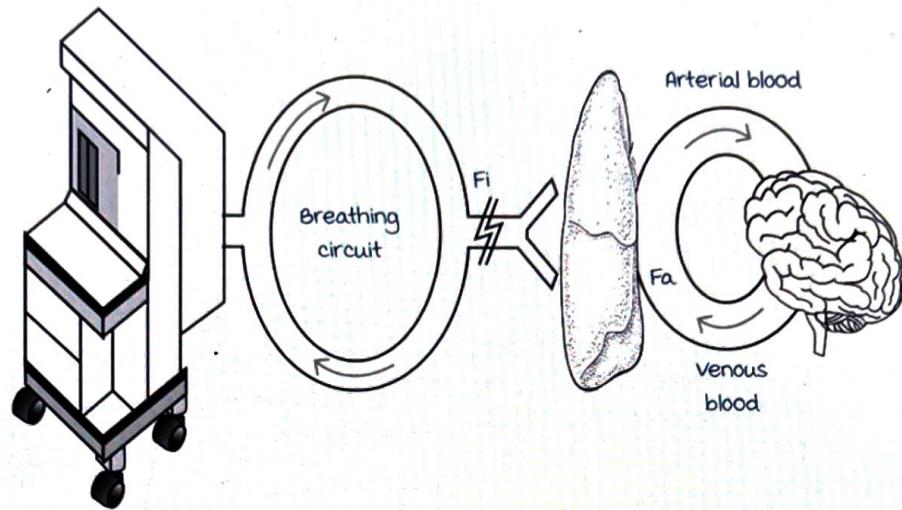
00:20:37

Decrease MAC	Increase MAC	No effect
<ul style="list-style-type: none"> • Age (maximum at 6 months) • Hypothermia • Pregnancy • Hypoxia • I.V Agents • Local anaesthetics • Hyponatremia • Raised calcium & magnesium • Acute alcohol intoxication 	<ul style="list-style-type: none"> • $> 42^\circ C$ • \uparrow Barometric pressure • Chronic alcohol • Hypernatremia 	<ul style="list-style-type: none"> • Sex • Thyroid disorder

Active space

Factors affecting uptake of agent (establish anaesthesia) :

Boyle's machine



3 main factors :

1. From machine to alveoli :

(Inspired concentration - ventilation - type of circuit - FRC).

2. From alveoli to pulmonary circulation :

(B/G ratio - cardiac output - arterio-venous PP difference)

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3. From pulmonary circulation to various tissues (CNS) :

(Brain blood partition coefficient - cerebral blood flow - A-V PP difference).

From machine to alveoli :

Inspired concentration/concentration effect :

The more the inspired concentration, the faster the induction of anaesthesia.

With the removal of nitrous oxide quickly from the alveoli (due to **faster diffusion capacity**), the size of the alveoli decreases → It increases the concentration of nitrous oxide in the blood.

With each and every breath, the concentration of nitrous oxide increases till it reaches equilibrium.

This is seen at the **start of surgery**.

Seen only if large concentration of nitrous oxide is used during induction.

Second gas effect

00:35:44

Second gas effect is when one gas affects the alveolar concentration of other gas.

Seen due to rapid movement of nitrous oxide (first gas) into pulmonary circulation.

The alveolar-capillary uptake of the first gas increases the alveolar concentration of other gases present.

Concentration effect and second gas effect occur simultaneously at the start of surgery.

This is a short lived effect.

Alveolar ventilation :

more the alveolar ventilation, more rapid is the induction of anaesthesia.

Functional residual capacity (FRC) :

more the FRC, more the delay in induction.

Induction happens faster in children as they have low FRC.

From alveoli to pulmonary circulation

00:45:42

Blood gas partition co-efficient:

$$\frac{B}{G} = \frac{\text{Concentration of agent in blood}}{\text{Concentration of the agent in alveoli}}$$

Indicator of solubility of agent.

more B/G ratio \rightarrow more soluble in blood \rightarrow moves to brain only once it gets saturated \rightarrow delayed induction.

Low B/G ratio \rightarrow less soluble \rightarrow floats on the pulmonary circulation and reaches brain quickly \rightarrow faster induction.

Xenon	0.16	Less B/G , less soluble \rightarrow faster induction
Desflurane	0.42	
N ₂ O	0.47	
Sevoflurane	0.69	
Halothane	2.4	
Isoflurane	1.38	
Cyclopropane	0.44	

Active space

Chloroform	8	
Trielene	9	
Ether	12	
methoxyflurane	15	more B/G, more soluble : Delayed induction

Effect of cardiac output

00:54:58

Always interrelated with solubility.

Less the cardiac output → more soluble the agent →

Preferentially goes to brain → Quicker the induction.

more the cardiac output → more soluble the agent →

Preferably settles in fat → Delayed induction.

vessel rich group (70%)	Intermediate	vessel poor group (10-15%)
Heart Kidney Lung	muscles Bone	Fat

Alveolar-venous (A-V) partial pressure difference :

Depends on blood flow to tissues.

more the A-V partial pressure difference, more uptake at the tissue level → Delayed onset of action.

Less A-V partial pressure difference → Less uptake by the tissues, more to the brain → Quicker onset of action.

Diffusion hypoxia

01:02:03

Also called as 'fink effect'.

Opposite of second gas effect. Seen at the end of surgery.

Withdrawal of mixture of maintenance anesthesia at end of surgery & only oxygen is supplied.

Rapid movement of nitrous oxide from pulmonary circulation to alveoli occurs.

Nitrous oxide fills the alveoli increasing its size → the concentration of oxygen is reduced in alveoli.

management : 100% oxygen should be supplied before extubating to prevent diffusion hypoxia.

INHALATION ANAESTHETICS :

PART - 2

Systemic effects of inhalational agents

00:00:11

All inhalational anaesthetics are depressants but increase intracranial pressure (ICP).

Respiratory system :

They are good bronchodilators.

Halothane : maximum bronchodilatation.

Sevoflurane : Preferred in asthmatics.

Isoflurane : Irritant

Desflurane : Very irritant.

} Avoided in asthmatics.

All inhalational anaesthetics decrease pulmonary vascular resistance except Nitrous oxide.

All agents reduce mucociliary clearance except Ether.

In lung injury : Sevoflurane is preferred (Desflurane causes maximum inflammatory response).

Effects on cardiovascular system

00:04:32

All agents are depressants (decrease systemic vascular resistance, heart rate, blood pressure and cardiac output).

Isoflurane, Desflurane & Sevoflurane : Equal in their action.

Desflurane :

Irritable nature will cause initial tachycardia, so avoided.

Isoflurane or Sevoflurane can be used.

Halothane :

- Used widely in earlier days.
- Causes maximum depression in heart rate.
- Causes nodal arrhythmia.
- Prolongation of QT interval.
- Sensitizes myocardium to catecholamines :
Ventricular arrhythmia.

Isoflurane :

- Preserves **preconditioning** (exposure of myocardium to brief episodes of ischemia will make the tissues resistant to subsequent episodes of ischemia).
- Theoretically, can cause **coronary steal phenomenon** (blood gets diverted away from ischemic myocardium. Found only in animal studies).

Effects on central nervous system

00:07:45

Increase cerebral blood flow & intracranial pressure.

Halothane : maximum increase in ICP.

Electrical silence :

Higher concentrations of inhalational agents produce flat lines on EEG.

For Isoflurane, level : 1.5 mac.

Enflurane : Causes epilepsy.

In neuro surgical patients, inhalational agent (Isoflurane) is used along with slight hyperventilation (increase in respiratory rate).

The PaCO_a levels are kept between 30 - 34 mm of Hg.

main controller of ICP is **PaCO_a level.**

Effects on GI & biliary tract

00:12:04

All inhalational agents preserve liver function, except Halothane.

Halothane :

- Causes **Halothane hepatitis.**
- Maximally metabolized in the body (20%).
Produces metabolic end products which react immunologically with hepatic cells and result in Halothane hepatitis.
- Reduces liver blood flow.

Desflurane :

- Least metabolized in body.
- Preferred in chronic liver disease.

Isoflurane :

- Cheaper.
- Equal in action to Desflurane.
- Widely used.

Renal system

00:14:16

Addition of fluoride ions converts an agent from flammable to non flammable.

But fluoride causes nephrotoxicity.

methoxyflurane : Contains maximum fluoride ions, hence maximum nephrotoxicity.

Sevoflurane :

- Also contains fluoride ions, but intra renal production of fluoride ions is less.
- Generally avoided.
- If used; in low concentrations for a short duration of time is preferred.
- Sevoflurane + soda lime = compound A which is nephrotoxic.

Desflurane : Preferred agent for renal and liver problems.

uterus :

- Can cause muscle relaxation and lead to PPH.
- used for manual removal of placenta.

muscular system : Potentiates action of muscle relaxants.

Ocular system : Decreases IOP.

Analgesia : Inhalational agents are not analgesic except Trielene (used in treatment of trigeminal neuralgia).

Active space

metabolism :

Halothane : maximally metabolized in the body.

Des-flurane : Least metabolized in the body.

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Nitrous oxide :

- Does not metabolize in body.
- Interacts with vitamin B₁₂ and causes megaloblastic anemia.
- On prolonged exposure : Sub acute combined degeneration of spinal cord (SACD).
- **Teratogenic** drug.

Newer agents : Halothane

00:19:55

Colorless volatile liquid.

Stored in amber colored

bottles (prevents exposure to sunlight).

Sweet smelling : Second preferred for induction in children.

Causes Halothane hepatitis.

1 in 34,000 patients developed acute fulminant hepatitis.

maximally metabolized in body.

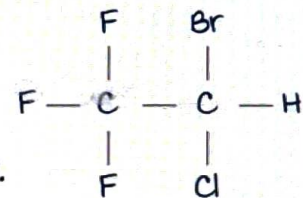
metabolic end products like **Trifluoro acetic acid (TFA)** react with hepatic cells resulting in hepatitis.

Severe, if it occurs in anaerobic environment.

Risk factors Halothane hepatitis :

- Females.
- 40 years.
- Obese.
- multiple exposure of Halothane.
- Auto immune disorders.

Enflurane was created which was found to be an epileptogenic, hence was discarded.



Isoflurane

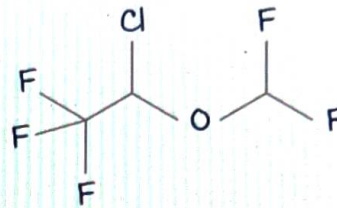
00:25:25

Isomer of Enflurane.

Preferred in cardiac and neurosurgeries.

Irritant in nature, hence avoided in children.

MAC : 1.15, Blood gas partition coefficient (B/G) : 1.38.



Desflurane

00:26:48

Lowest B/G value : 0.47.

Least soluble, hence faster induction & recovery.

2nd preferred for day care surgeries (due to irritant nature, patients develop post operative laryngospasm and bronchospasm).

Highest vapor pressure (666) and least boiling point (22°) : Requires specialized vaporizer called Tec6.

Very expensive.

Reacts with soda lime to produce maximum CO.

Least metabolized in the body (hence preferred in long duration surgeries, old age, in patients with liver and renal diseases).

maximum interaction with ozone (O₃) layer.

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Sevoflurane

00:29:08

Sweet smelling liquid.

First agent preferred for pediatric patients.

First agent preferred for day care surgery (B/G: 0.69).

Produces fluoride ions, hence avoided in renal surgery (but intra renal production of fluoride is low, so if in need, low concentration for a short duration can be used).

Reacts with soda lime to form compound A (proven nephrotoxic).

Can be used in cardiac or neuro surgeries.

Active space

Xenon

00:30:06

Ideal gas.

Highly expensive.

Not readily available.

Least B/G.

Does not cause greenhouse effect.

No second gas effect/teratogenic effect/diffusion hypoxia.
kumarankitindia1@gmail.com

Nitrous oxide

00:33:00

Cylinder : Blue.

Stored in liquid form.

Critical temperature : 36.5° .

Also known as laughing gas.

First demonstration done by Horace wells.

MAC value : 104 (least potent).

B/G : 0.42.

Usually used as a carrier gas ($50\% O_2 + 50\% N_2O$).

Produced by heating of ammonium nitrate (NH_4NO_3).

Interferes with vitamin B_{12} metabolism and causes megaloblastic anemia.

On prolonged exposure, it interferes with myelin sheath production and causes SCD.

maximum diffusion capacity, hence contraindicated in :

- Pneumothorax.
- Pneumomediastinum.
- Pneumoencephalus.
- middle ear surgery.
- Some ocular surgeries.

Older agents

00:35:38

Ether :

First demonstrated by morton.

Irritant smell.

B/G : 12 (maximum solubility).

Bronchodilator : Preserves muco ciliary function.

Trielene :

Has analgesic property.

Trielene + soda lime = Phosgene (respiratory irritant) +
dichloroacetylene (neuro toxic).

methoxyflurane :

Least MAC value (very potent).

Highest β/α value.

Potent nephrotoxic because of fluoride ions.

60c6b3eeaa8ded0e4e7e5ea7

Active space

LOCAL ANAESTHETICS : PART - 1

History of local anaesthetics (LA)

00.00:30

First used LA : Cocaine (by Karl Koller for an ophthalmic surgery).

Classification of LA (based on structure) :

- Any LA = **Aromatic component** (lipophilic component) + **tertiary amine** (hydrophilic component), connected by an **intermediate chain**.
- Intermediate chain :

	Amino amides	Esters.
Physical property	Stable solutions.	Unstable solutions. Structure resembles PABA (Para amino benzoic acid). Prone to cause allergic reactions.
Metabolism	Liver.	Enzyme : Esterases
Exception	Artikane metabolized by esterase.	Cocaine metabolized in liver.
Examples	Lignocaine, Bupivacaine.	Procaine, Chlorprocaine etc.,

Classification based on duration :

Amide : Two i's.
Esters : One i.

Short duration (Low potency)	Intermediate duration & potency	Long duration (High potency)
Procaine. Chlorprocaine (shortest acting).	Lidocaine. mepivacaine. Prilocaine.	Bupivacaine. Tetracaine. Etidocaine. Ropivacaine. Dibucaine (longest acting).

Active space

Mechanism of action of LA

00:08:13

All LAs block conduction of impulses in the nerve.

All LAs are **sodium channel blockers** (predominantly).

Also blocks K^+ and Ca^{2+} channels.

Nerve :

Sodium outside, potassium inside. Depolarization : Sodium tries to move in, potassium moves out.

Henderson Hasselbalch equation :

Inject a drug into a medium, depending on the surrounding pH, drug dissociates into :

- Non ionized form (lipid soluble).
- Ionized form (water soluble).

$$pH = pK_a + \log \frac{\text{(non-ionized)}}{\text{(ionized)}}$$

Active component of LA : **ionized form.**

Due to the slight difference in extra cellular (7.35) and intracellular (7.34) pH, non ionized component which moved inside the cell converts into the active component (ionized component) & blocks the sodium channel conduction.

pH drops down in case of dirty/ necrotic wound, thus when LA is injected, whole drug converts into ionized form. Cannot enter into cell (as water soluble) & cannot bind to sodium channel. Hence, action not exerted.

Q. A patient with tooth abscess posted for extraction of tooth. Which of the following preferred?

- Inferior alveolar block.
- General anaesthesia (since pH is low).
- MAC.
- None of the above.

Sodium channels

00:21:17

1 alpha unit + 2/3 beta units.

Each alpha unit has 4 domains : D1, D2, D3, D4.

Each domain has 6 helical regions : S1, S2, S3, S4, S5, S6.

S5 - S6 from one domain connects to the S1 - S6 of the next domain through P - loop. This creates the

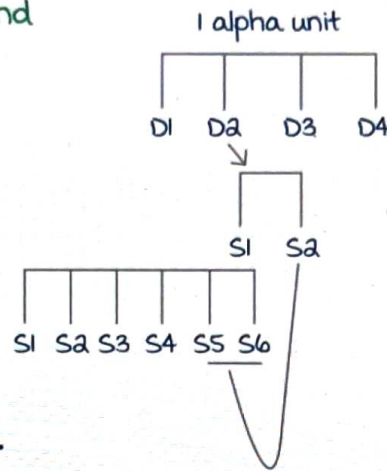
communication between intra and extra cellular spaces.

This appears like a pore.

Na⁺ channel :

1. Open channel.
2. Inactive channel.
3. Closed channel.

LAs have higher affinity to block open and inactive channels.



Sequence of nerve blockade

00:26:20

Nerves fibres are of 2 types :

- myelinated fibers.
- unmyelinated fibers.

LAs easily block small, myelinated nerve fibers.

Erlanger Gasser classification of nerve fibers :

Fiber class	Sub class	myelin	Diameter	Function
A	α	+	6-22 μ	motor, proprioception.
	β	+	6-22 μ	motor, proprioception.
	γ	+	3-6 μ	muscle tone.
	δ	+	1-4 μ	Pain, touch, temperature.
B		+	<3 μ	Autonomic functions (preganglionic sympathetic).
C		-	0.3-1.30 μ	Autonomic functions (postganglionic sympathetic).
		-	0.4-1.2 μ	Pain, temperature touch.

Correct sequence of blockade :

- multifactorial.
- Conventional teaching :

Smaller nerve fibres are easily blocked.

In vivo experiments with super perfusion of peripheral nerve with drug (analogues to peripheral nerve block).

$A \gamma > A \delta > (B = C = A \beta = A \alpha) > C$.

$A > B > C$.

Spinal anesthesia :

$B > C > A$.

Sequence is $B > C = A\delta > A\gamma > A\beta > A\alpha$.

Sequence of blockade Autonomic \rightarrow Sensory \rightarrow motor fibres.

The sensory blockade order is :

Temp (cold \rightarrow hot) \rightarrow Pain \rightarrow Touch \rightarrow Deep pressure \rightarrow proprioception.

Regression is in reverse order.

Clinical pharmacology

00:36:19

Potency of a LA directly proportional to its hydrophobic/lipophilic nature.

Onset : Concentration directly proportional to onset (quicker).

pKa defined as pH when concentration of non-ionized equals to ionized components.

If pKa low or close to body pH, onset is quicker.

- Lignocaine pKa 7.7.
- Bupivacaine pKa 8.4.

Action of Lignocaine is faster than Bupivacaine.

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Additives :

- Lignocaine + Adrenaline.
Adrenaline causes reduced systemic absorption.
Hence, duration of LAs can be prolonged.
- Opioids/ Alpha 2 agonists, Dexamethasone can also be used as additives.

To have a quicker onset of LAs :

Addition of Sodium bicarbonate (surrounding pH rises \rightarrow more amount of non-ionized form \rightarrow more amount of drug goes inside \rightarrow Quicker onset).

Absorption :

Spinal anaesthesia : Quicker onset.

- Brachial plexus block : 10 - 15 mins delay.

Absorption depends on site of injection.

maximum systemic absorption occurs at :

- IV anaesthesia > intercostal nerve block > caudal nerve block > paracervical nerve block > epidural nerve block > brachial plexus block > sciatic nerve block.

By addition of vasoconstrictors, reduced systemic absorption is seen.

Pregnancy :

Due to hormone progesterone, nerve fibers become sensitive to LAs.

mixture of LAs :
60c6b3eeaa8ded0e4e7e5ea7
Onset is quicker + duration is longer.

Chances of LA toxicity.

Example : Chlorprocaine (short acting) + Bupivacaine (long acting) = Immediate effect + prolonged effect.

Disadvantage : Crosses maximum threshold leading to LA toxicity.

Dosage of LAs :

Balance using correct concentration + dosage + volume of the LA.

LOCAL ANAESTHETICS : PART - 2

Dosages of local anaesthetics

00:00:18

60c6b3eaa8ded0e4e7e5ea7

Lignocaine : 3 - 5 mg/ Kg.

Lignocaine + Adrenaline : maximum 7 mg/ Kg.

Bupivacaine, Ropivacaine, Levobupivacaine : 2 - 3 mg/ Kg.

Dosage of commonly used LA : 70 Kg/ person.

Drug	minor nerve block	major nerve block	Epidural	Spinal
Lignocaine	50-200 mg (1%)	350 mg (1-2%) 500 mg (with adr)	350 mg (1-2%) 500 mg (with adr)	30-100 mg (1.5-5%)
Bupivacaine	12.5-100 mg (0.25-0.5%)	175 mg (0.25-0.5%) 225 mg (with adr)	175 mg (0.25-0.5%) 225 mg (with adr)	15-20 mg (0.5-0.75%)
Ropivacaine	10-100 mg (0.25-0.5%)	200 mg (0.25-0.5%) 250 mg (with adr)	200 mg (0.25-0.5%) 250 mg (with adr)	15-20 mg (0.5-0.75%)
Levobupivacaine		200 mg (0.25-0.5%) 250 mg (with adr)	200 mg (0.25-0.5%) 250 mg (with adr)	15-20 mg (0.5-0.75%)
Procaine	100-400 mg (2%)	350 mg (1-2%) 500 mg (with adr)		100-200 mg (10%)

Active space

Always reduce the concentration of local anaesthetic used to required amount to reduce the chance of toxicity.

LAST (Local Anaesthesia Systemic Toxicity) 00:04:01

Affects CNS and CVS mainly as they are dependent on sodium channel conduction.

1. CNS : Approximately 80% energy/activity spent to maintain sodium channels.

Lignocaine injected intravenously or used as LA in higher amounts can cause :

- Light headedness, followed by
- Circumoral numbness
- Tinnitus.
- Vision disturbances/ hallucinations.
- muscle twitchings.
- Generalized tonic-clonic convulsions (seizures).

Treatment :

On showing CNS symptoms : Stop injecting the drug.

In case of GTCS :

- Short acting Benzodiazepines like midazolam.
- Intubate using Thiopentone/Propofol and muscle relaxant.
- Continue mechanical ventilation (Hyperventilate → Decreased P_aCO_2 → Decreased cerebral blood flow → Less amount of LA reaches the brain).

2. CVS :

All LAs show negative inotropic action.

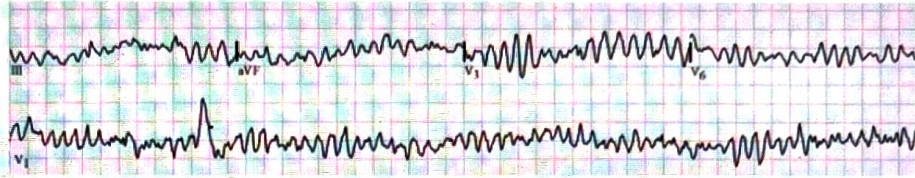
Increase PR and QTc interval → ventricular arrhythmias, which are resistant to treatment.

Bupivacaine is known to cause CVS symptoms.

Treatment :

- Stop injecting the drug.
- Start CPR according to ACLS guidelines.

- 20% intra-lipid is used in the management of Bupivacaine induced arrhythmias. It binds to Bupivacaine → Prevents sodium channel conduction in the heart.
- Dosage : 1.5 ml/kg bolus followed by 0.5 ml/kg/hour infusion.



ventricular fibrillation

minor toxicities :

Prilocaine toxicity : methemoglobinemia.

Treatment : methylene blue IV (converts Fe^{2+} to Fe^{3+}).

Prilocaine when toxic → Produces ortho toluidine → Binds to hemoglobin and converts ferrous iron (Fe^{2+}) to ferric iron (Fe^{3+}) which has low affinity to oxygen.

SpO_2 shows falsely low values.

mixture of Lignocaine + Adrenaline contraindicated in :

- Surgeries of fingers, toes, ear lobules, tip of the nose.
- Circumcision.

as these areas have end artery supply.

Application of LA

00:19:31

1. Labor analgesia (given via epidural) :

- Low dose LA : Blocks only autonomic sensations.
- Slight increase in dosage → Sensory segments blocked, further increase in dosage blocks motor segments.

Example :

Bupivacaine 0.5% → If reduced to 0.0625% → Only autonomic functions are blocked.

On making the concentration to 0.125% → No pain during

delivery (sensory blocked, motor spared).

On increasing the concentration to 0.25% or 0.5%, there will

be motor weakness and the mother will not be able to bear

down or actively participate in labour.

This is known as **differential blockade of conduction**.

Order of blockade of fibres : $B > C > A$.

Autonomic (B fibres) → Pain (C fibres) → motor (A fibres).

Ropivacaine 0.2% used now.

2. Painless IV cannulation :

EMLA cream (Eutectic mixture of LA) : 2.5% Lignocaine +
2.5% Prilocaine.

Applied with occlusive dressing (sticker).

Place the sticker for 30 - 45 mins → Remove it →

IV cannula inserted over that location.

3. Bier's block/ intravenous regional anesthesia :

Injecting LA intravenously into forearm after application of
tourniquet (post inflation).

Tourniquet pressure :

SBP > 250 mm Hg or 100 mm Hg above SBP.

Secure IV line on opposite hand with all resuscitative
equipment in anticipation of toxicity.

Drugs used :

- Lignocaine 0.5%.
- Prilocaine 0.5%.

Drugs contraindicated :

- Bupivacaine.
- Ropivacaine.
- Levobupivacaine.

Generally use 2 tourniquets and inflate them for safety
reasons (in case 1 gets deflated).

Indication : Day care or short procedures.

Not used for long procedures as there is a risk of nerve
compression and injury.

Contraindications : Sick cell anemia

(tourniquet → sickling).

Precautions :

make sure cuff doesn't deflate.

Do not remove the block suddenly (slowly deflate).

Pharmacology of amino esters

00:34:52

Cocaine :

- CNS stimulation.
- Eye : mydriasis.
- 4% concentration.
- Potent vasoconstrictor (do not use in IV line as it can cause angina).
- metabolized in liver.

Procaine :

- 1 - 2% concentration.
- LA of choice in patients with h/o malignant hyperthermia (now Lignocaine can also be used).
- Procaine interacts with Sulfonamide antibiotics.

Chlorprocaine :

- Short onset of action.
- Previously thought to have caused local nerve toxicities (later proved that nerve damage is due to preservatives used).
- Now preservative free.
- used in day care anesthesia.

Lignocaine :

- pKa : 7.7
- Previously, 5% lignocaine used for spinal : Transient neurological symptoms (not used now).

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Prilocaine :

- EMLA cream (2.5%).
- Toxicity : methemoglobinemia.

Bupivacaine :

- Long acting LA.
- Spinal anesthesia (0.5% of preservative free bupivacaine). kumarankitindia1@gmail.com
- 3 mg/kg maximum dose.

Levobupivacaine : Less cardiotoxic.

Ropivacaine :

- Preferred nowadays for labor analgesia (0.2%) due to less motor effect.
- Slight vasoconstrictors.

Agents not used routinely

00:43:30

1. Dibucaine : Longest acting, most potent, and most toxic. used in identifying abnormal pseudocholinesterase.
2. meperidine : used if patient is allergic to both amides & esters.
3. Etidocaine : Good surgical relaxation. Long acting, so not preferred.
4. Tetracaine : Available as crystals -
Can be made hyperbaric by mixing with CSF.
Can be made hypobaric by mixing with normal saline.

New trends in local anaesthetics :

1. Tumescence anaesthesia : Used in liposuction.
Very dilute large concentrations of LA injected subcutaneously and fat sucked out.
Drug : 0.1% Lignocaine + Adrenaline.
maximum dose : 35 - 55 mg/kg.
2. Liposomal encapsulation : Bio degradable.
3. Synera (S-Caine) : Lignocaine + Tetracaine + heating element (creates exothermic reaction and produces surface anaesthesia).
4. TAC : Tetracaine 0.5% + Epinephrine 1:200000 + Cocaine 10%). Not effective on skin.

Active space

MUSCLE RELAXANTS : PART - 1

Purpose of administering muscle relaxants

00:00:34

- To secure the airway of the patient.
- To provide relaxation for GI surgeries.

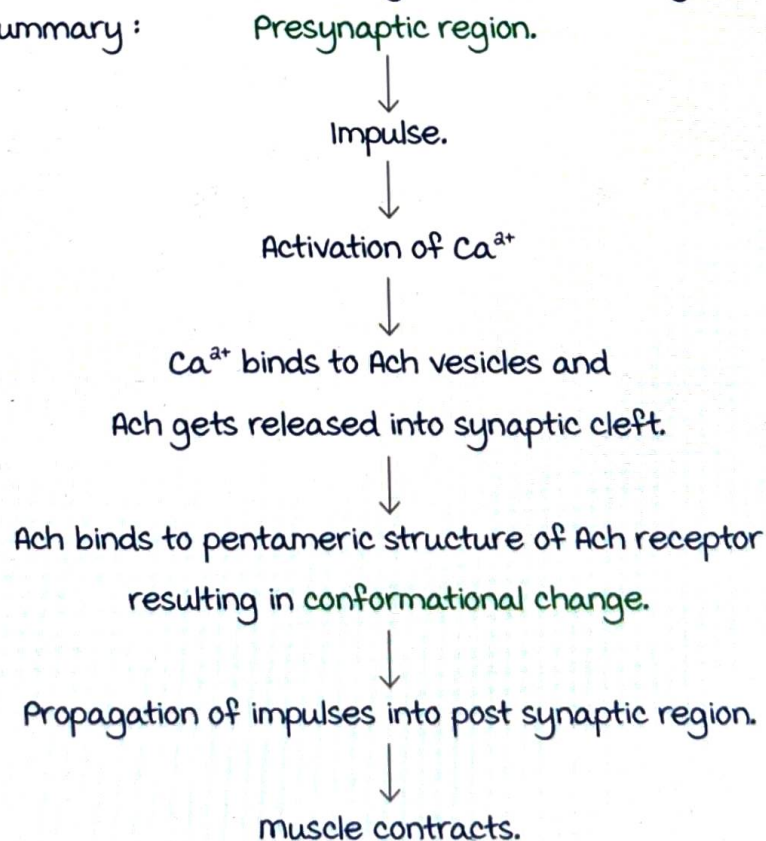
Neuromuscular junction (NMJ) physiology :

The neurotransmitter responsible at the junction is acetylcholine (ACh). ACh vesicles are present at the presynaptic region and ACh receptors are present at the post synaptic region.

The ACh receptors have a pentameric structure, which consists of α , β , α , δ and ϵ subunits.

ACh has 2 legs which occupy both α subunits, causing a conformational change. All the ions subsequently gets transmitted into post synaptic region. This causes Na^+ to move in, propagate the impulse & cause action potential. Additional ACh is inactivated by ACh esterase enzyme.

In summary :



Pharmacology of neuromuscular blocking agents :

Classification based on mechanism of action :

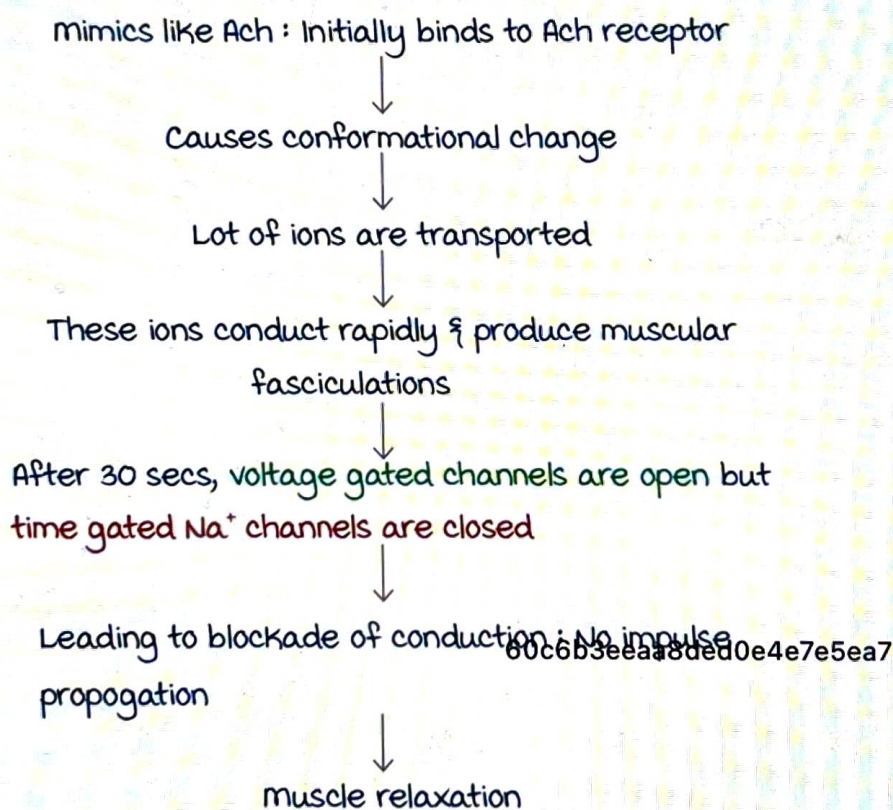
- Depolarizing agents : Succinylcholine.
- Non depolarizing muscle relaxant (NDMR) :
Pancuronium, Vecuronium, Atracurium, etc.,

Succinylcholine (Sch)

00:09:22

Consists of 2 molecules of acetylcholine bound by either acetate or methyl group.

mechanism of action :



Structure : 2 molecules of Ach.

Onset of action : 30 - 60 seconds. Quick in onset.

Agent of choice in :

- **Emergency intubations.**
- Rapid sequence intubation.
- Difficult airway management.

Duration of Action : 10 mins (Pseudocholinesterase metabolizes Sch).

Dose : 1 - 1.5 mg/kg.

metabolized by pseudocholinesterase produced from liver

and transported in plasma → Slowly diffuses in NMJ and terminates action of Sch.

Reasons for non withdrawal of effects of Sch :

- Decrease in concentration of pseudocholinesterase :

Usually not a problem because liver has large reserves of pseudocholinesterase.

- Decrease in activity :

Fewer number of Sch molecules are hydrolyzed in unit time.

Seen in cases of : Chronic liver disease, pregnancy, old age patients, cancers, OCP users, Esmolol user, Organophosphate poisoning, Neostigmine/Tyrosinase user, Bambuterol (prodrug of Terbutaline) users.

Atypical pseudocholinesterase

00:27:16

Due to abnormal genetic variant of pseudocholinesterase/ butyrylcholinesterase, at 209th position, the nucleotide sequence changes from **guanine to adenine**. Atypical pseudocholinesterase has **reduced activity** as compared to pseudocholinesterase.

To identify the individuals with the abnormal variant, we use **Dibucaine number**.

Dibucaine is a local anesthetic which has got **affinity** for normal pseudocholinesterase enzyme. Qualitative analysis of pseudocholinesterase is done by mixing Dibucaine with patient's blood sample and checking its level after a period of time (like 6 hours). **Reduced Dibucaine levels** indicate **good activity** of pseudocholinesterase.

Normal value is **80 : 20**, also called as **homozygous typical**. (80% normal pseudocholinesterase & 20% atypical pseudocholinesterase).

Heterozygous atypical (seen in 1 : 480 population) :

Here the duration of Sch is prolonged by about 50 - 100%.

Action of Sch maybe prolonged to 20 - 30 minutes.

Homozygous atypical (seen in 1 : 3200 population) :

The dibucaine number is 20.

Action of Sch can be prolonged from 4 - 8 hours.

Quantitative analysis : measurement of plasma Cholinesterase.

In cases of atypical homozygous patients under Sch/
Scoline apnea :

- Continue mechanical ventilation.
- Administer Fresh Frozen Plasma (FFP) : This will increase the patient's levels of pseudocholinesterase.

Administering high doses of Sch (dose > 5mg/kg)/repeated bolus doses can cause damage to the patient's Ach receptors and cause prolonged duration of action. This mimics non depolarising muscle relaxant (NDMR) blockade and shows features like **fade and train of four**. This kind of block is known as **Phase II blockade**.

In such cases, do not attempt to reverse with Neostigmine.

Only **continue mechanical ventilation**.

New receptors will be produced in 24 - 48 hours.

Effects of Sch on other systems

00:48:21

CVS : Causes bradycardia. Adults can tolerate slight amount of bradycardia but children cannot, therefore **premedication with atropine** is given in children. It can also cause nodal rhythms, ventricular arrhythmias.

Eye : Increases intraocular pressure due to tonic contractions of extraocular muscles.

GIT : Increased fasciculations → Increased intragastric pressures.

Skeletal muscles : Repeated muscular contractions can cause **post operative myalgia**. This can be **prevented by** giving a small dose of **NDMR before giving DMR**, this process is called as **precurarization**.

Acetyl salicylate : Prostaglandin inhibitor which helps in reducing post op myalgias very efficiently.

Q. Patient with raised IOP presents for emergency intubation, can Sch be given?

A: Yes, airway management is of more importance, after which raised IOP is taken care in cases of emergency.

Contraindications of Sch

00:56:11

- History of malignant hyperthermia.
- Pre existing hyperkalemia can lead to ventricular arrhythmias (can be worsened with Sch).
- Head injury (due to raised intracranial pressure).
- Glaucoma (raised IOP).
- muscular disorders, e.g. Duchenne's muscular dystrophy, myotonia dystrophica.
- History of burns in 6 days to 6 months.
- Hemiplegia, paraplegia.
- Advanced liver failure (reduced pseudocholinesterase activity).
- Sepsis.

In muscular disorders, burns and hemiplegia :

There is a change in structure of Ach receptor. Instead of ϵ subunit, δ is present which can cause hyperkalemia.

myasthenia gravis :

These patients are resistant to depolarizing muscle relaxants and sensitive to NDMR. This is because of :

- Pyridostigmine used for its treatment will reduce the activity of pseudocholinesterase enzyme.
- Structural change in Ach receptors.
- Pyridostigmine used for its treatment will reduce the activity of psuedocholinesterase enzyme.
- Structural change in Ach receptors.
- Pyridostigmine used for its treatment will reduce the activity of psuedocholinesterase enzyme.

MUSCLE RELAXANTS : PART - 2

Non-depolarizing muscle relaxants (NDMR) 00:00:08

Previously they were classified as :

- Pachycurare which were bulky molecules.
- Leptocurare. Eg. : Succinylcholine.

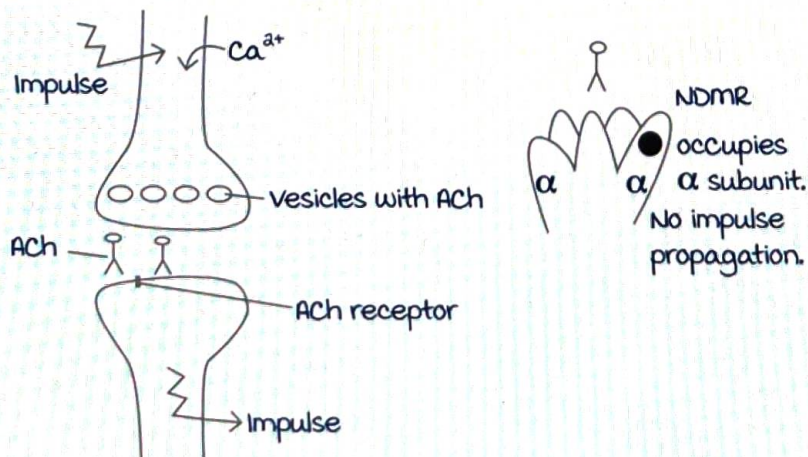
Classification based on structure :

Steroidal compounds	Benzyl isoquinolinium compounds
Pancuronium. Vecuronium. Rocuronium. Pipcuronium.	D - tubocurare. Atracurium. Cis - atracurium. Mivacurium.

Classification based on duration of action :

Long acting	Pancuronium.
Intermediate acting	Vecuronium. Rocuronium. Atracurium. Cis - atracurium.
Short acting	Mivacurium.
Ultra short acting (in clinical trials)	Gantacurium.

Mechanism of action :



Active space

NDMR molecule occupies the α - subunit of acetyl choline (ACh) receptor \rightarrow Prevents the binding of ACh \rightarrow No conformational change \rightarrow No propagation of impulses. This is a classical example of **Competitive** type of blockade.

Depolarising muscle relaxant : Non-competitive blockade.
Non-depolarising muscle relaxant : Competitive blockade.

Reversal :

At the end of the surgery, NDMR molecules are weakened due to body metabolism.

Neostigmine (ACh esterase inhibitor) is administered around this time \rightarrow **Increases in ACh levels** \rightarrow displace remaining NDMR molecules \rightarrow restoring normal neuromuscular physiology.

Sequence of muscle blockade

00:09:52

Small muscles are blocked quickly.

- Exception : **Diaphragm**, despite being a large muscular structure, gets blocked first due to the **maximal blood flow**.

Order of muscle blockade :

Diaphragm > Smaller muscles > Intermediate muscles > Larger group of muscles.

Recovery occurs in reverse order.

- Diaphragm > **Larger** group of muscles > Intermediate group > **Smaller** group of muscles.

Upper airway muscles like pharyngeal and laryngeal muscles, though part of the intermediate group, are very **sensitive** to effects of muscle relaxants.

After extubating the patient, there is a chance for **dynamic airway obstruction** as the remaining small concentrations of NDMR will act on the upper airway muscles.

Neuromuscular blockade :

- monitored by ulnar nerve & **adductor pollicis muscle** (small muscle).

- Recovery of adductor pollicis implies that the diaphragm and the airway muscles have recovered from the effects of the muscle relaxants ; Ulnar nerve stimulated.

To ensure **complete recovery**, Train of four ratio (TOF) > 0.9.

Practical approaches to blockade :

Routine procedure :

- Succinyl choline given first for fast relaxation.
- maintained using NDMR → Reversal with Neostigmine.

In case of **elective ocular surgeries with raised IOP**, NDMR is used **alone** → Reversed with Neostigmine.

In case of emergency intubation, where succinyl choline is contraindicated.

- Large doses of NDMR given to quicken the onset of action.
- But, failure to intubate can result in death of the patient.

Priming :

- Small doses of NDMR given.
- Patient is induced to sleep, and then muscle relaxation is maintained by normal doses of NDMR.
- Onset of action is quicker.

Steroidal NDMR

00:21:28

Pancuronium :

Type.	Long acting steroidal NDMR kumarankitindia1@gmail.com
Duration.	45 mins. Avoided in day care anaesthesia.
metabolism and excretion.	15 - 20% metabolized in kidney. Eliminated via renal route. Avoid in renal and liver failure.

Active space

Benzyl isoquinoline NDMR

00:29:54

Atracurium :

Type	Intermediate acting benzyl isoquinoline NDMR.
Duration	15 - 20 min.
Unique property	metabolized by Hoffman's degradation . (Non enzymatic, non organ dependent clearance). Atracurium pH : 4, stored at 4°C. Human body : 7.35 pH & 37°C, metabolizes on its own due to change in pH & temperature. Preferred for liver and renal failure.
Disadvantage.	Histamine release → Anaphylaxis. Continuous infusion (2-3 days) produces laudanosine → Crosses blood brain barrier and causes seizures .

cis - Atracurium :

Type and properties.	Isomer of Atracurium. Similar to Atracurium.
Advantage over atracurium.	Less histamine release. Less laudanosine production. 4 times more potent. Agent of choice for liver and renal transplant.

mivacurium :

Type.	Short acting benzyl isoquinoline NDMR.
Duration.	10 mins. Agent of choice for day care anaesthesia.
metabolism and excretion.	metabolized by plasma esterases .

Active space

Agents preferred for day care anesthesia :

Rocuronium + Sugammadex > mivacurium > cis - Atracurium
> Atracurium > Rocuronium + Neostigmine.

Ultra short acting muscle relaxants : Not in use yet.

Duration.	3 - 4 mins.
metabolism and excretion.	Cysteine adduction. Ester hydrolysis.
Drugs	Gantacurium. <ul style="list-style-type: none"> • First marketed ultra - short acting muscle relaxant. • Stopped as it did not show good results in trials. CW002, CW1759 - 50 : under trial.

CW002, CW1759 - 50 : Drugs are metabolised by cysteine adduction & ester hydrolysis.

Duration of action : 3-4 minutes.

Older agents

00:39:21

D - Tubocurare.	1 st muscle relaxant used by Harold Griffith. Maximum histamine release. Maximum ganglion blockade property → Hypotension.
Pipecuronium.	Properties similar to Pancuronium without vagolytic action .
Rapacuronium.	Causes severe bronchospasm → Discontinued.
Gallamine. kumarankitindia1@gmail.com	Only NDMR which crosses placenta.
Alcuronium.	Steroidal compound that causes anaphylaxis. Degrades when exposed to sunlight.

metocurine.	Synthetic derivative of D - Tubocurare. Less cardiovascular side effects.
Doxacurium.	most potent long - acting muscle relaxant. 60 min duration.

Interactions

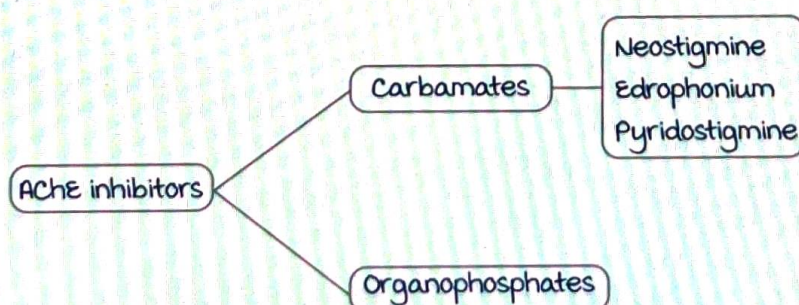
00:42:02

Prolong the action	Shorten the action
Elderly, pediatric, obese (steroidal). Renal & hepatic diseases (except Atracurium). Inhaled anaesthetics. Dantrolene (peripheral muscle relaxants). Hypothermia . Antibiotics (Aminoglycosides and Tetracyclines). Local anaesthetics (stabilizes post synaptic & muscle). Ca ²⁺ channel blockers. Hypocalcemia. Hypokalemia. Magnesium & Lithium. Neuromuscular diseases.	Procaine Phenytoin Carbamazepine Calcium Azathioprine Steroids

The previous practice to wash the abdomen post-surgery was discontinued as aminoglycoside antibiotics prolonged the action of muscle relaxants.

Reversal of block

00:43:42



Active space

AChE inhibitors increase ACh levels & displace NDMR molecules thereby bringing about reversal of the block.

Neostigmine :

Type	Quaternary ammonium compound → Does not cross the blood brain barrier.
Dose	50 - 70 µg/ Kg.
Duration	2 hours. Peak duration ~ 10 mins.
Side effect	Bradycardia • mixed with Atropine/ Glycopyrrolate to prevent it.

Edrophonium :

Does not inhibit pseudo cholinesterase → Preferred for the reversal of mivacurium.

Pyridostigmine :

Treatment of **myasthenia gravis**.

Long acting ~6 hours.

Signs of adequate reversal :

- Regular respiration with adequate tidal volume.
- Spontaneous eye opening (unreliable).
- Spontaneous limb movement.
- Able to protrude tongue.
- Able to cough, no cyanosis.
- Able to lift head > 5 sec → **most reliable bedside test**.
- Able to hold tongue depressor between central incisors.
- Train of four ratio > 0.9 → **Guaranteed recovery**.

Clinical correlation :

1. If a pregnant patient is given GA, muscle relaxant reversal need not be given to newborn.

All muscles relaxants do not cross placenta or blood brain barrier.

2. Neuromuscular blockade in ICU :

Can be used for securing airway.

Not used for prolonged period as it causes critical illness myopathy (disuse atrophy).

Provide sedation but not use muscle relaxants for a prolonged period in ICU patients.

ANAESTHESIA IN CO-EXISTING DISEASES : PART – 1

Cardiac patient for non cardiac surgeries

00:02:15

Goal : To provide hemodynamic stability.

Pre - anaesthetic checkup :

Stop Aspirin/ Clopidogrel/ Warfarin 5 - 7 days before surgery.

Risk stratification according to ACC/ AHA guidelines.

Premedication :

When a patient is posted for surgery → Stress → sympathetic activation → Increased BP & HR.

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Use a good anxiolytic (Tab. Alprazolam on the night before surgery) along with small amount of opioid.

E.g. Benzodiazepine like midazolam + Fentanyl (opioid)

This combination is a potent respiratory depressor so strict monitoring required.

monitors :

ASA standard monitoring to be done which includes ECG, HR, SpO₂, RR, BP, EtCO₂, temperature.

In cardiac patients,

Invasive BP (IBP) monitoring : Beat to beat variation of BP.

CVP monitoring : To assess the amount of fluid that can be transfused & right heart status to prevent fluid overload.

In very sick patients, transesophageal echocardiography monitoring can also be done.

Induction :

Induction agent of choice is intravenous etomidate (not available).

Combination of benzodiazepine + opioid can also be used.

Though large doses of opioid can lead to chest wall rigidity (wooden chest syndrome).

Active space

Inhalational agent :

Isoflurane or Sevoflurane.

Desflurane is not preferred as it is an irritant that causes initial tachycardia.

Halothane should be avoided.

muscle Relaxant (MR) :

Vecuronium is the muscle relaxant of choice as it is cardiostable.

Post op :

Keep patient in ICU and on ventilator if required.

Hemodynamic stability refers to a balance between oxygen consumption and oxygen delivery.

Increased O_a consumption :

Anxious state.

Pain.

Fever.

Hypovolemia (increased HR).

Increased O_a consumption & decreased O_a delivery : Post op MI.

Decreased O_a delivery :

Deeper planes of respiratory depression (like opioids).

Hypotension.

Anaemia.

Cardiac patient for cardiac surgery

00:15:18

Cardiopulmonary bypass (CPB)

A specialized machine which is used to oxygenate the blood and pump it into circulation.

It includes :

- Venous reservoir (where deoxygenated blood is collected).
- Oxygenators (to where blood is passed for oxygenation).
- Roller pumps (which pumps blood back into circulation).

There are 2 types of oxygenators :

- membrane oxygenator (preferred).
- Bubble oxygenator (not used).

Heparin 300 - 400 microgram/kg is required to prevent blood from clotting.

monitor the activity of heparin using Activated Clotting Time (ACT). Keep the values around 300s.

ACT value in normal person = 120s.

myocardial protection :

Cold cardioplegic solution containing high levels of K^+ is given to arrest heart in diastole. Hypothermia reduces basal metabolic rate. It also contains glucose to keep the heart viable.

Rheumatic heart disease :

Mitral Stenosis (MS)/ Aortic Stenosis (AS) :

Fixed output condition. Low volumes in left ventricle.

Goal : To prevent tachycardia/ hypotension (as they further decrease LV diastolic filling).

Spinal anaesthesia is contraindicated as it brings about drastic hypotension.

Epidural anaesthesia can be given as it slowly and mildly reduces BP giving time for adjustment to the body.

In general anaesthesia, avoid sympathomimetics (ketamine), do gentle laryngoscopy & intubation to prevent pain & subsequent tachycardia and hypovolemia.

Induction agent : Etomidate, muscle relaxants : Vecuronium, Isoflurane = Sevoflurane can be given.

Mitral Regurgitation (MR) /Aortic Regurgitation (AR) :

Goal : Avoid bradycardia inducing agents as it increases regurgitant fraction. E.g. Beta blockers.

Spinal anaesthesia is indicated as vasodilatation can improve LV out-flow to systemic circulation.

For general anaesthesia : Atropine, Pancuronium can be used.

Congenital heart diseases :

In right to left shunts, agent of choice is ketamine.

Left to right shunts : Thiopentone and Propofol can be used. Avoid ketamine.

N_2O should be avoided in all heart diseases as it increases pulmonary vascular resistance.

Anaesthesia for neurosurgeries

00:32:12

Goal : Avoid increase in ICP.

$$CPP = MAP - ICP.$$

CPP : Cerebral Perfusion Pressure;

MAP : mean Arterial Pressure; ICP : Intra Cranial Pressure.

As increase in ICP can reduce cerebral blood flow.

No sedative premedications should be used, as they lead to slight respiratory depression. CO_2 retention even in mild amounts lead to increase in ICP.

ASA standard monitoring along with IJV/IBP monitoring.

Preferred induction agent : Thiopentone sodium due to its anti - epileptic property and maximal reduction of ICP.

All inhalational agents increase ICP by increasing cerebral blood flow. This is counteracted by manually increasing RR (with the help of ventilator) which causes CO_2 washout, thereby reducing the rise in ICP due to inhalational agents. maintain $EtCO_2$ values at 30 - 32 mmHg.

muscle relaxants :

Avoid succinylcholine as it increases ICP. use cardiostable muscle relaxants like Vecuronium.

Posterior fossa surgeries :

Patient is operated in sitting position for adequate exposure.

Cons :

- Prone for venous air embolism (seen in surgeries above level of heart).

Concept : Heart is taken as level 0.

Below the level of heart : Higher pressure.

Above the level of heart : Lower pressure.

So, when a vessel is cut, air gets sucked in from the atmosphere leading to mechanical obstruction of the heart, increasing the chances of forming air emboli.

- macroglossia due to edema from compression of the tongue by the mouth.
- Increased chances of nerve injuries (cervical spine instability, nerve compression in the elbows).

Presentation of venous air embolism (VAE) :

Sudden hypotension, increased airway resistance, initial **tachycardia** followed by **bradycardia** (when hypoxic).

To detect VAE :

Echo > carotid doppler > ↑ pulmonary arterial pressure > sudden ↓ EtCO_a > ↓ CO > ↑ CVP > ECG (right heart strain pattern) > Windmill type of murmur on stethoscope.

Sudden drop of EtCO_a during surgery is due to 2 causes :

- Disconnection of ET tube.
- Venous air embolism.

management :

Immediately stop surgery and close the operating area.

Place patient in head down position and try to aspirate the air bubble through central venous line.

Head injury :

Rule out **cervical spine injury**.

use manual inline stabilization to secure the airway.

In basal skull fractures, **do not use nasopharyngeal airway/ nasal intubation**.

Anaesthesia for hepatic diseases

00:47:00

Goal : To maintain normal perfusion of liver.

Pre operative considerations :

- Coagulopathy : Regional anaesthesia is contraindicated.
- Encephalopathy : Delayed recovery, thus requires ICU care.
- Variceal bleeding : Risk of aspiration present.
- Portal hypertension, Ascites, jaundice : Hyperdynamic circulation/ hypotension.
- Rule out hepato renal/ pulmonary syndrome.

ASA monitoring along with CVP monitoring and transfuse fluids accordingly.

Induction agent of choice : Propofol in incremental doses.

Inhalational agents : **Avoid Halothane**.

Preferred : Isoflurane.

Desflurane (best).

muscle relaxants : Cis atracurium / Atracurium.

Anaesthesia for renal diseases

00:52:18

Goal : To avoid hypoperfusion of renal system.

Pre op concerns :

- Volume overload : Can predispose to pulmonary edema.
- Diabetes mellitus.
- Hypertension.
- Anaemia (site of erythropoietin production).
- Hyperkalemia.
- metabolic acidosis.

- uremia/ uremic encephalopathy.

ASA monitoring along with CVP monitoring.

Note the time since last dialysis. Heparin - free dialysis should be done before surgery.

Assess for volume depletion after dialysis.

Induction agent of choice : Propofol.

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Inhalational agents :

Avoid Sevoflurane, as it produces compound A with soda lime which is nephrotoxic. But can be used for short duration at good O_2 flow rates in less concentration.

Avoid halothane.

Preferred : Isoflurane/ Desflurane.

muscle relaxants : Cis atracurium/ Atracurium.

Eliminated by Hoffman's degradation which is non enzymatic/ non organ dependent clearance.

urological surgeries :

Fluid overload due to excess fluid used in irrigation.

In Transurethral Resection of Prostate (TURP) syndrome, Glycine (& mannitol) was used as irrigating fluid which caused fluid overload and temporary blindness/ visual disturbances.

Now normal saline is used along with bipolar cautery.

At Na^+ levels $< 120mEq/L$: Patient becomes irritable, confused,

develops chest pain and ventricular arrhythmias.

Fluid overload causes **hyponatremia**.

Treatment of hyponatremia :

1st line : Remove excess water by **Furosemide**.

Followed by slow infusion of NaHCO_3 at 0.5 - 1 meq/hour in case of arrhythmias.

Rapid correction leads to central pontine myelinolysis.

Regional anaesthesia in the form of spinal subarachnoid block is preferred.

Avoid hypothermia in elderly patients which can occur due to excess fluids.

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Active space

ANAESTHESIA FOR COEXISTING DISEASES : PART - 2

Anaesthesia in blood disorders

00:00:16

Anemia : Acceptable Hb for elective surgery is **8 gm%**.

Thrombocytopenia : minimum platelets required for performing surgery is **1,00,000/ml**.

In bleeding disorders like, haemophilia etc., regional anaesthesia is contraindicated.

In sickle cell anaemia : Intra Venous Regional Anaesthesia (IVRA)/ Biers block is contraindicated.

Tourniquet usage is contraindicated (increases sickling).

Anaesthesia in respiratory system diseases

00:02:03

In obstructive diseases like COPD/ asthma, regional anaesthesia is preferred.

Agent of choice in patient who is actively wheezing :

- Elective surgery : Cancel surgery.
- Emergency surgery : Ketamine.

N_2O is avoided as bullae/ blebs in the lungs might enlarge and rupture, causing pneumothorax.

N_2O has 33 times more, rapid diffusion capacity.

Inhalation agent of choice for asthma :

Sevoflurane > Halothane (maximum bronchodilation).

Inhalation agent to be avoided : Isoflurane/ Desflurane.

In restrictive diseases, patient can develop cor-pulmonale.

2D - echo should be done to rule out Pulmonary Arterial Hypertension (PAH).

In Kyphosis/scoliosis, PFT should be done to rule out pulmonary distress. These patients may require mechanical ventilation in post-op period.

In cases of upper respiratory tract infections, surgery should be postponed **4 - 6 weeks**.

Anaesthesia in neuromuscular diseases

00:06:52

myasthenia gravis :

Regional anaesthesia is preferred as it is :

- Resistant to Depolarising MR.
- Sensitive to NDMR.

Mnemonic : RD NS (Radio Diagnosis No Seat)

Neuromuscular monitoring required.

Pyridostigmine should be continued in the peri-operative period.

Short acting agents should be used to avoid residual action.

muscle relaxants : Rocuronium + Sugammadex have a better recovery profile.

Lambert Eaton syndrome :

Sensitive to both depolarizing MR and NDMR.

muscular dystrophy :

Avoid Succinylcholine (triggers malignant hyperthermia).

Use NDMR or regional anaesthesia.

Anaesthesia in endocrine disorders

00:12:10

Diabetes mellitus :

Goal : maintain sugar levels between 120 - 200 mg/dl.

Pre - op concerns :

Skip oral hypoglycaemic agents like SGLT - 2 inhibitors 24 hours prior to surgery as it causes euglycemic ketoacidosis.

Long acting insulin dosage adjustment should be done.

There are chances of difficult intubation in patients with long standing diabetes having positive prayer sign (cervical spine immobility).

Rule out diabetes related problems like nephropathy, retinopathy, autonomic dysfunction (anaesthesia may cause extreme hypotension/gastroparesis/ aspiration).

Diabetic nephropathy : use agents that are not cleared via venous drainage (Atracurium).

monitoring :

monitor GRBS every 30 mins when under GA and maintain

target levels using short acting regular insulin

(peak onset : 10 minutes, duration of action : 30-40 minutes).

Anaesthesia plan :

Always rule out/ document **diabetic neuropathy** before giving regional anaesthesia as patient might already have tingling & numbness.

Thyroid disorders :

Large thyroid swellings including retrosternal goitre may cause airway obstruction/difficult airway.

In all elective procedures, make the patient euthyroid before

Surgeon
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Hyperthyroidism :

Thiopentone sodium is preferred in emergency surgeries (prevents peripheral conversion of T_4 to T_3). **Thyroid storm** typically happens during thyroid surgeries. Presents as sudden unexplained tachycardia, hypertension and hyperthermia.

Hypothyroidism :

Induction agent of choice : **Ketamine** in emergency surgeries.

If patient develops **myxoedema coma**, insert a ryle's tube and deliver crushed thyroxine tablets in post - operative period. ICU care is needed.

Anaesthesia in bariatric surgeries

00:21:03

Pre op concerns in obese patients (difficult to secure IV line) :

- Hypertension.
- Diabetes mellitus.
- Obstructive sleep apnoea syndrome (very sensitive to any sedatives).
- Ischemic heart diseases.

Rule out PAH, RVF by an echo.

Difficult airway management as they have a short, bull neck.

During intubation, keep patient in **RAMP position**.

Longer needles required for spinal blocks.

Regional anaesthesia also becomes difficult.

Induction agents of choice : **Propofol** (short acting drugs as

they have quicker recovery profile). Doses based on ideal body weight.

Inhalational agents : **Desflurane**.

Post-op care : Patient might require CPAP/ BiPAP/

O_a supplementation.

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Day care procedures should be done carefully.

Obstetric anaesthesia

00:26:17

Caeserean section :

Preferred : Regional anaesthesia (spinal anaesthesia).

General anaesthesia is avoided as it :

- Affects fetus & can cause respiratory depression.
- Difficult airway as there is breast engorgement.
- Prone for aspiration.

General anaesthesia :

Done in emergencies like fetal distress, bleeding, cord prolapse.

Rapid sequence intubation (Sellick's manoeuvre) should be done.

Anaesthetic agents of choice in PIH :

1. mild : Spinal anaesthesia.
2. moderate : Combined spinal - epidural/ epidural anaesthesia.
3. Severe (eclamptic fits/ HELLP syndrome) : GA.

Labour analgesia :

Augment power by minimizing pain.

Previously : Hypnosis, meditation, Entonox (50% O₂ + 50% N₂O).

Best : Lumbar epidural anaesthesia.

Administer at 3 cm of cervical dilation, along with adequate bearing down efforts.

Level of anaesthesia :

1st stage : Till T₁₀ (as pain d/t cervical dilation & effacement).

2nd stage : S_a - S₄ (baby's head at perineum/ episiotomy)

For manual removal of placenta : Inhalation agents (also cause uterine relaxation).

Halothane has maximum smooth muscle relaxant property. Sevoflurane is preferred. NTG can also be used.

Anaesthesia for ocular surgeries

00:38:42

Goal : To maintain IOP.

Regional anaesthesia is preferred, most commonly peribulbar block. Needle introduced into orbital cavity in parallel and LA injected.

Earlier retrobulbar block used to be performed, now avoided as it causes optic nerve injury/ hemorrhage as needle is directed above. Dosage of LA should be monitored.

Oculo - cardiac reflex :

Trigemino - vagal reflex that causes bradycardia when rectus (medial) muscles are held.

Can be seen during squint surgeries.

management :

1st step : Stop surgery.

2nd step : Atropine.

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In some retinal surgeries SF₆ is injected. N₂O use should be avoided at that time (increases gas bubble size).

Anaesthesia in ENT surgeries

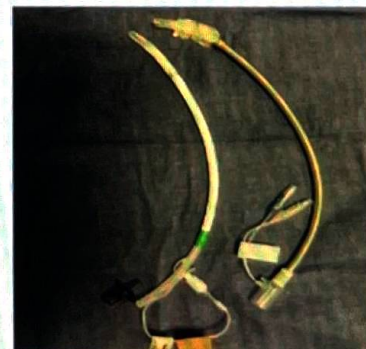
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Sharing of airway can lead to accidental circuit disconnections.

In adenotonsillectomy, RAE (precurved ET tube) is preferred. Monitor patients 6 - 8 hours post operatively for bleeds.

In enlarged adenoids, nasal intubation cannot be done. LASER (Light Amplification by Stimulated Emission of Radiation).

- Prone for fire accidents because of presence of O₂.
- Can damage ETT, so LASER resistant tubes to be used. These are covered in silicone/ aluminium wrap.



- 2 cuffs are present.
- Cuff should be filled with normal saline mixed with small amounts of methylene blue to detect leak during fire.

Airway fire : **Blow torch kind of fire**

is visible.

management : Remove the ETT immediately & use manual compressions.

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Stop administering all gases if fire accident is elsewhere in the body.

Usually, LASER surgeries done under jet ventilation to avoid airway fire accidents.

Anaesthesia in pediatric surgery

00:51:35

Difficulty in IV line insertion. Thus apply EMLA cream (2.5% Lignocaine + 2.5% Prilocaine) to make the surface numb. Another concern in children is bradycardia as cardiac output is rate dependent.

Children have **low FRC**, that can cause hypoxia leading to bradycardia.

GA preferred mostly as children would be less compliant to LA.

Inhalation induction preferred : **Sevoflurane** > Halothane.

If inhalational induction is not possible, use Ketamine intramuscularly or intravenously.

Narrowest part of airway in children : **Subglottic region**.

Narrowest part of airway in adults : **Glottic region**

micro cuffed ETT > uncuffed is used.

Cuffed ETT causes pressure necrosis.

Magill's airway : Straight blade is used to pass the ETT.

Regional anaesthesia can be used for post - op pain management.

Anaesthesia in orthopaedic surgeries

00:56:48

Preferred : Regional anaesthesia.

Rule out fat embolism.

Tourniquet should be tied at a pressure maximum of 3 times of SBP.

Tourniquet deflation should be done slowly and carefully.

Anaesthesia in laparoscopic surgeries

00:58:16

Preferred gas for surgeries : CO_2 .

Avoid N_2O as it has 33 times rapid diffusion capacity.

Pneumoperitoneum \rightarrow Increase in intra - abdominal pressure \rightarrow Increase in systemic vascular resistance \rightarrow Decreased preload \rightarrow Decreased afterload.

As patient is in Trendelenburg position, increased chances of v/Q mismatch or basal atelectasis.

In cases with raised ICP, laparoscopic surgeries (use CO_2) are contraindicated.

Anaesthesia in remote location/ office based anaesthesia :

Similar to day care anaesthesia.

Done in unconventional places like MRI or X - ray rooms.

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For procedures like endoscopy, colonoscopy.

Short acting agents used.

Should be preferably done with monitored anaesthesia care.

MALIGNANT HYPERTHERMIA

Clinical case scenario

00:02:44

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A 19 year old man met with RTA and was scheduled for emergency surgery. Information obtained from family members indicated an otherwise healthy person, except for allergy to Penicillin. In the OT after induction of anaesthesia patient became progressively tachycardic (> 150 bpm) and feverish (103°F) with raising end tidal CO_2 to 66 mm Hg and started having ventricular arrhythmias.

Diagnosis : malignant hyperthermia.

Ruling out other differential diagnoses :

Symptoms and signs	Differential diagnosis
Allergic to Penicillin.	Anaphylaxis : must have increased heart rate, decreased BP, increased airway resistance.
Tachycardia.	maybe due to induction by ketamine; hypovolemia, hyperthyroidism, pain, fever with sepsis.
High blood pressure.	may be a known case of hypertension; pain, ketamine.
High body temperature.	Sepsis.
Raised end tidal CO_2 .	Incompetent inspiratory valve on Boyle's machine, exhausted soda lime - specific to MH.
Ventricular arrhythmias.	specific to MH.

Active space

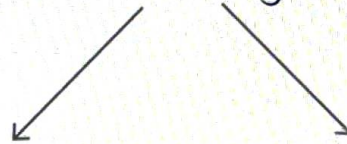
Introduction

00:10:24

Rare disease. Incidence is 1 : 10,000 to 1 : 25,000.

Etiology & risk factors :

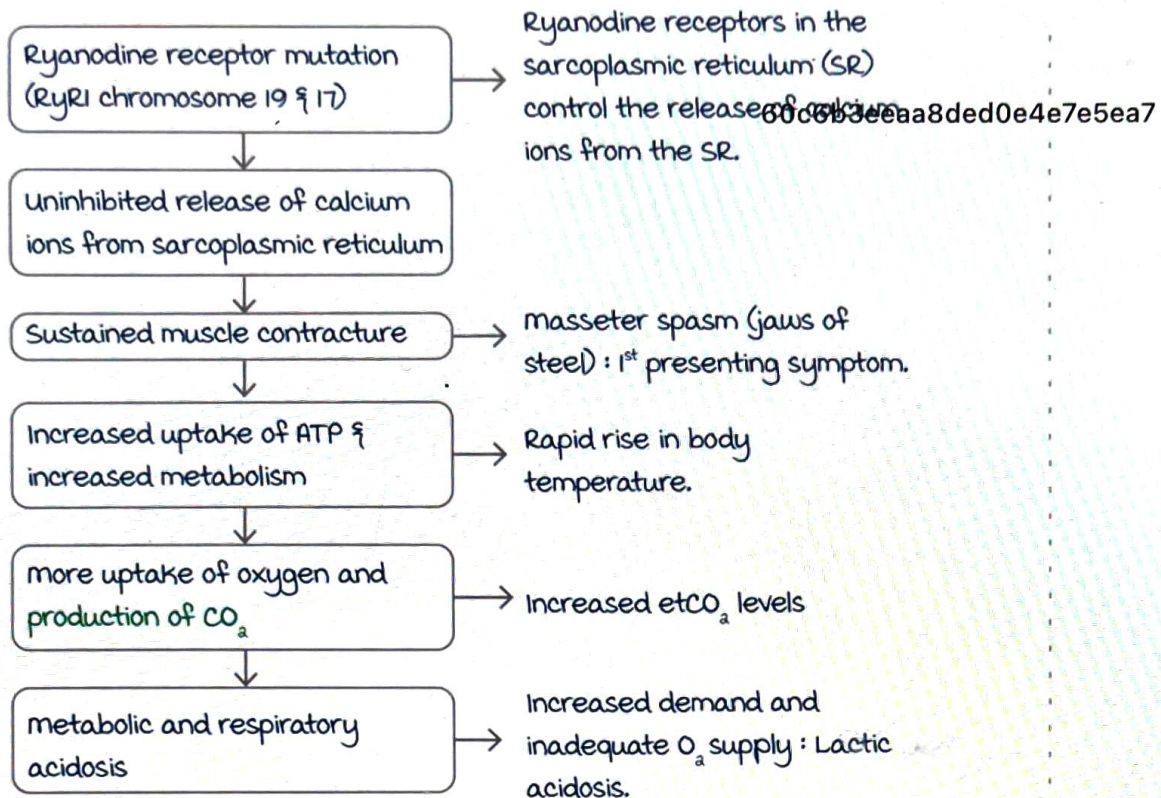
- Family h/o malignant hyperthermia.
- Any patient receiving Succinylcholine (depolarizing neuromuscular relaxant) and/or halogenated volatile anaesthetic (Halothane, Isoflurane). Incidence less with Desflurane and Sevoflurane.
- H/o any neuromuscular disorder like Duchenne's muscular dystrophy, myotonia dystrophica.
- Patients who develop masseter spasm (jaws of steel) after administration of succinylcholine.



Without risk factors & no additional symptoms	with risk factors/ other symptoms of MH
<p>mostly due to inadequate dose of succinylcholine. Slowly increase the dose of Succinylcholine and try to intubate the patient.</p>	<p>Consider MH. Stop all anaesthetic agents immediately and start MH protocol.</p>

In India, if there is suspicion of MH, protocol for malignant hyperthermia is instituted immediately because of the high mortality rate (60 - 70 %).

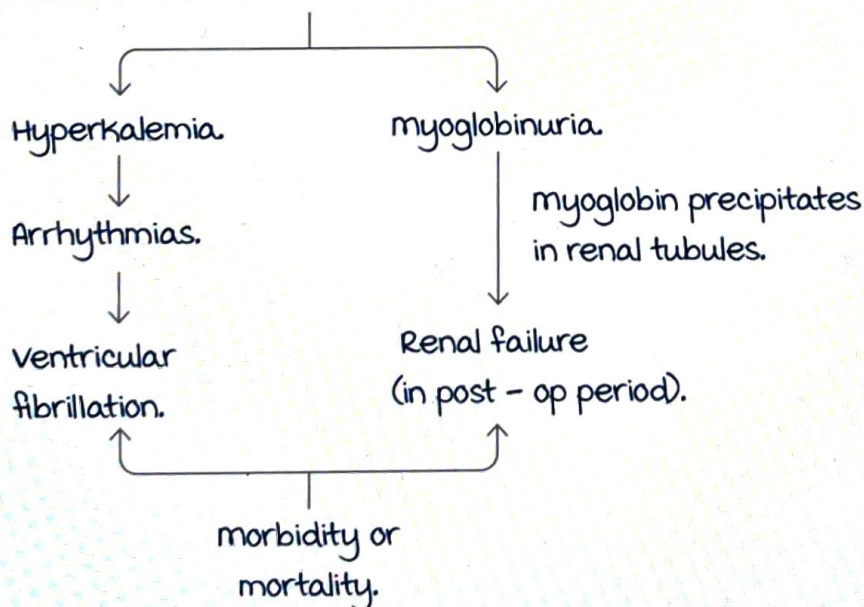
Pathophysiology of malignant hyperthermia :



Pathophysiology

00:18:21

Complications of excessive muscle contractions.



Clinical presentation

00:23:29

- Sudden unexplained **tachycardia**.
- **Tachyarrhythmias** in ECG.
- Increased blood pressure.
- Sweating.

Active space

- Increased body temperature.
- **Raised end tidal CO_2** levels.
- **Exhausted soda lime** (d/t increased production of CO_2).
- myoglobinuria.
- Severe muscle rigidity.

Treatment :

1. **Stop** administering all anaesthetic agents.
2. Give **100% oxygen**.
3. **Inj. Dantrolene sodium** (hydantoin derivative that reduces calcium release from sarcoplasmic reticulum).
600 μ g/kg/dose, 1-2 mg/kg/dose. **600 μ g/kg/dose** diluted in **distilled water** (since it has very high pH > 9).

Ventricular arrhythmias (VF) due to hyperkalemia :

Defibrillation/ shock.

Hyperkalemia :

- (a) **10% Calcium gluconate 10 ml slowly over 10 min**
(rule of 10) : Antagonizes K^+ action on cardiac muscle.
- (b) **Salbutamol nebulization or Insulin infusion with glucose.** } Translocates ECF K^+ to ICF.
- (c) K^+ binding sachets/ resins taken orally, takes 2 - 3 days to bind to the excess potassium and excreted via feces.

Symptomatic management

00:30:06

High body temperature : Cool i.v fluids.

Acidosis : Administer Sodium bicarbonate.

monitor **urine output** because the myoglobin that accumulates in the renal tubules causes occlusion. Try to alkalinize the urine and extract it. If it fails, dialysis.

Key points :

Triggering agents : Inhalational anaesthetic agents + Succinylcholine.

Conclusions about malignant hyperthermia were derived from porcine (pigs) stress models.

In patients with positive family history :

muscle biopsy : Subject sample to invitro halothane contracture testing or i.v caffeine testing.

Regional anaesthesia is preferred for these patients.
maintain mild hypothermia since rise in body/ room
temperature sometimes triggered MH.

If symptoms present during surgery, abandon surgery
immediately, shift to critical care unit, continue Dantrolene
sodium infusion, as it can occur in post - op period and serial
monitoring of urine output, ABGs and other investigations to
be done to prevent MH.

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DAY CARE ANAESTHESIA

SAMBA (Society for Ambulatory medicine and Anaesthesia) states the guidelines for daycare setup, its maintenance, patient selection and discharge criteria.

Biggest advantage of day care anaesthesia is decrease in hospital bases/nosocomial infections.

Day care surgery/ambulatory anaesthesia

00:03:16

Definition :

Patient gets operated & discharged on same day (<24 hours).

Procedures :

- Previously, any surgery <3hrs.
- Surgeries not associated with post-op surgical complications.

Examples : Hernia, hydrocele, fibroadenoma of breast, laparoscopic cholecystectomy etc.

Patient selection :

- ASA grade I/II patients.
- Some ASA grade III patients.
- Age < 50 weeks, >50 years are prone for complications.
<50 weeks : Risk for post op apnea.
- Patient should be accompanied by responsible attender.
- **Obstructive sleep apnoea** : Relative contraindication as they are sensitive to sedatives/narcotics.
Risk for respiratory obstruction in the post-op period.

Anaesthesia factors :

Guidelines for regular surgery are to be followed for the following components without any compromise :

- Pre-anaesthesia check up (PAC).
- Fasting : 6-8 hours for solids in adults.

In children : 2 hours for clear liquids.

4 hours for semisolids.

6 hours for solids.

- monitoring.

Premedication	Short acting benzodiazepines (midazolam) to release anxiety. Newer BZD: Remimazolam (metabolised by ester based hydrolysis).
monitoring	No compromise. All ASA standards will be applied.

General anaesthesia

00:12:24

Induction agents	Propofol
Opioids	Short acting opioids: Remifentanyl/Fentanyl . All opioids are respiratory depressants, hence short acting opioids are preferred.
Inhalational agents	Sevoflurane : B/G ratio = 0.46, preferred for day care anaesthesia. Though desflurane has quick onset and quick recovery, it is a potent irritant & has increased risk of bronchospasm and laryngospasm.
muscle relaxants	Short acting muscle relaxants: mivacurium mixture of Rocuronium + Sugamadex = better recovery profile than mivacurium. Sugamadex binds covalently to the drug and is excreted in urine. Agent of choice (Rocuronium + Sugamadex) > mivacurium > Cisatracurium > Atracurium.
Airway management	No contraindication for Endotracheal Intubation (ETI). But 40 - 45% of intubated patients complain of sore throat . Hence LMA is preferred especially Proseal LMA .

Q. Choose the muscle relaxant of choice in daycare anaesthesia:

- | | |
|----------------------|---------------------------|
| a) Rocuronium | a) Rocuronium + Sugamadex |
| b) mivacurium | b) mivacurium |
| c) Atracurium | c) Vecuronium |
| d) Vecuronium | d) Pancuronium |

Active space

Regional anaesthesia

00:21:10

- **Chlorprocaine** : Preferred drug (short onset of action).
- Spinal anaesthesia can be given.
- **Selective spinal anaesthesia** : Low dose of local anaesthesia

is used to block a certain region.

E.g : 1) In order to give sacral block for haemorrhoidal surgery, the patient is made to sit and low dose of anaesthetic is given. The drug will settle down and blocks the sacral region alone.

2) Keep the patient in right lateral position after giving hyperbaric drug to anaesthetise the right leg for surgery.

- Epidural anaesthesia can be given.
Epidural analgesia via catheter can be used for post op pain management.
Hence, the attenders should be trained to use the epidural catheter so that they are more responsible in handling.
- All blocks can be given.

Discharge criteria/modified Aldrete Scoring :

Activity	
Able to move 4 extremities	2
2 extremities	1
None	0
kumarankitindia1@gmail.com	
Respiration	
Breathe deeply and freely cough	2
Dyspneic/ limited breathing	1
Apnoea	0
Circulation	
BP +/- 20% of preanesthetic level	2
20-49%	1
>50%	0
Consciousness	
Fully awake	2

Active space

Arousable	1
Not responding	0
Oxygenation	
>92% saturation	2
Needs O ₂ supplementation to maintain >90%	1
<90%	0

The patient is kept in early recovery post operative ward.

The scoring is done 1-2 hours following the procedure.

Step down if score > 9.

In step down :

The patient is allowed to sit comfortably, have a sip of water, walk and use the washroom. Clothing is changed and the patient is then prepared for discharge.

PADSS - Post Anaesthesia Discharge Scoring System :

Alert, stable hemodynamically, minimal pain, mild nausea/vomiting, walk without dizziness, no unexpected bleeding, accompanied by responsible attender.

Voiding is not mandatory.

Post tonsillectomy : 6-8 hours of observation (increased chances of bleeding).

most common cause for re-admission after day care surgery : **Surgical complications.**

most common side effects of daycare anaesthesia :

- Drowsiness (60%).
- Post op sore throat (45-50%).
- Dizziness (20-30%).

most common cause of delay in discharge of patient : **Post-op nausea/vomiting (17%) > Pain.**

In patients who are not premedicated, incidence of post-op nausea/ vomiting is 30%.

AIRWAY MANAGEMENT

Functional anatomy of airways

00:05:29

The airway is divided into the upper and lower parts .

Upper airways :

Nasal cavity :

The medial wall is formed by the Nasal septum.

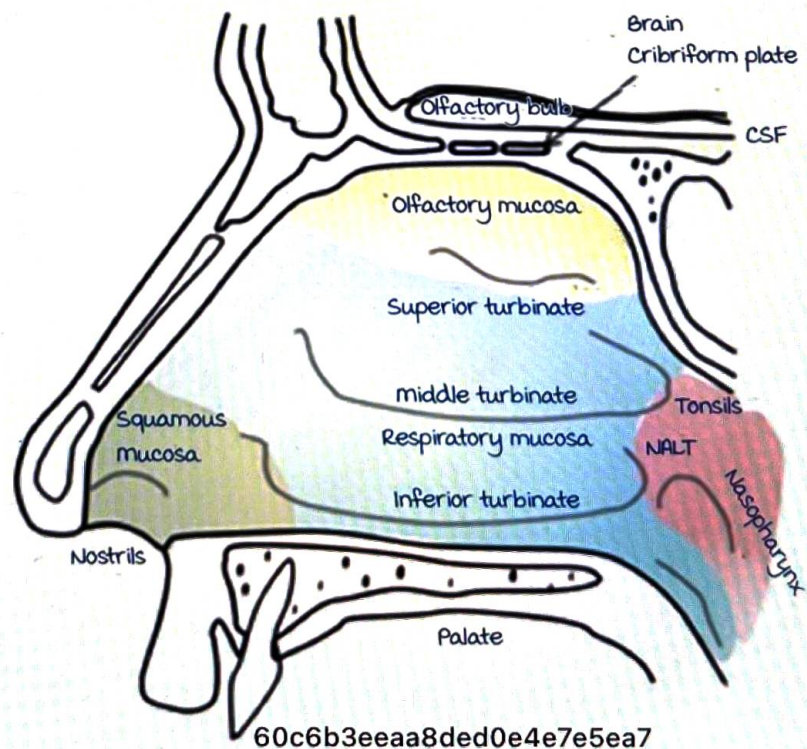
- Anteriorly : Cartilage.
- Posteriorly : vomer and ethmoid bones.

The lateral wall : Has turbinates.

Roof : Cribriform plate (vascular).

The preferred route for instrumentation : Between the inferior turbinate and the floor of the nasal cavity (to avoid injury to other vascular areas).

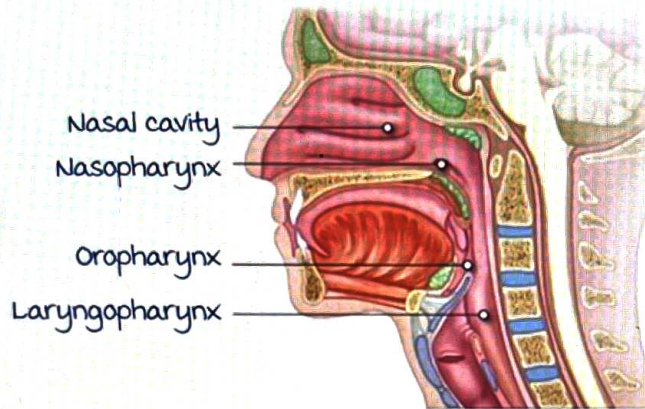
- Look for septal deviation.



Pharynx : muscular tube.

Parts of pharynx : Nasopharynx, oropharynx, laryngopharynx

- Nasopharynx : Contains adenoids.
- Velopharynx : Commonest site of collapse → obstruction.
- Oropharynx : Has tonsils.



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Pharyngeal muscle tone is maintained in awake conditions.

In unconscious conditions, the muscle tone is reduced leading to dynamic obstruction.

This can be relieved in the **left lateral position**.

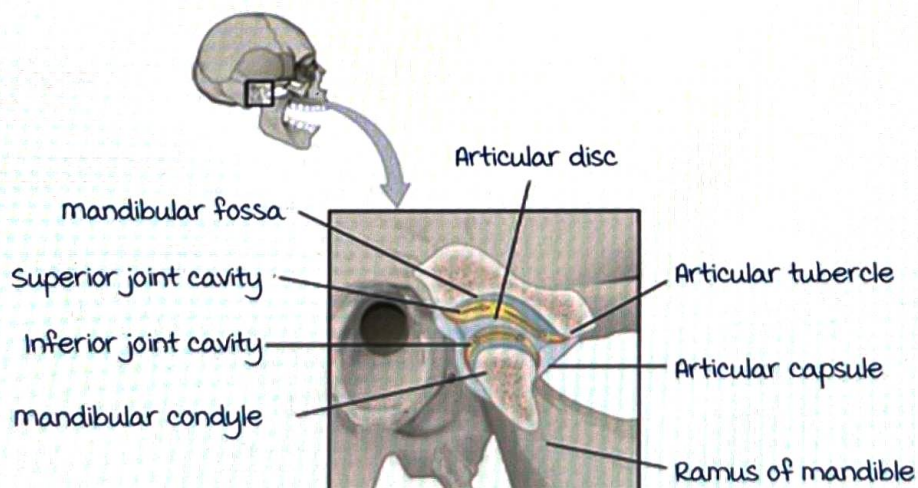
Oral cavity :

Examining the oral cavity :

Temporomandibular joint / TMJ function :

Slight mouth opening (rotary movement at joint) : Rotational component.

Jaw thrust manoeuvre : Sliding component is involved (wide mouth opening).

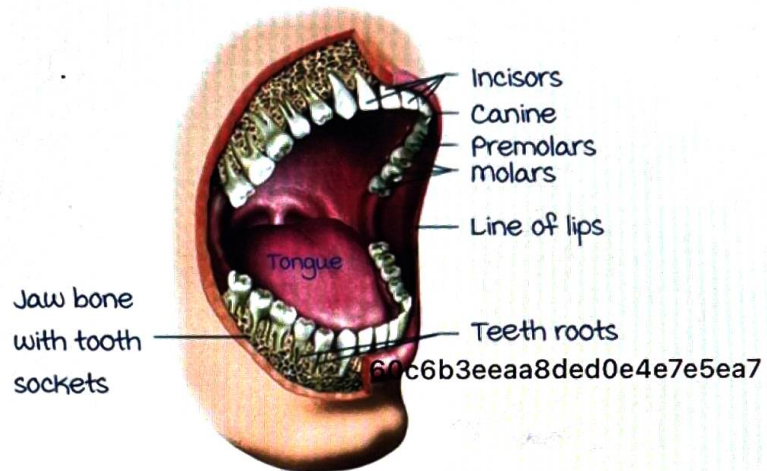


Active space

Tongue :

most common cause of airway obstruction in an unconscious patient : Tongue falling back with dynamic obstruction of pharynx

Jaw thrust (used in Triple manoeuvre) helps to keep the tongue away.

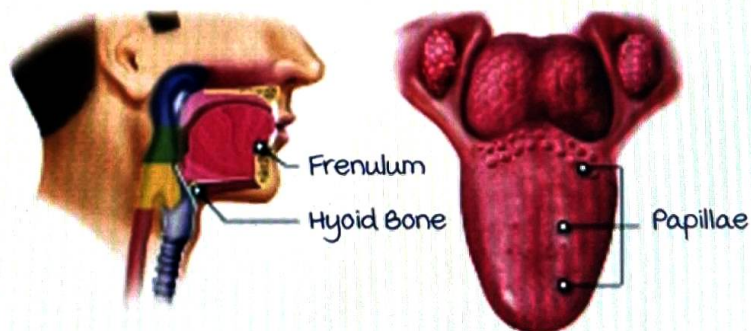


mylohyoid :

muscle below the tongue.

Separates sublingual space from submental space.

Any infection here can reduce the compliance of the space making intubation difficult. E.g. : Ludwig's angina.

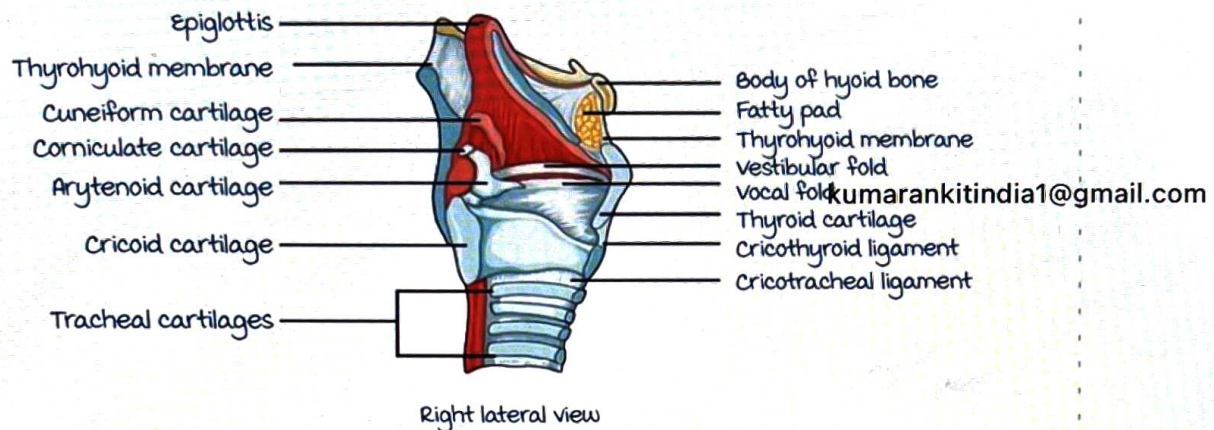
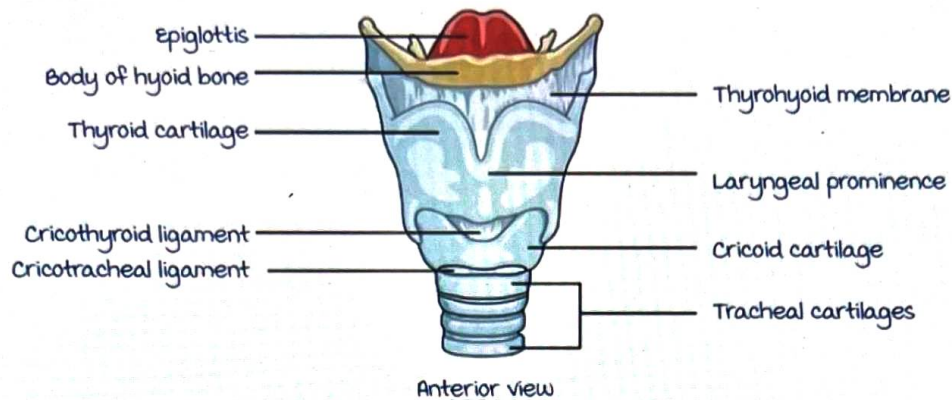


Laryngopharynx :

It contains : 3 paired cartilages.

- Arytenoid cartilages.
- Corniculate cartilages.
- Cuneiform Cartilages.

Active space



3 unpaired cartilages :

- Epiglottis.
- Thyroid cartilage.
- Cricoid cartilage : C shaped cartilage.

Semi circular cartilage : Encircles the airway completely.

Trachea :

Bifurcates into right and left bronchi.

Aspirated material goes immediately to the right bronchus (wide and directly leading from the trachea).

Airway examination

00:17:46

History : Ask for the previous history of surgeries/ difficult intubation.

Look for predictors :

- Syndromic babies (Down syndrome, Pierre Robin syndrome, Klippel Feil syndrome, Turner syndrome).
- Pregnancy.
- Burns.
- Large goitre.



Pierre Robin Syndrome



Burns in neck



Large goitre

Predictors of difficult intubation.

Mnemonic: **OBESSE**.

Obesity.

Bearded.

Edentulous (no teeth).

Snorers.

Elderly.

Predictors of difficult laryngoscopy:

- Long upper incisors.
- Inability to protrude the lower jaw.
- Small mouth opening.
- Mallampatti 3 or 4.
- High arched palate.
- Short thyromental distance.
- Short thick neck.
- Limited cervical spine mobility.

Predictors of difficult mask ventilation:

- Obstructive sleep apnea or history of snoring.
- Age older than 55 years.
- Male gender.
- Body mass index of 30 kg/m² or greater.
- Mallampatti classification III or IV.
- Presence of a beard.
- Edentulous.

Bedside tests

00:22:04

TMJ function :

mouth opening : **Finger breadth technique.**

(Good TMJ function : > 3 fingers between incisors).

Look for dentition : Loose teeth, removable dentures.



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Chronic tobacco chewing results in submucosal fibrosis. Resulting in restricted mouth opening.

Mallampati Scoring :

For assessment of difficulty in Intubation.

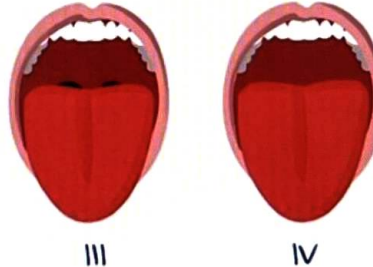
Grade I :

- Faucial pillars & soft palate are seen.
- The uvula is seen hanging freely.



Grade II :

- The tip of the uvula is not seen.



Grade III :

- Half of uvula is not seen.

Grade IV : **Sampson & Yong.**

- Only the hard palate is seen.
- The uvula is not seen.

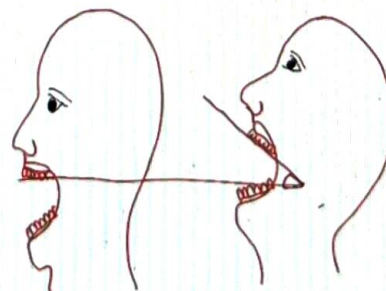
Grade 0 :

- Epiglottis is also visible.

Grade III, IV & 0 have difficult intubation.

Atlanto occipital movement :

An imaginary line from upper incisors with mouth wide open and another imaginary line by asking the patient to extend neck fully.



Active space

Normal mobility : 15° to 35°

Angle made by forehead : $> 80^{\circ}$ (from extreme flexion to extension).

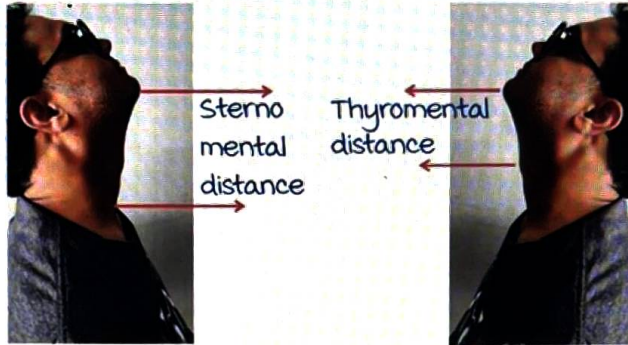
$< 15^{\circ}$: Neck mobility restricted. (E.g. Ankylosing spondylitis)

Thyro mental distance :

Tip of the thyroid cartilage to the tip of the chin (mentum).

Normal : > 6.5 cm.

Difficult intubation : < 6 cm.



Sterno mental distance :

Tip of the sternum to the tip of the chin (mentum).

Normal : 12.5 - 13 cm.

mandibular protrusion test :

Also known as the upper lip bite test.

Lower jaw : If the vermilion border of the upper lip can be touched, it indicates good protrusion.

CT scan, MRI and ultrasound can also be used.

Other scoring systems to assess difficulty intubation :

Wilson score	El - Gonzalez index	Lippman colleagues
Weight. Head and neck movement. Jaw movement. Receding mandible. Buck teeth.	mouth opening. MPG. Thyromental. Neck movement. Prognathism. Weight. History of DI.	Bmi. mouth opening. Thyromental. MPG. Receding mandible.

Active space

Steps of intubation

00:33:14

1. Pre oxygenation :

The patient is administered 100% O_2 for 3 minutes with anatomical face mask (before elective intubation).

In case of emergency 8 breaths of vital capacity.

Extends the apnea time for up to 10 minutes.

In an emergency : 8 vital capacity breaths.

In a dire emergency : 4 vital capacity breaths.

2. Induction agents.

3. muscle relaxants.

4. Attenuation of response.

Sequence of intubation :

1. Pre oxygenation.

2. Laryngoscopy.

3. Visualization of vocal cords.

4. Insertion of endotracheal tube.

5. Remove the laryngoscope.

6. Inflate the cuff.

7. Checking.

Prerequisites for intubation : kumarankitindia1@gmail.com

- Trained assistant.
- working laryngoscopes with 2 blades.
- ≥2 sizes of endotracheal tubes.
- Introducers (stylets/ bougies).
- Oral and nasal airways.
- Reliable suction equipment.

Modifications in intubation

00:40:13

In normal intubation : "Sniffing of morning air".

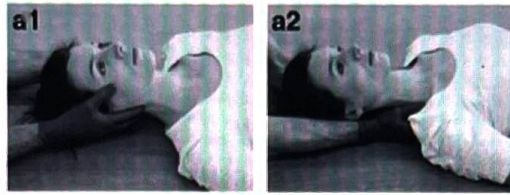
Flexion at lower cervical spine.

Extension at atlanto occipital joint.

Suspected cervical spine injury : manual in line stabilization.

Hard collar/Philadelphia collar : To restrict neck movement.

manual in line stabilization



minimal immobilization



Immobilization in 30° : Supine position without cervical collar



Complete immobilization



Emergency intubation/ Rapid Sequence Intubation (RSI) : The muscle relaxant of choice is Succinylcholine.

In patients who just had food, to prevent aspiration.

Selick's manoeuvre :

Application of cricoid pressure and compression of the oesophagus to prevent aspiration.

Pressure of about 30 N is applied.

During RSI / whenever there is a chance of aspiration, providing pre oxygenation/positive pressure ventilation increases the risk of aspiration.



modified RSI:

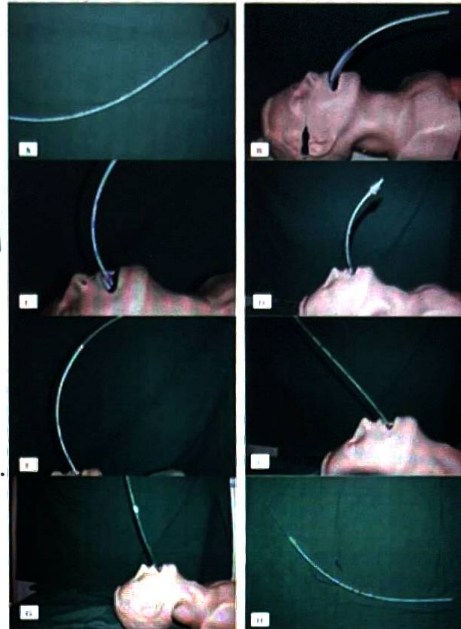
Here, positive pressure ventilation is provided **gently** (with PIP < 20cm).

Awake Intubation : Assisted by nerve blocks.

Lignocaine to topicalize the airways.

- **Glossopharyngeal** nerve block given near Anterior pillar of tongue
- **Superior laryngeal** nerve block given near superior cornua of thyroid.
- **Trans laryngeal** injection given in between tracheal rings.

Fibreoptic Intubation :
After giving nerve blocks, a fibreoptic bronchoscope is passed and visualized via a monitor, then an endotracheal tube is inserted.



Nasal intubation

00:54:04

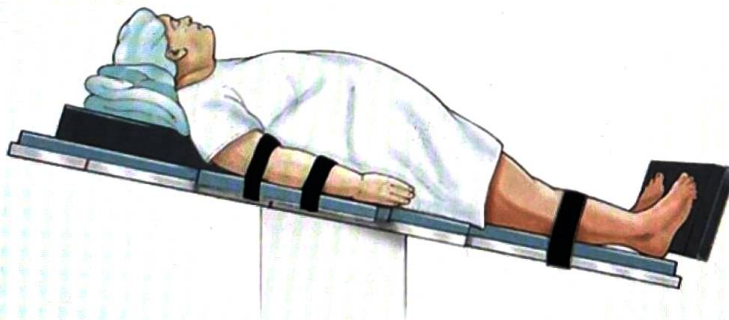
Indications : Any surgeries on the tongue or oral cavity.

Contraindications : Fracture base of skull, large adenoids, bleeding disorders.

Advantages : Well tolerated by patients.

Disadvantages : The procedure is difficult to perform.

Obese patients : Ramp position

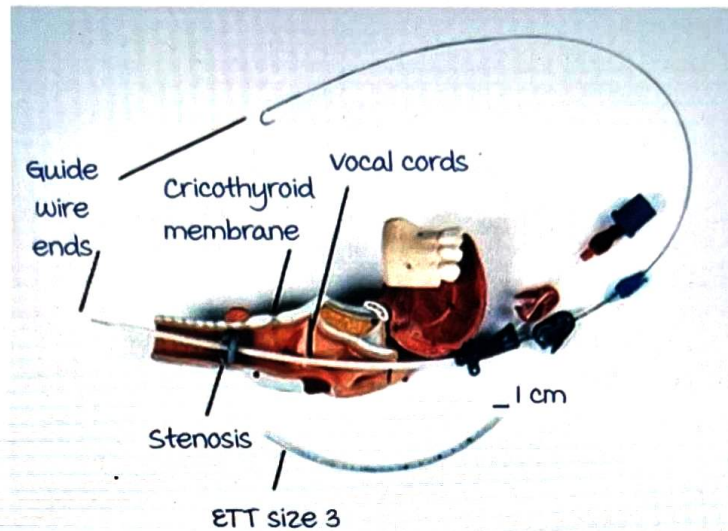


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Retrograde intubation :

A guide wire is passed through the cricothyroid membrane and comes out of the nose. Endotracheal tube is passed along the guide wire.

useful for difficult intubations like cancer patients.



Trauma Patients :

The following to be ruled out :

Cervical spine injury.

Tension pneumothorax : (Decompress immediately).

- Decreased air entry on the affected side.
- Tympanic note on percussion.
- Absent breath sounds.

Absolute contraindication for positive pressure ventilation :

Presence of Pneumothorax

Signs of correct placement of endotracheal intubation :

Chest lift : Bilateral equal.

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mist formation inside ETT.

Bilateral equal air entry.

Capnography (EtCO_2) : Surest sign of intubation.

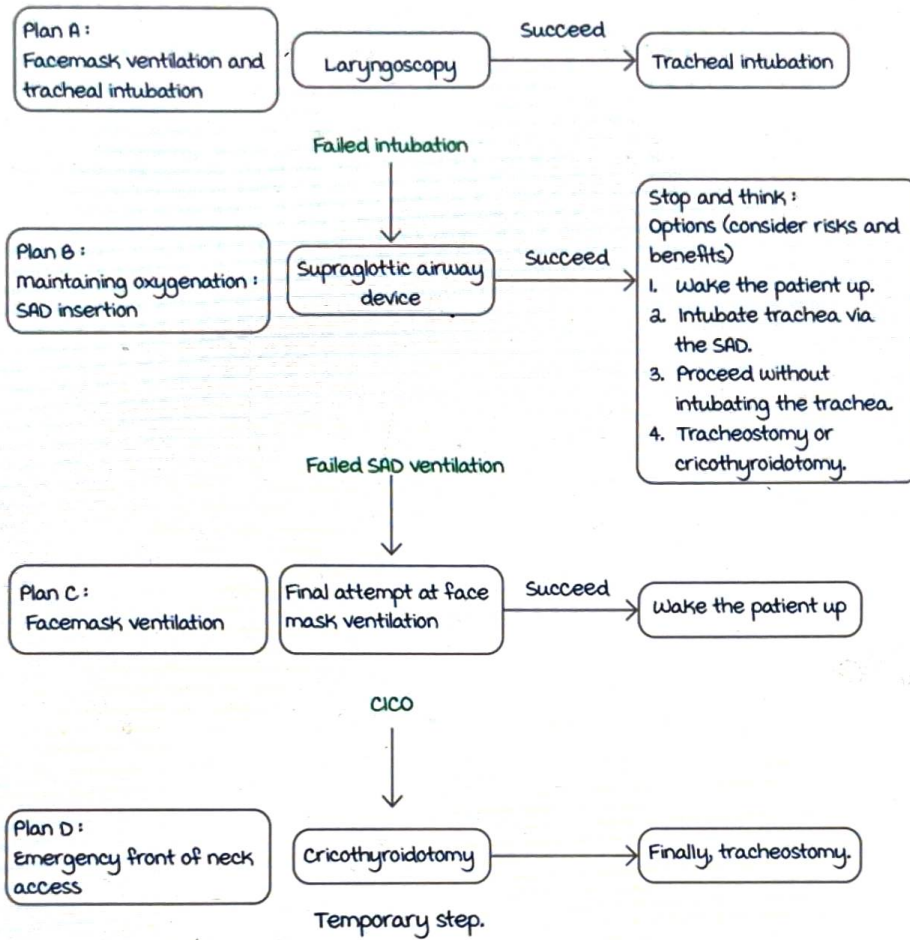
Fibreoptic bronchoscope : Gives the exact location of ETT (during one lung ventilation).

Chest X ray.

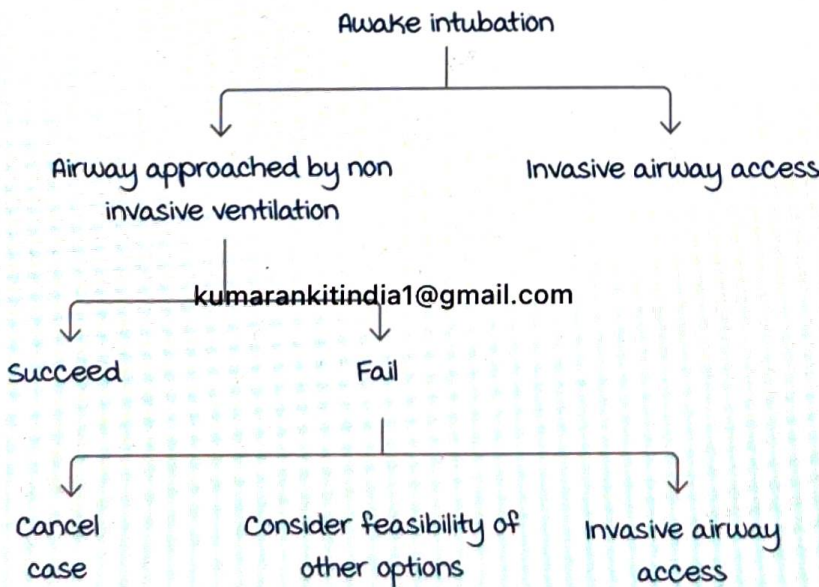
Failed intubation / Difficult airway

01:02:08

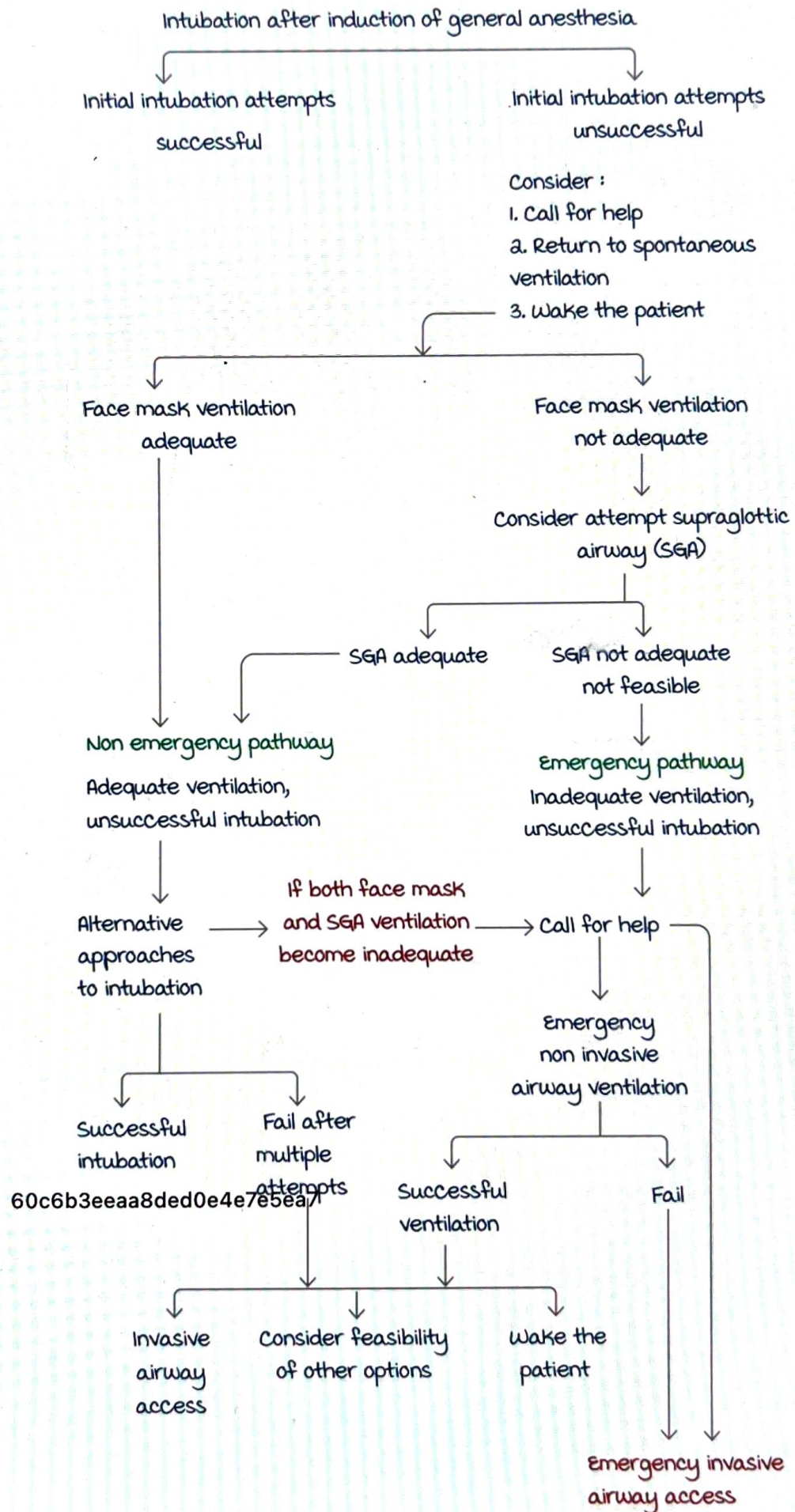
DAS difficult intubation guidelines



ASA guidelines for management of difficult airway



Active space



Active space

ANAESTHESIA EQUIPMENTS

Anatomical face mask

00:00:53

made of silicon rubber.

Non disposable.

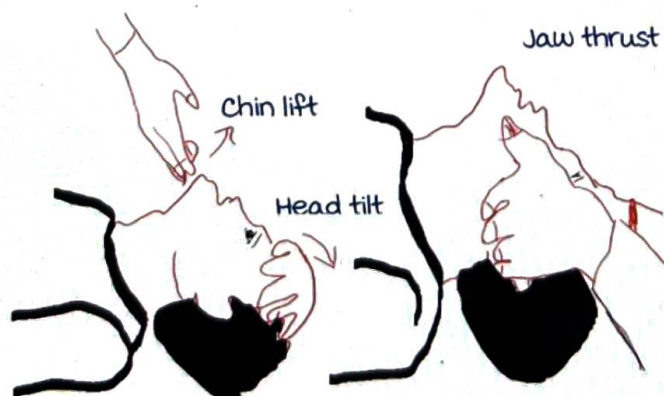
Purpose : To provide pre-oxygenation.

Available in size ranging from 00 to 4.

used while performing **triple manoeuvre**.

(Includes head tilt, chin lift and jaw thrust).

Disadvantages : Increases dead space ventilation.



Active space

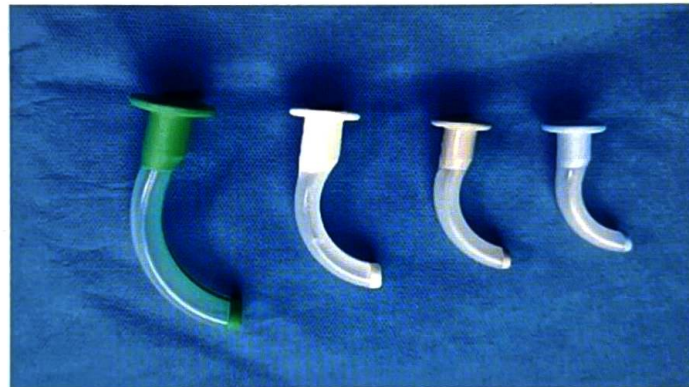
Dead space :

Increases	Decreases	No effect
Pre - oxygenation. Triple manoeuvre. Atropine/ Salbutamol to asthmatics. mechanically ventilated patient.	Intubation. Tracheostomy.	morphine

Trans nasal Rapid Insufflation of ventilatory exchange (THRIVE) provides 60 L of O_2 /minute for 3 minutes. It is an effective method of pre-oxygenation.

Guedel's airway

00:08:23



Also called oropharyngeal airway.
Purpose : Prevents fall back of tongue.
Has an opening which helps in suction.

Identification of correct size :
Distance between tragus to angle of mouth or
Distance from angle of the mouth to angle of mandible.



Active space



Disadvantages :

Gag reflex.

Requires deeper planes of anaesthesia.

Nasopharyngeal airway

00:11:18



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Purpose : Prevents collapse of the velo pharynx.

Prevents fall back of tongue.

Range in size from 6.5 - 8.5 mm.

Advantage : **Better tolerated** than Guedel's airway.

Contraindications :

- **Base of skull fracture.**

(Identified by the presence of raccoon/panda eyes).

Active space

- Bleeding disorders.
- Large adenoids.

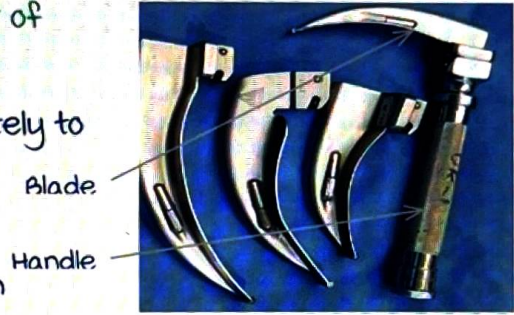
Laryngoscope

00:13:53

Purpose : Intubation.

Procedure :

- Hold the laryngoscope in the left hand.
- Insert it from one corner of mouth (right).
- Push the tongue completely to one side.
- Visualize epiglottis.
- Lift hand 45° away from the patient.
- use **deltoid** or **triceps** muscle for lifting.
- visualize vocal cords and intubate.



Curved /macintosh blade

2 types of blades :

- Curved /macintosh blade.
- Straight blade.



Straight blade.

Straight laryngoscope :

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Also called millers blade (children).

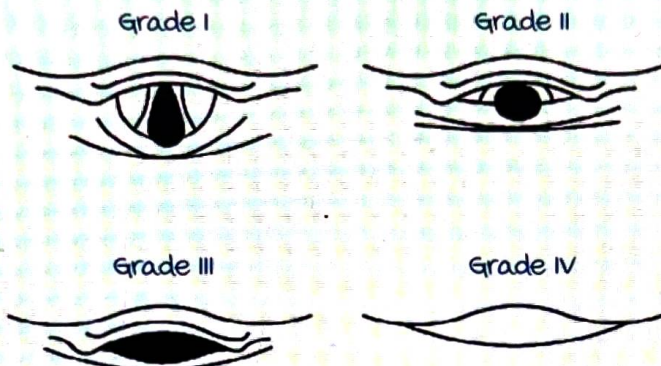
Procedure :

- Hold the laryngoscope in the left hand.
- Insert it from the center of the mouth.

Active space

- Depress the tongue.
- visualize epiglottis : Include epiglottis & lift hand 45° away from the patient using triceps/deltoid.

Cormack lehane scoring



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Cormack lehane scoring.

Amount of glottic opening visualized after doing laryngoscopy.

Grade 1 : Laryngeal aperture seen.

Grade 2 : Only posterior portion of laryngeal aperture seen.

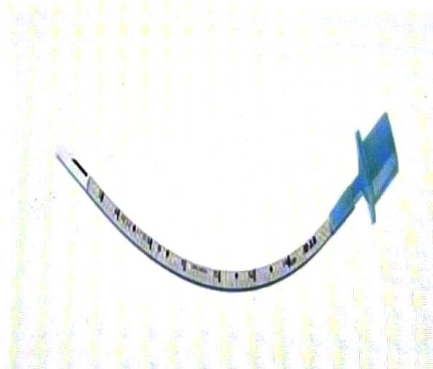
Grade 3 : Only epiglottis seen.

Grade 4 : No epiglottis seen.

Endotracheal tubes

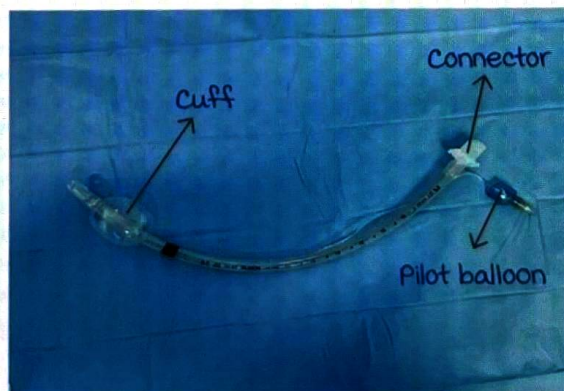
00:21:38

2 types : Cuffed/ uncuffed.



uncuffed ET tube

Purpose of cuff :
Prevents aspiration
of gastric contents.



Cuffed ET tube

Active space

micro cuffed ET tube :

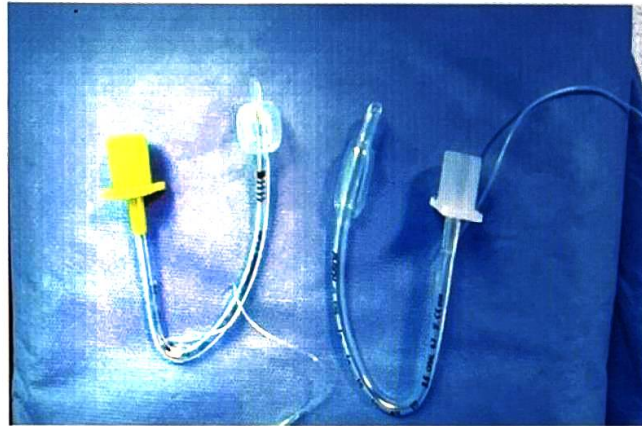
Recently introduced.

Previously uncuffed tubes were preferred in children.

Narrowest portion of trachea :

- Adult : Glottic opening.
- Children : Sub glottis (trachea conical in shape).

As per latest guidelines, **micro cuffed ET tubes are preferred** over uncuffed tubes in children (to avoid pressure necrosis).



micro cuffed ET tube (green) & conventional cuffed tube

maximum allowable pressure to inflate cuff : < 25 cm of H_2O .

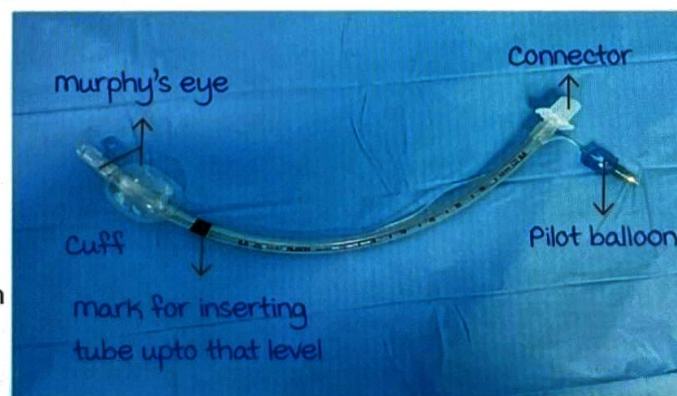
Endotracheal tubes are available in size from **2.5** in preterm babies to **9** in adults (internal diameter).

Black line : mark for directing the insertion.

An alternate opening called '**murphy's eye**' present, in addition to 2 openings in a conventional endotracheal tube (alternate lumen can be used even if main lumen is blocked).

Depending on the material used, endotracheal tubes can be divided into :

- Red rubber ETT.
- Polyvinyl chloride ETT.



Polyvinyl chloride ETT



Red Rubber ETT

Depending on cuff, it is divided into

High-pressure low-volume cuff : Red rubber ET Tube

(> 25 cm of H_2O).

Complications : Pressure necrosis & Tracheal stenosis.

Low-pressure high-volume cuff : PVC ET Tube.

PVC ET Tube :

Single use ET tube.

Less chances of **tracheal mucosal injury**.

Disadvantage : Chances of leakage of cuff.

Identification of size of ET tube

00:32:00

Preterm baby : 2.5 ; Term baby : 3.0

up to the age of 1 year : 3.5

• Age < 6 years = $A/3 + 3.75$

• Age > 6 years = $A/4 + 4.5$

(In children, **use a size less** than the calculated value).

Length of endotracheal tube : $A/2 + 12$

To get nasal intubation length, add 3 cm to calculated value.

Reflex response to intubation/laryngoscopy is an **attenuation** response.

Laryngoscopy/intubation are powerful **sympathetic stimulants**.

- CVS : Increases heart rate and blood pressure.
- RS : Increases respiratory rate (in spontaneous breathing).
- CNS : Increases intracranial pressure.
- Hormonal : Increases catecholamine release.
- Pharmacological methods to inhibit response :
 - xylocard IV (Preservative free Lignocaine).
 - Lignocaine spray.
 - Nitroglycerine (IV/Spray).
 - Short acting beta blocker (Esmolol).
 - Short acting opioids (Alfentanyl).
 - Deeper the plane of anaesthesia (Propofol).

Modifications of ET Tube

00:38:52

1. Reinforced ET tube.

Also called as flexo-metallic ET Tube.

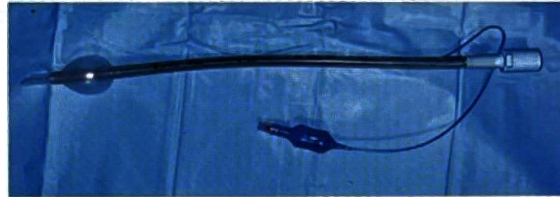
Prevents kinking of ET tube.

Kinking will cause airway resistance.

used in :

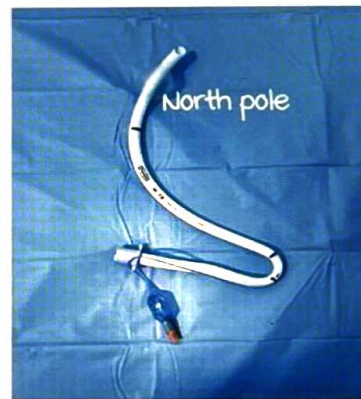
- Prone surgeries (spinal/neurosurgery).
- Head and neck surgery.

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2. RAE tube (Ring Adair Elwyn tube) :

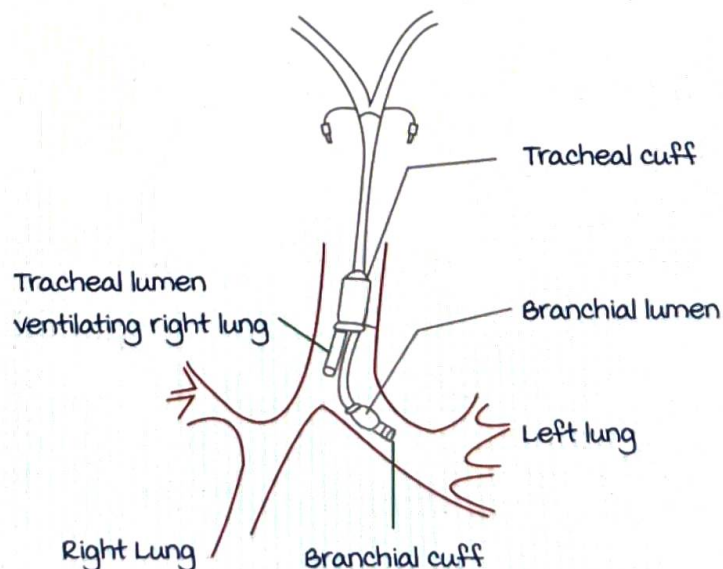
Prefix/preformed ET Tube used for cleft lip/ cleft palate surgery. Does not obstruct surgeon's view.



3. Double lumen ET tube:

used for single lung ventilation.

used in pneumonectomy/lobectomy.



Active space

Supraglottic airway devices

00:43:23

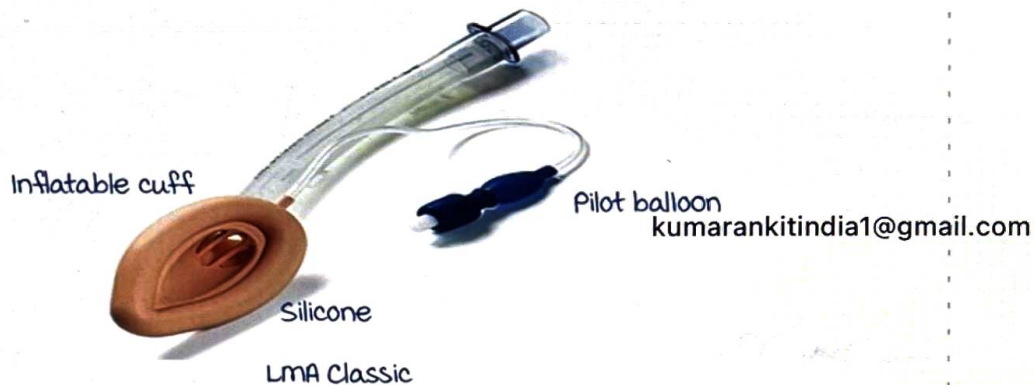
Laryngeal mask Airway (LMA). Ambu LMA is a modification of LMA.

LMA Classic :

Introduced by Dr. Archie Brain.

made up of :

- Pear shaped inflatable cuff (silicone material).
- Pilot balloon.



Procedure :

Open oral cavity & hold LMA like a pen.

Inserted into oral cavity blindly.

Tip of LMA sits above esophageal opening.

Gas supplied directly to lungs.

Range in size from 1 - 6.

Advantages :

- Least invasive (compared to endotracheal intubation).
- Emergency situations.
- Difficult airway management.

Disadvantages :

- Cannot prevent aspiration.
- Not used in obese patients & pregnancy (increased gastric motility time) or laparoscopic procedures (CO_2 inflation will relax lower esophageal sphincter).
- Can not provide positive pressure ventilation (PPV), as on increasing pressure, gas moves into stomach and causes insufflation of stomach leading to aspiration. So, PPV is kept <20 cms H_2O & cuff pressure at <60 cms H_2O .

modifications of LMA classic :

1. LMA Unique :
made of polyvinylchloride.
Single usage.

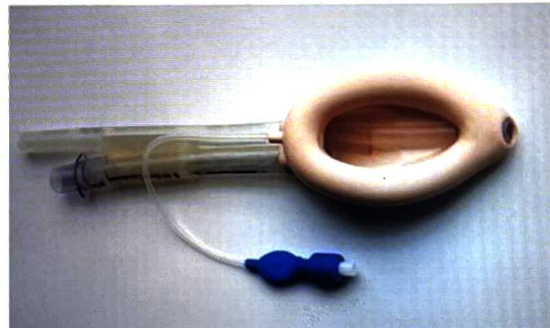


LMA Classic Excel

2. LMA Classic Excel :
Could also be used for intubation.

3. LMA Flexible :
Tubing has flexible material.

4. Pro Seal LMA :
Advantages :
Prevents aspiration.
An additional suction drain tube present.



Pro Seal LMA

LMA Supreme

00:54:20

made up of polyvinylchloride.
Has gastric aspiration port.
Better sealing than other forms (enables high pressure ventilation). It also prevents aspiration.



Active space

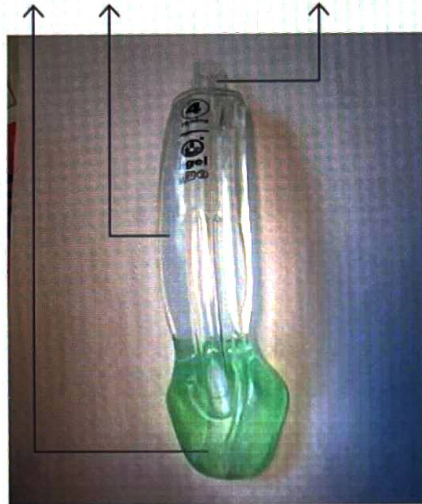
I-gel:

Second generation LMA.

No pilot balloon.

Assumes the shape of space due to body temperature
and forms a perfect seal.

Has silicone gel, bite block & drain tube.



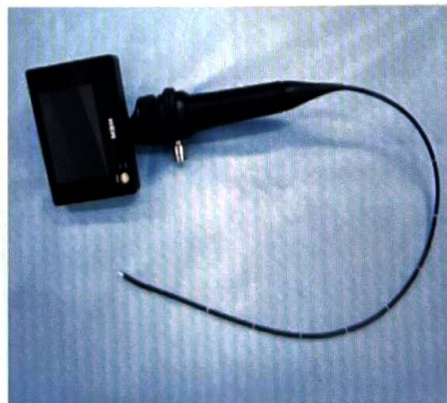
Peri laryngeal sealers :
(SLIPA).



Esophageal combitube :
Cuffed pharyngeal
sealers.
Tube contains 2 cuffs.

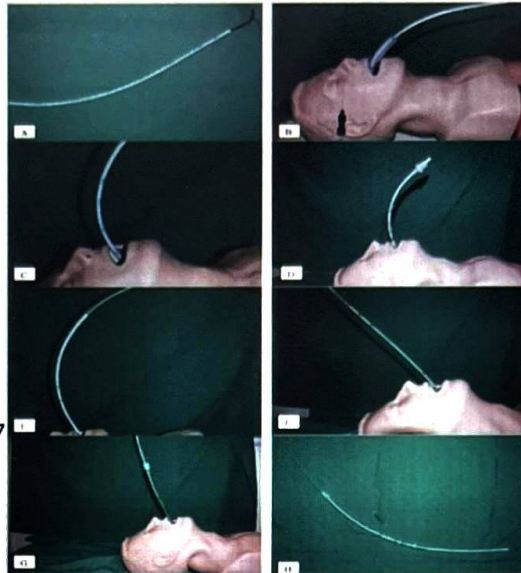


Fiber optic bronchoscope :



Active space

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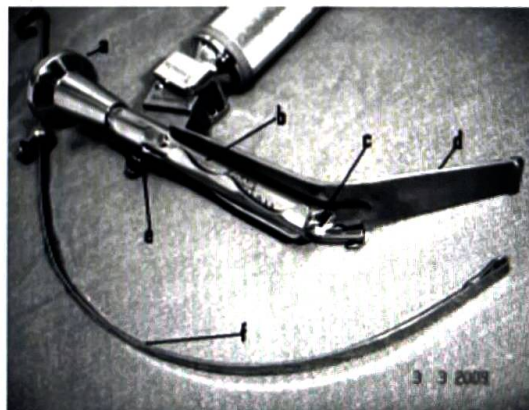


Laryngoscopes :

- Videolaryngoscopes :
Normal laryngoscopes generated aerosols during intubation. Hence, this became more popular during Covid-19.



- Tru view laryngoscope :



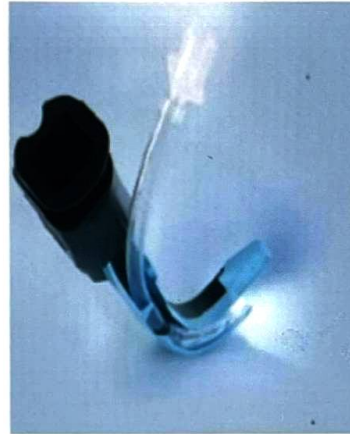
Active space

- Air traq scope :



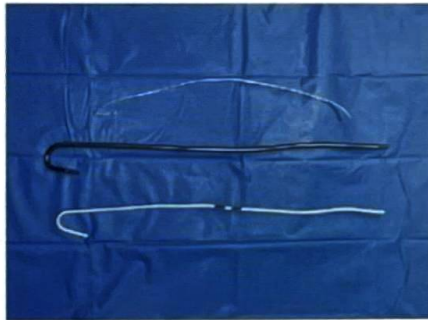
kumarankitindia1@gmail.com

- Bullard laryngoscope

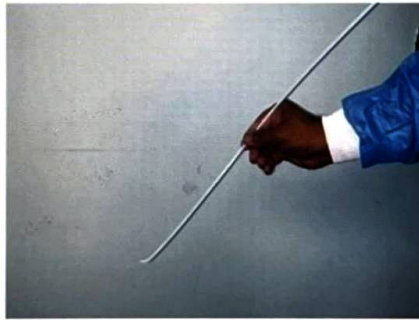


Endotracheal tube: accessory gadgets

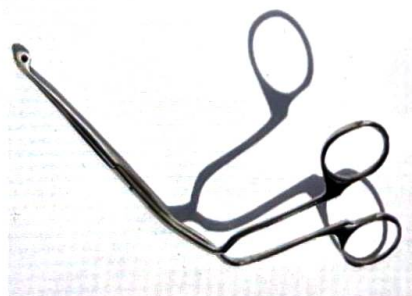
01:00:08



stylet



Gum elastic/Eschmann bougie



magill's forceps

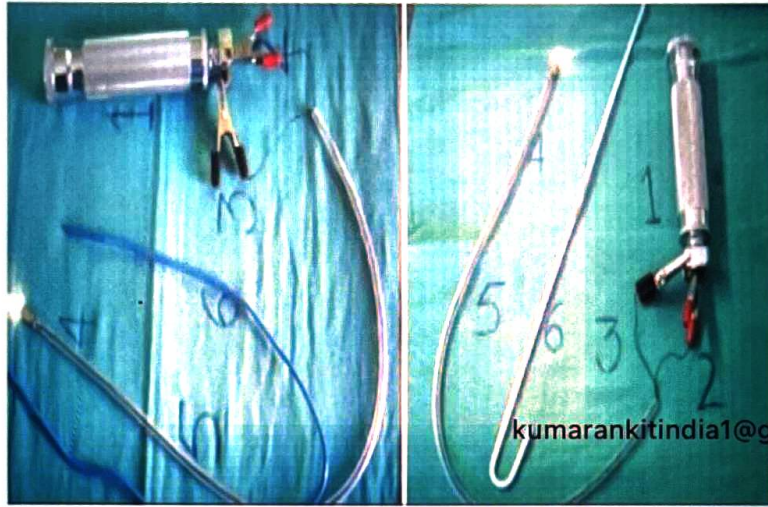


Active space

Light optical stylet :

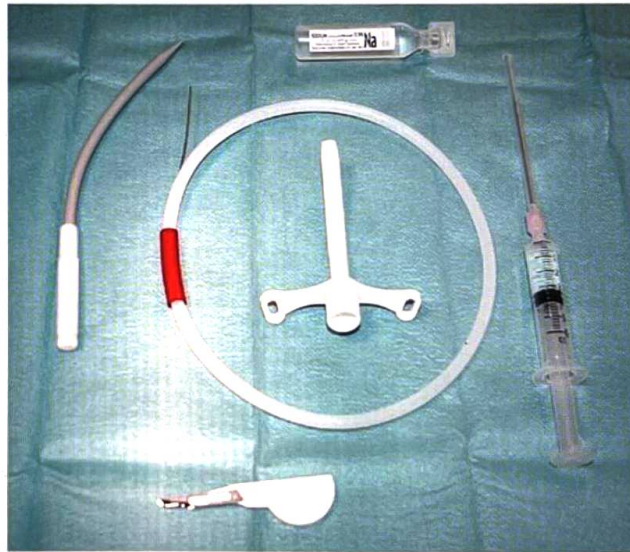
If placed in trachea, illumination visible.

No illumination if in esophagus.

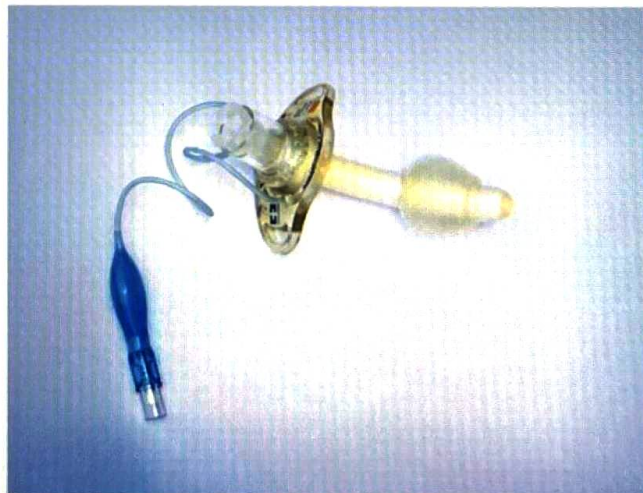


Cricothyrotomy set :

Temporary management of airway in difficult airway situations.



Tracheostomy tube :



Active space

HOW TO APPROACH A PATIENT IN ICU

Clinical scenario

00:03:52

A 40 year old patient who was resuscitated in casualty from MI is being shifted to your ICU. How would you approach this patient?

A. Airway management :

First look if the patient has definitive airway management in the form of endo tracheal tube (ETT). If the patient has an ETT, look if the connection is good and the patient is receiving adequate amount of oxygen.

If he is conscious and not intubated, monitor the patient → Airway patent → Look at the breathing pattern.

B. Breathing :

If the patient is on ETT and connected to the ventilator, make sure ventilator should be working properly, and the patient should receive oxygen properly.

If the patient is not intubated → Look at breathing pattern (respirations are regular or not).

Some patients may have shallow or rapid breathing → Risk of respiratory failure.

C. Circulation :

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First assessed by pulse (whether the patient is adequately perfused or not).

Perfusion indicators : Skin color (normal/pale/pinkish).

Temperature of skin (cold extremities : suggests hypoperfusion).

Capillary refill time.

Urine output : Poor man's cardiac indicator.

Active space

Patient is not getting adequate perfusion : Start IV fluids (isotonic crystalloid solutions).

Patient with MI :

Do echocardiography → See left ventricular (LV) ejection fraction.

If LV function is good & patient is having low pulse volume : start IV fluids immediately.

If LV is not contracting properly → If IV fluids is pushed continuously → Pulmonary edema.

IV fluids : Isotonic crystalloid solutions (RL or NS).

Avoid colloid solutions.

Inotropes : If a patient is in septic shock, he might be having hypotension.

IV fluids given → Patient doesn't improve → Start inotropes (Adrenaline, Noradrenaline, Dobutamine, Isoprenaline, Dopamine).

Before starting inotropes → Check BP of patient (continuous monitoring to see trend in the values).

mean arterial pressure (MAP) measurement tells about overall perfusion of the body.

If BP is low (heart is normal) → Start IV fluids.

If pressure doesn't pick up start inotropes.

If patient is in septic shock (DOC : Noradrenaline).

If patient is in cardiac failure (DOC : Dobutamine).

Patient with chronic renal failure with hyperkalemia
→ RL can't be given.

Needs to be resuscitated with NS.

Active space

Very important task in an ICU :

A ↔ B ↔ C → Reassessment.

Categories of ICU care in a patient

00:16:35

Supportive care :

- Airway management
- Hemodynamic support
- Oxygenation.

Treatment of primary illness :

- make differential diagnoses.
- Necessary investigations.
- Adequate treatment with antibiotics.

Preventive care :

- Prevention of stress ulcers.
- Prevention of Bed sores.
- Ventilator associated pneumonia (VAP).
- Nutrition of the patient.
- Prevention of Nosocomial infection.
- Prevention of DVT.

Psychological Counselling.

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Active space

OXYGEN THERAPY IN ICU

Oxygen therapy

00:01:00

Case scenario :

A 68 year old male with a h/o COPD on home oxygen therapy presented to the ER with cough, chills & shortness of breath.

O/E : Temperature and respiratory rate were increased, and his SpO₂ was 94% on 2 L of O₂. Rest of pulmonary examination was unremarkable.

Provisional diagnosis : Community Acquired Pneumonia.

Investigation :

Chest X ray shows B/L basal infiltration.

Treatment given :

1. O₂ with Nasal Prong/ face mask.
2. Propped up position.
3. IV antibiotics.
4. IV fluids.
5. IV pantoprazole.

Post treatment, patient appears somnolent and minimally arousable.

O/e : vitals appear normal with a spo₂ of 94 to 98%.

ABG was done and is suggestive of respiratory acidosis.

Patient was shifted to ICU and started on NIV ventilation, patient's condition worsened and was intubated → 2 days later extubated → Discharged.

Insights :

- h/c/o COPD on home O₂ therapy suggests that the patient is in Type 2 respiratory failure.

SpO₂ goal in Type 2 respiratory failure : 88-92%.

- In Type 2 Respiratory failure :

Drive of respiration is due to increased pCO₂.

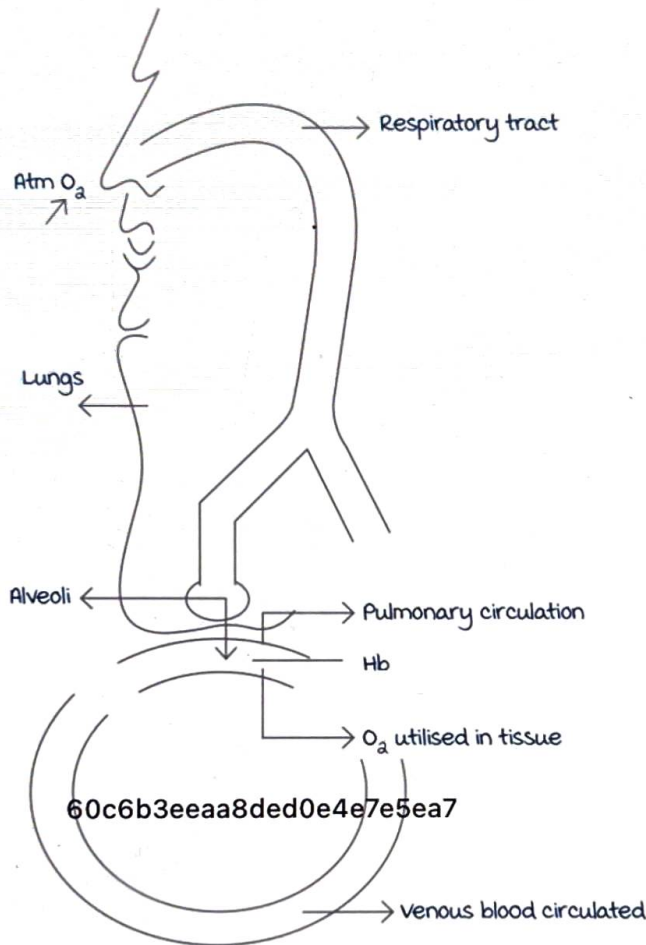
If O₂ is administered injudiciously in COPD patients :

1. Drive for inspiration is lost. ABG is a must.
2. Causes ventilation perfusion mismatch.

Physiology of O_2 therapy

00:10:48

O_a from the atmosphere \rightarrow Respiratory tract \rightarrow Bronchioles
 \rightarrow Alveoli \rightarrow Pulmonary circulation \rightarrow O_a binds to hemoglobin
 \rightarrow Tissue.



Types of hypoxia :

1. Hypoxic hypoxia
2. Anaemic hypoxia
3. Stagnant hypoxia
4. Histotoxic hypoxia

Abnormalities along O_a pathway :

1. Decrease in atmospheric O_a concentration (high altitude).
2. Airway obstruction.
3. Lung pathology (asthma, COPD, pulmonary edema, ARDS).
4. Deranged diffusion of O_a in alveoli.
5. Abnormality in hemoglobin binding (carboxy hemoglobin, severe anemia).
6. Decrease amount of blood flow (reduced cardiac output).
7. Tissue level (cyanide poisoning).

Active space

All hypoxia cannot be

treated with supplemental O_2 .

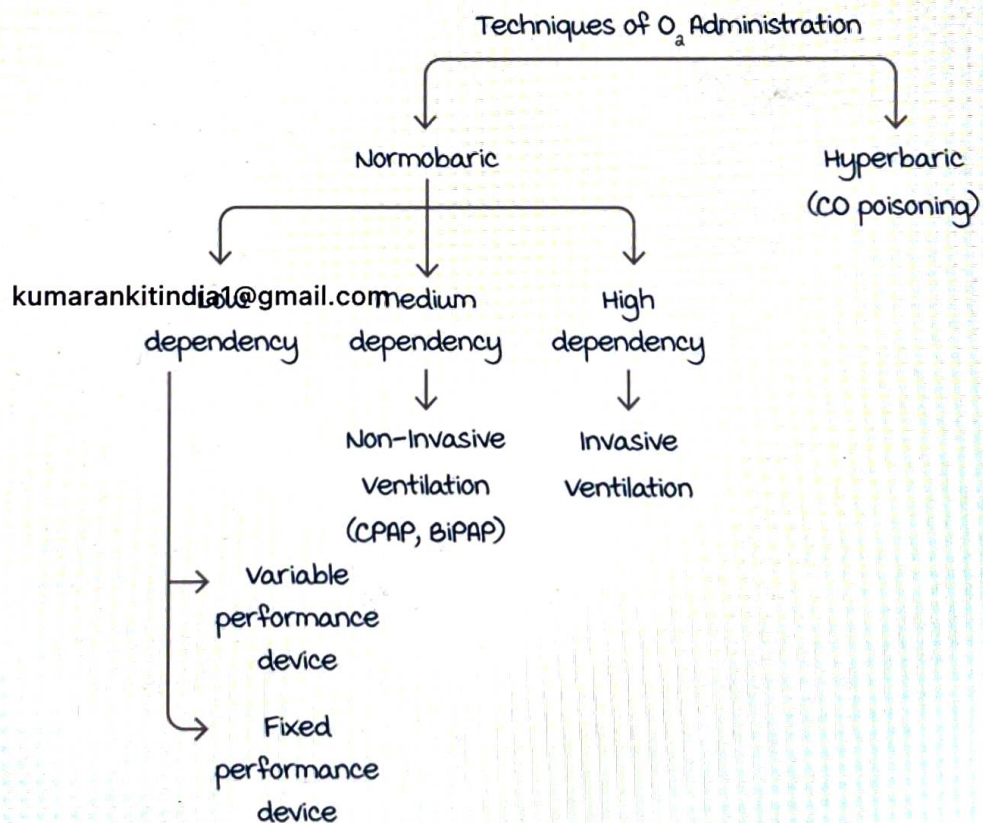
(O_2 therapy is primarily given in hypoxic hypoxia where there is decreased O_2).

Indication of O_2 Therapy :

1. Acute hypoxemia ($PaO_2 < 60$ mmHg).
2. $SpO_2 < 98\%$ for normal individuals.
3. Cardiac/respiratory arrest.
4. Low cardiac output states.
5. Metabolic acidosis.
6. Respiratory distress ($RR > 24$ /min).

Techniques of O_2 Administration

00:16:13



1. Administration of O_2 to the patient .

Hyperbaric O_2 : Oxygen is administered at greater pressure than atmospheric air.

Normobaric O_2 : Oxygen is administered at one atmosphere pressure.

2. Patient requirement.

Classification based on how dependent the patient is on O_2

- Low dependency :

Patient not fully dependent on supplemental O_2 . Divided into 2 categories : variable and fixed performance devices.

- medium dependency :

Air needs to be 'pushed' Ex: NIV, CPAP, BIPAP.

- High dependency :

Invasive ventilation.

Low flow Oxygen Devices

00:18:38

Also called variable performance devices.

Low flow : O_2 supplementation to patient is lower than minute volume (mv).

minute ventilation = Tidal volume (V_T) x Respiratory rate.

Healthy adult : 5 L/ min.

Principle :

Low flow oxygen devices trap the atmospheric oxygen, thereby the O_2 given to the patient is diluted with atmospheric air.

In hypoxia, the minute ventilation is increased due to increased demand of O_2

Example :

In a normal individual, mv = 5 L/min, after onset of disease, mv maybe increased to 10 L/min.

If low flow oxygen device is used at the flow rate of 6L/min, it traps 3 L more of atmospheric air and supplies it.

FiO_2 varies with the flows.

Nasal prongs :

Flow rate = 6 L/min

For, every 1 litre increase in O_2 → FiO_2 is increased by 4%.

Calculation of $FiO_2 = 20\% + (4 \times O_2 \text{ Flow rate})$

2 small prongs placed into the nostril to deliver oxygen.

Principle : Nasopharynx acts a reservoir, trapping and storing the delivered gases, which is taken in the next breath.



Active space

Advantage :

1. Light weight comfortable, daily activities may be done (eg: Eating while on nasal prongs).
2. Can be used for home oxygen therapy.
3. Cheap.

Disadvantage :

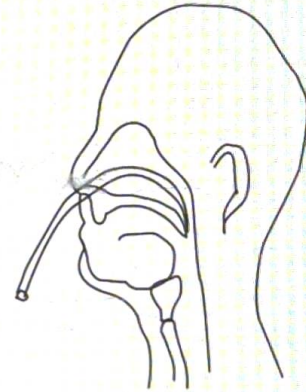
1. Cannot provide high flow O_2 .
2. In case of upper or lower airway obstruction, not effective. eg : nasal polyp , severe Bronchoconstriction.
3. Cannot be titrated.
4. At high flow rate airway secretion dries and may affect mucociliary mechanism of airway.

Nasal catheter :

Single lumen catheter inserted into nose of patient.

Demerits :

- Chances of dislodgement.
- Causes trauma to mucosa.



Nasal catheter

Simple face mask :

Also known as Hudson's mask.

Made of transparent material .

Side holes : Entrapment of atmosphere air.

Flow rate at 5 to 10 L/min of O_2 .

**Advantages :**

It increases oxygen concentration up to 40 to 60 %.

Disadvantage :

- Claustrophobia.
- Cannot eat.
- Need a tight seal to get accurate/appropriate values.
- FI_{O_2} is variable.

Non re-breathing mask :

Simple face mask with a reservoir bag.
Gases enters reservoir bag → It provides for inspiration in the next breath.
Reservoir bag needs to be inflated by more than half.

It requires 10 to 15 liter per minute for providing maximum amount of FiO_2 (90 to 100% of FiO_2 may be provided):

Advantages :

Highest possible of FiO_2 is delivered avoiding intubation or NIV.

Can be used in severe hypoxia.

Disadvantages : High flow might be not suited for long term.



High flow systems (fixed performance device)

00:29:18

Venturi mask :

Comes with a number written on it which determines the gas flow to be given and the FiO_2 it delivers.



Blue color : Improves FiO_2 by 24%.

Working principle : Venturi principle.

When liquid/gas moves in high speed a sub atmospheric pressure is created.

A small amount of negative pressure is created.



Depending on size of hole : Entrapment of atmospheric oxygen occurs.

Can be used to precisely deliver oxygen.

Advantage :

Preferred in COPD patients due to accuracy.

Disadvantage :

- High flow required.
- Expensive.



Advantage	Disadvantage
<ul style="list-style-type: none"> • Fine control of delivered oxygen • Fixed, reliable, & precise FiO_a • High flow comes from the air, saving the oxygen cost • Can be used for low FiO_a also • Decision making 	<ul style="list-style-type: none"> • Uncomfortable . • Expensive(400-600) • Cannot deliver high FiO_a • Interferes with activities

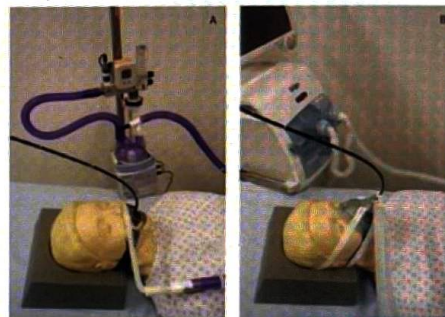
High flow nasal cannula (HFNC)

00:32:40

Flow rate of 40 to 60 L/minute
(Vapotherm uses 120L).

Flow rate and temperature
can be set.

Heated humidified O_a
administered with nasal
prongs which creates a
positive pressure in the nasopharynx.



Increased reservoir in nasopharynx allows increased amount
of oxygen to be taken in the next breath.

Acts like a pressure support.

Closing of mouth provides PEEP effect.

Prevention of collapse occurs.

In COVID, use of HFNC reduces mortality and ventilator use.

Ambubag/bag valve mask

00:36:26

Artificial manual breathing
unit (company name).

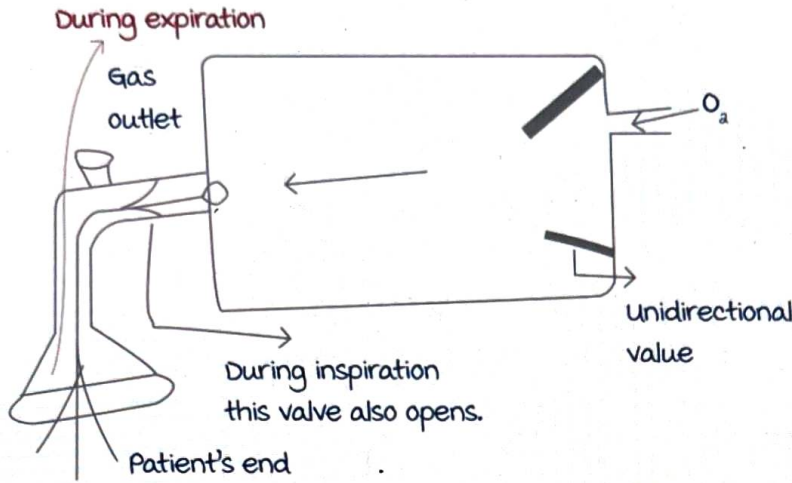
Called as manual
resuscitator or self inflating
bag mask valve.

Maximum O_a delivered.

Easily dismantled.

If connected to O_a source maximum amount of O_a to be
delivered is 100%.





Principle :

Press bag → Unidirectional valve ensures air goes inside, the other valve opens → O_a is delivered to patient
 During expiration the inspiratory valve closes → Gases out through outlet.
 There is provision for PEEP valve to set maximum pressure.

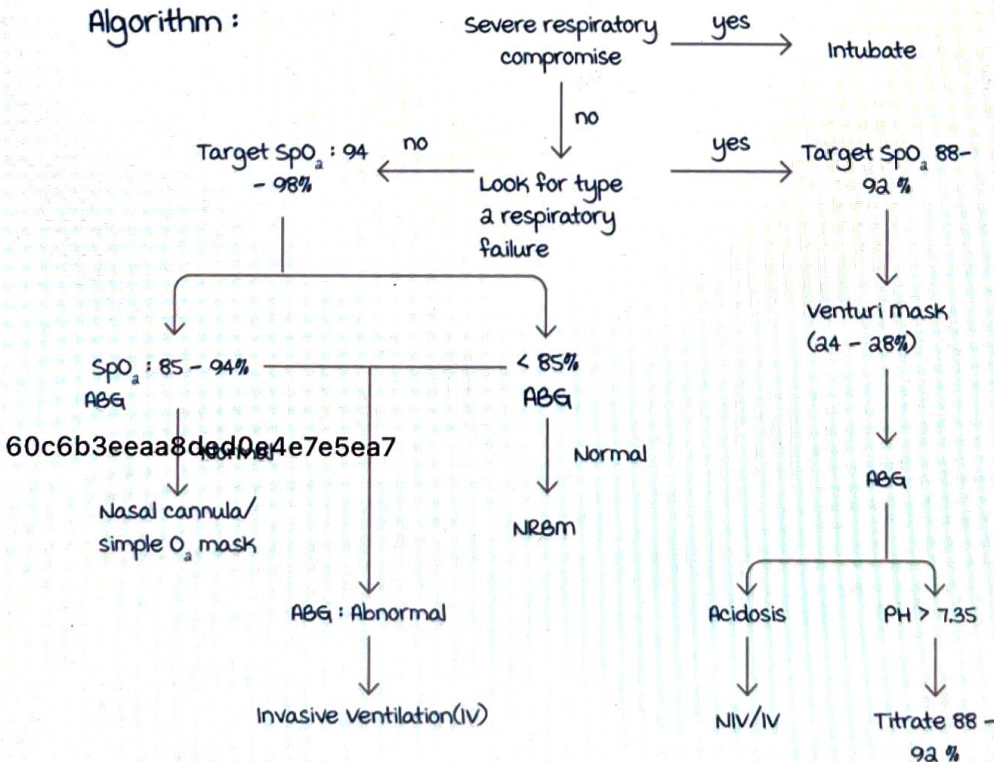
Advantages :

100% oxygen to patient if connected to O_a source.
 21 percentage of O_a is delivered if not connected to O_a source.

Criteria for selecting a device :

1. Depends on percentage of oxygenation to be improved.
2. Tolerance of patient.
3. Performance : Low requirement, high requirement.

Algorithm :



Active space

MECHANICAL VENTILATION

It is a **Positive Pressure Ventilation (PPV)**.

Normal physiology

00:02:08

In **normal** breathing, inspiration is a **negative pressure process**.

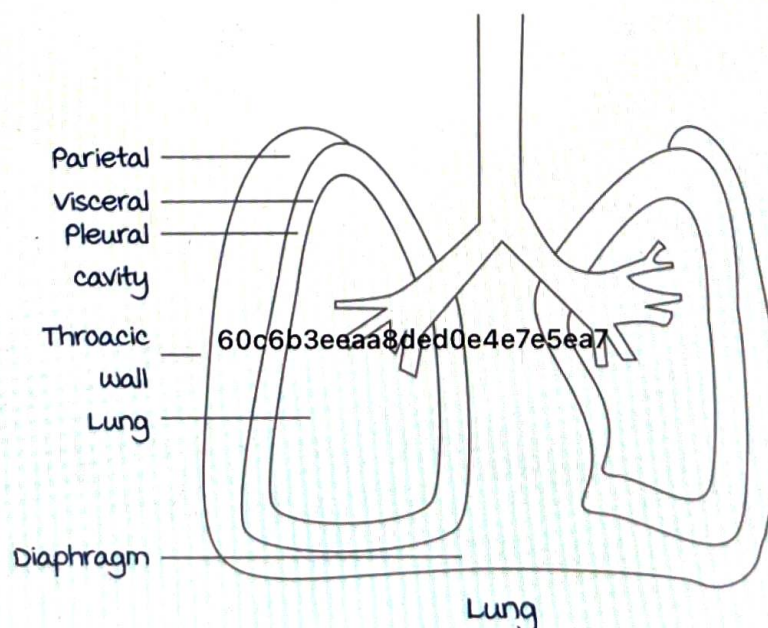
This is because normally the pressure in our lungs is equal to the atmospheric pressure. But at the start of inspiration, Respiratory centre → Phrenic nerve → Diaphragm moves down → Lung capacity increases → Negative pressure in alveoli.

The **negative pressure** in the alveoli, is because of **Boyle's Law** ($P \propto 1/V$).

Expiration is a **passive process** (in normal breathing) and requires no muscle as the lung is predominantly **elastic tissue** and so when **negative pressure** is developed, it expels air out to bring about positive pressure.

Inspiratory pressure : **-5 to -8 cm of water**.

Expiratory pressure : **'0'** due to **elastic recoil** of lungs.



Active space

Ventricular perfusion V/Q

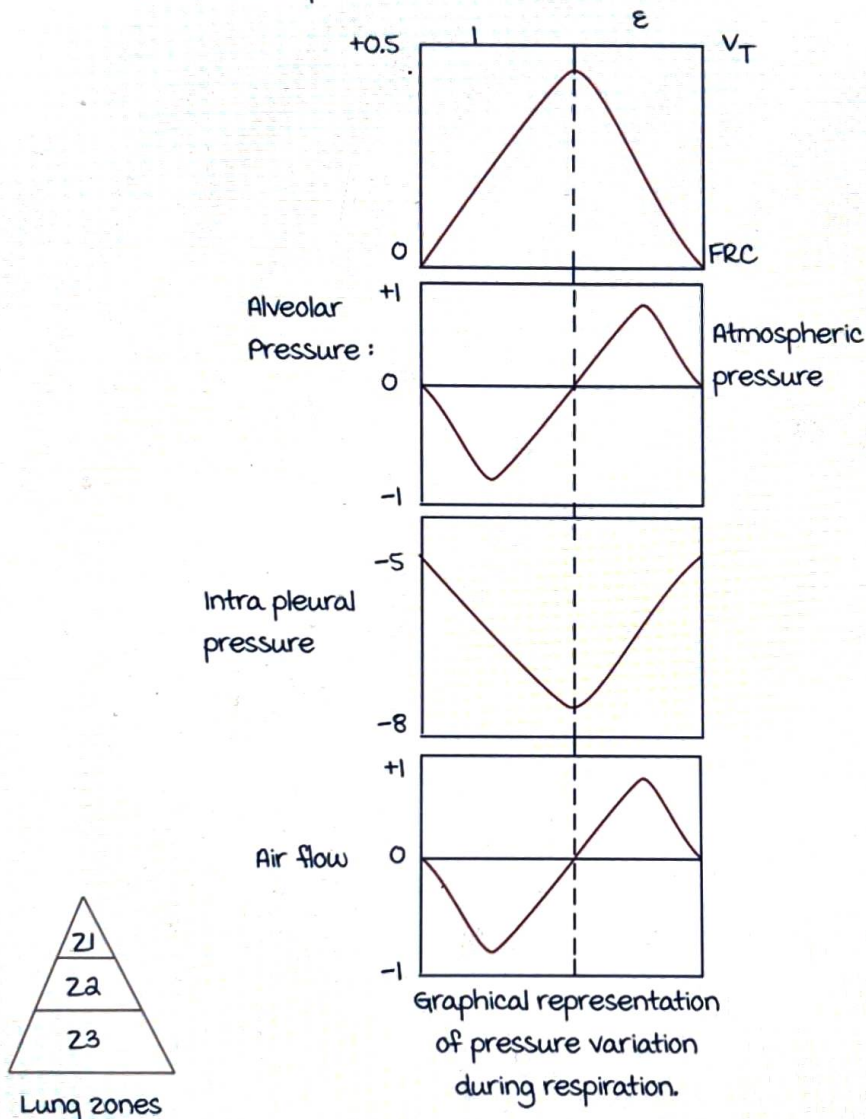
00:07:28

West zones of the lung :

Each lung is divided into 3 zones.

Ventilation is minimal at upper zone as large alveoli do not freely expand when compared to smaller alveoli.

Perfusion will be very minimal at the upper zone, and it does not follow Boyle's law.



Zones	Size of alveoli	Ventilation/movement of gases (v)	Perfusion/blood flow (q)	v/q	Inference
Zone 1 (upper zone)	Very big	Less	Less	2/1	wasted ventilation
Zone 2	Small	Optimum	Optimum	4/5	ideal zone
Zone 3	Very small	maximum	maximum	6/10	wasted perfusion

Active space

Inference :

Upper zones have wasted ventilation.

Lower zones have wasted perfusion.

∴ **Ideal** would be **zone 2** as it has optimum amount of ventilation and perfusion.

E.g., In case of opioid poisoning, this will lead to central depression. The patient will not get impulses of respiration and will need positive pressure ventilation.

Similarly, if the nerve is damaged, or if there is any muscular pathology like muscular dystrophy or diaphragm is not functional, patient may need ventilator support.

When a patient is on ventilation, it is necessary to provide maximum in zone 2 i.e., appropriate amounts of tidal volume/ V_T so that ventilation & perfusion of the whole of lungs is maximized.

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Pleural effusion or any pathology in the lower lobe will cause a V-Q mismatch, in which case we must try and maximize zone 2 where there is optimum amount of ventilation and perfusion.

Changes expected after PPV initiation

00:16:28

Normally, there is negative pressure in pleura and thoracic cavity, which is why size of alveolus increases and there is adequate supply of preload.

When taking a deep breath, as veins have no walls, larger amounts of preload come out.

∴ In normal inspiration process there will be augmentation of some amount of preload to heart. Increase in preload causes increase in after load (Frank Starling law).

If thoracic negative pressure is replaced by positive pressure ventilation, **positive intra thoracic pressure** → **decrease in preload** which causes hypotension.

∴ **Cardiac output decreases and BP also decreases.**

The positive pressure in thoracic cavity will be reflected via the **jugular veins** and there will be resistance to the cerebral blood flow causing **increased intracranial pressure/ICP.**

Mechanical ventilation

00:20:08

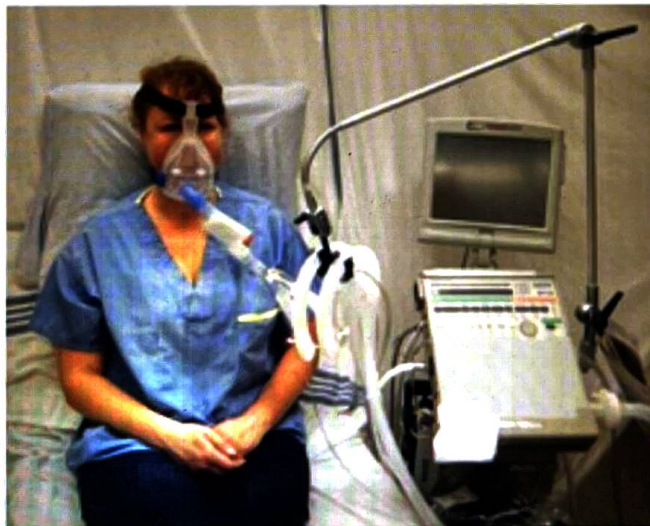
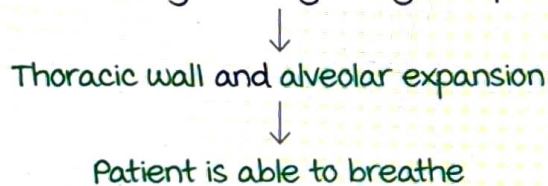
Iron lung

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First introduced at the time of polio pandemic (~1920s) as children used to die due to ascending paralysis. mechanical ventilation was provided via iron lungs.

The equipment works by creating a negative pressure

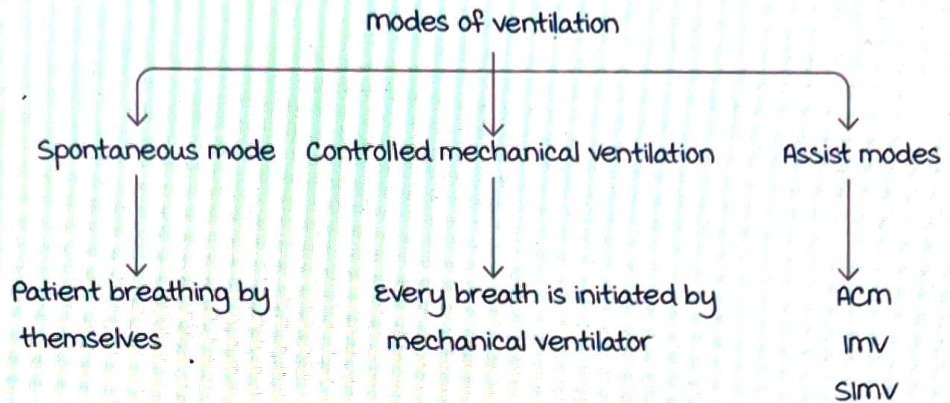


Noninvasive mode of positive pressure ventilation first demonstrated in Massachusetts during 1950s.

Active space

Modes of ventilation

00:25:14



modes of ventilation are as follows :

1. **Spontaneous mode** : Patient breathes on his own.

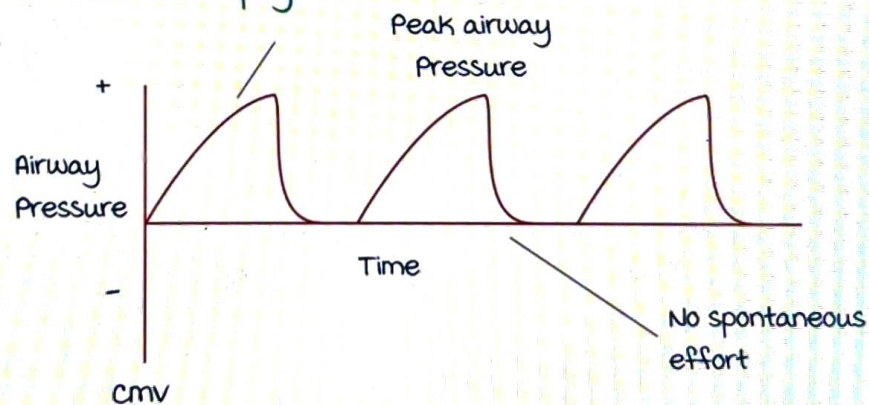
Not a mode.

2. **Controlled mechanical ventilation mode (CMV)** :

Every breath is initiated and controlled by mechanical ventilator.

Control mode is opted in cases of general anesthesia where **muscle relaxants** are given, **poisoning** and **muscle paralysis**.

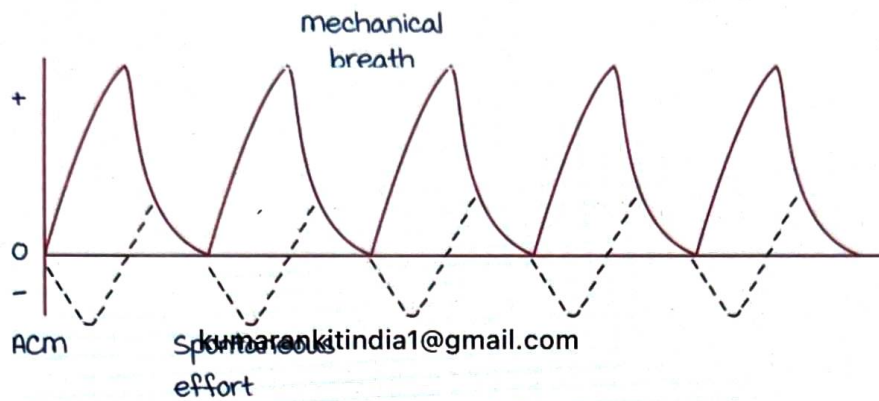
It should not be instituted for long term in ICU because it may cause muscle atrophy.



3. **Assist Control mode (ACM)** :

mechanical breath will be initiated for every spontaneous breath.

Advantages	Disadvantages
Tidal volume can be set.	Patients require deep sedation to ensure synchronization.
Alarm can be set.	



Intermittent mandatory ventilation (IMV) :

In this mode, number of breaths and tidal volume (V_T) are preset.

In between patient can breathe on his own.

E.g., Suppose it was previously fixed that;

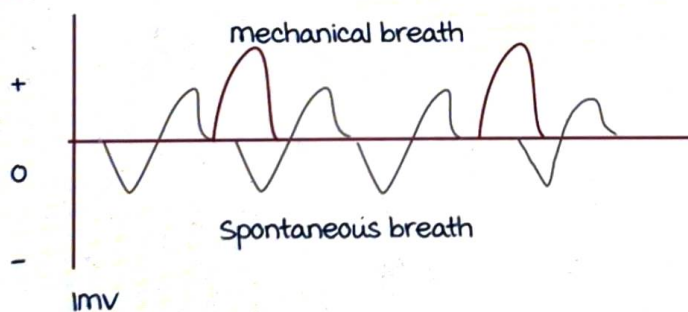
V_T : 500ml.

RR : 12/ min.

Then it means, 1 breath every 6 seconds.

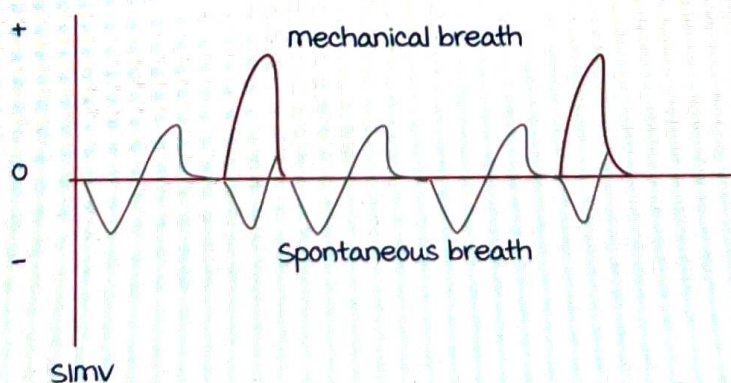
In this case, the ventilator generates mechanical breath only if spontaneous breath is absent.

But chances of **asynchrony** are high. This may lead to **breath stacking**.



Synchronised Intermittent mandatory ventilation (SIMV) :

It **synchronizes** with the respiratory effort so that there is no **breath stacking**. And is used as a weaning mode.



Terminologies used

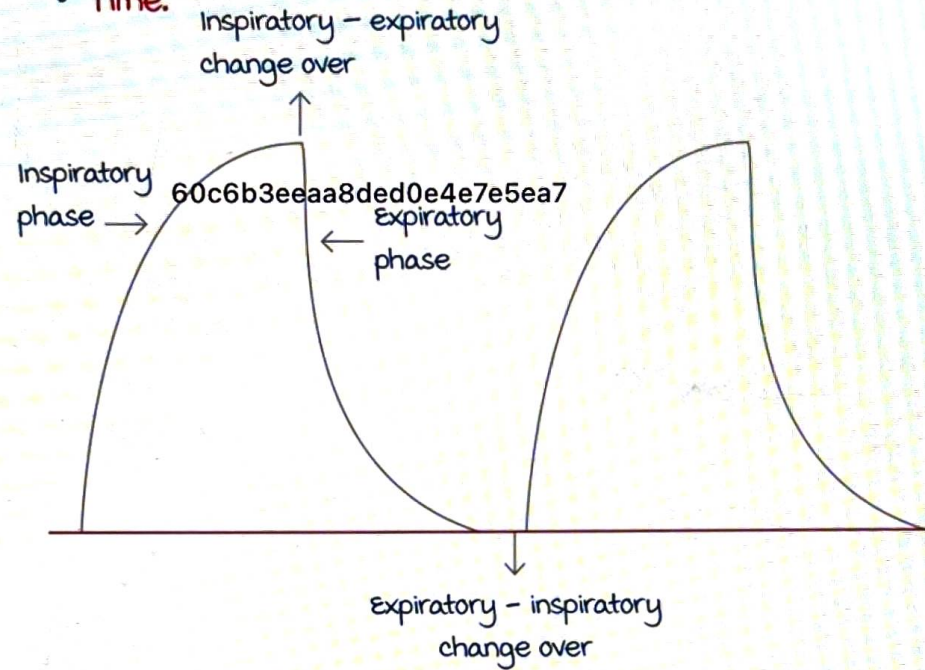
00:35:08

Ventilator cycling mechanism :

It is the inspiratory - expiratory change over.

They can be :

- Volume cycled : Based on preset V_T .
- Pressure cycled : Based on peak inspiratory pressure.
- Flow cycled.
- Time.

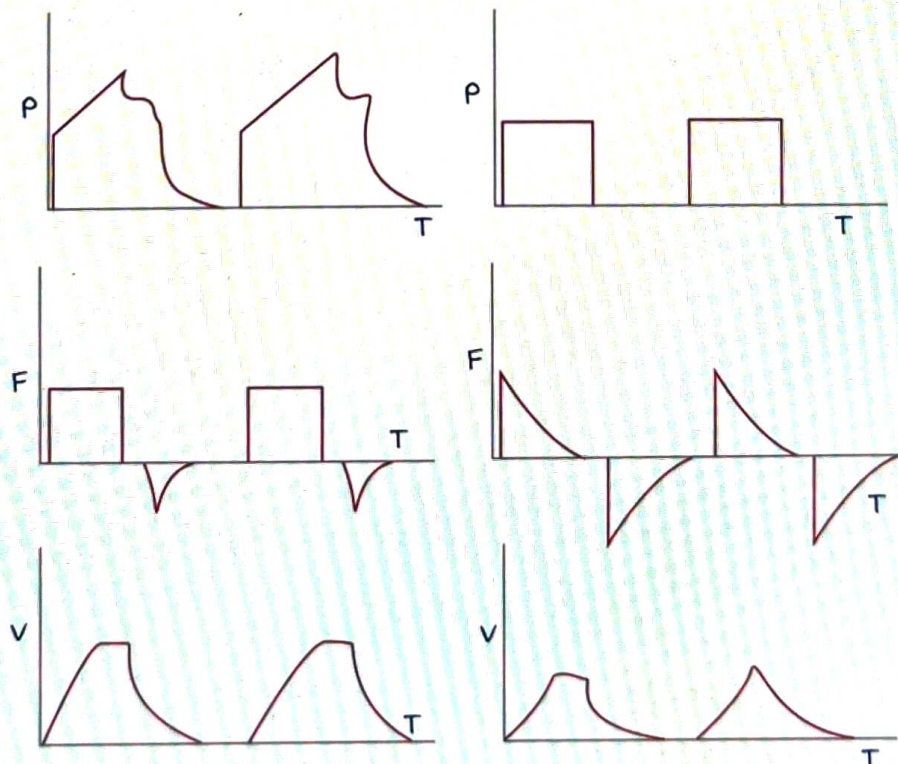


Wave forms : Volume mode vs pressure mode

00:38:58

(VC) volume mode

(PC) Pressure mode



Active space

In **volume mode** (V_c), preset V_T will be delivered. So if a graph between pressure & time is plotted, graph will be as shown to demonstrate how V_T is achieved and the difference.

In **pressure mode** (P_c), the pressure is fixed. So the graph plotted between pressure and time will be as shown in the image above.

Flow increases during inspiration and decreases during expiration.

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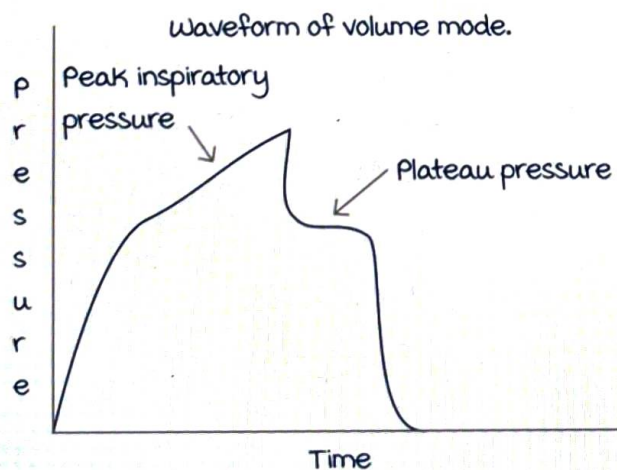
In a ventilator we need to set the following parameters :

- mode of ventilation of patient.
- Respiratory rate.
- Tidal volume or pressure.
- Inspiratory flow.
- I : E ratio.
- PEEP.
- FiO_2
- Inspiratory trigger.

Volume mode

00:40:31

In volume mode since the volume is preset, the pressure must be monitored.



That is, we must monitor :

- Peak inspiratory pressure (PIP).
- Plateau pressure.

Elastance, compliance and resistance are characteristics of normal lung.

- **Elastance** is the property of the substance to bounce back to its original form.

- **Compliance** is the change in volume for change in pressure.
- **Resistance** is the amount of pressure applied.

In cases of increased airway resistance/narrowing of airway, the gas will take a much longer time to reach the lungs this is known as **peak inspiratory pressure**.

- It also determines the **amount of air flowing** into the circuit.
- It is **higher** in cases of **obstructive airway diseases**, i.e., higher P_{IP} indicates airway is narrowed. e.g., BA / COPD which show obstructive pattern, difficulty in expiration due to loss of elastic tissue.

At the end of P_{IP}, if inspiration is momentarily put on hold, immediately there is a pressure drop, this is called as **plateau pressure** which will indicate the pressure build up in lungs/compliance of lungs.

It is **high** in conditions where compliance of the lung is affected: **Restrictive diseases** of the lung.

e.g., Pulmonary edema, there is difficulty in initiation of inspiration or ARDS.

Both obstructive and restrictive conditions have increased airway resistance.

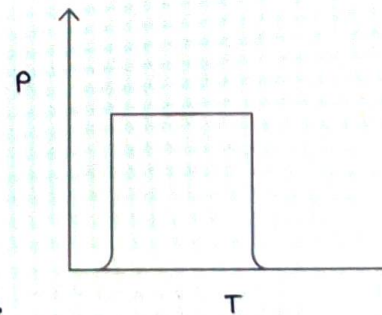
In COPD where there is both bronchial constriction and loss of elastic tissue, if mechanical ventilation is kept in volume load it is imperative to monitor the peak inspiratory pressure and the plateau pressure.

Pressure mode

00:51:50

The graph plotted between pressure and time in pressure mode appears as shown.

In pressure control mode the volume to be monitored is exhaled V_T . This is because inspired V_T does not give any result.



Exhaled V_T relays information about the amount of gas patient is receiving.

Fraction of Inspired Oxygen conc. (FiO_2)

00:53:08

Normally we inspire 21% or 0.21 of oxygen.

However, in pathologies, we need to increase the oxygen concentration. Initially, 100% FiO_2 is kept, thereafter the FiO_2 may be titrated to 90% → 80% → 70%.

The goal is to maintain $PaO_2 > 60\text{mmHg}$ and $SpO_2 > 90\%$.

Tidal Volume/ V_T

00:54:48

Amount of breath an individual inhales (or exhales) in a

normal respiratory cycle.

$$V_T = 500 \text{ ml.}$$

$$\text{or } V_T = 6 - 8 \text{ ml/kg.}$$

$$\text{or } V_T = 4 - 6 \text{ ml/kg.}$$

In patients with restrictive lung disease like pulmonary oedema or ARDS as seen in covid patients, V_T has to be low with increased respiratory rate.

This is to maintain the minute ventilation (mv).

$$MV = V_T \times RR$$

In pressure control mode, we need to monitor exhaled V_T (more sensitive).

Normal RR = 12 to 15 breaths/min, 10-20 in Adults, 20-30 in children, 30-40 in Newborn

Inspiratory trigger

00:56:48

- It is the amount of negative pressure that has been created so that the ventilator gets activated.
- It can be flow trigger or a pressure trigger.
- It is generally seen only in ACM or SIMV mode.

In SIMV there is a mode called trigger, which at a previously fixed point will support the patient's breath. If say, it is set at 50 ml then the ventilator will support patients' breath only after achieving 50 ml.

I : E ratio

00:58:18

Normally it is set at 1 : 2, that is if breath is given every 6 seconds, then initial inspiration is given 2 seconds and expiration is given 4 seconds.

In BA or other obstructive lung disease patients, the I : E is set at 1 : 2.5, 1 : 3 etc. in order to give more time for exhalation of gases.

In ARDS or pulmonary oedema, inverse ratio ventilation is preferred i.e., 2 : 1 this is due to difficulty to initiate inspiration in these patients.

Positive End Expiratory Pressure (PEEP)

01:00:00

In some cases, the alveoli which are elastic in nature may collapse due to loss of surfactant or due to disease pathologies, once collapsed it becomes difficult to reinflate the alveoli.

In these conditions, alveoli are given a positive pressure at the end of expiration to keep them inflated.

PEEP is supplied in cases where $PaO_2 > 60\text{mmHg}$ is not achievable, continuous 100% O_2 cannot be given as it may cause oxygen toxicity and absorption atelectasis.

- It helps in improving oxygenation.
- It also helps in recruitment of lungs.
- Prevents collapse of alveoli.
- Reduces work of breathing.

PEEP is especially useful in pulmonary edema.

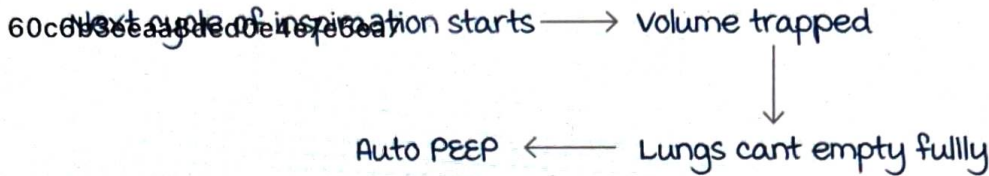
In ARDS patients like covid inflicted lungs, studies have shown usage of high PEEP has improved the survival rate in these patients.

Side effects of PEEP :

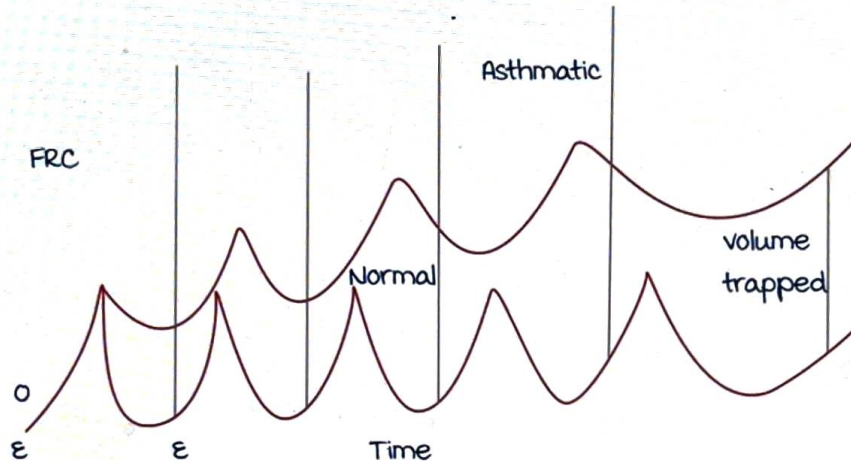
- Barotrauma because of positive pressure. Normally, under general anaesthesia physiological PEEP of 3 - 5 cm is kept, in ARDS we keep 8 - 10 cm and must strictly monitor.
- Decreases cardiac output. 60c6b3eaa8ded0e4e7e5ea7
- Increases intracranial pressure, so detrimental in neurosurgical patients.
- Regional hypoperfusion (of areas of lung).

Auto PEEP/**Dynamic hyperinflation** of lungs :

In an asthmatic patient, there is **expiratory delay** due to which the gases are not fully exhaled.



management : **Disconnect the ventilator.**



Pressure support ventilation (PSV)

01:06:39

When patient initiates a breath, it is supported by the mechanical ventilator, this is called as pressure support.

It is generally used with **SIMV** mode and helps in **weaning**.

Non invasive modes of ventilation (NIV)

01:07:41

There are 2 modes of NIV :

- **Continuous Positive Airway Pressure/ CPAP** : It is similar to PEEP, but CPAP is NIV, whereas PEEP is invasive. used to supplement oxygen in cases with good muscle tone like Covid patients. usually started with a pressure of 5 - 10 cm of water.
- **Bilevel Positive Airway Pressure/ BiPAP** : We can set inspiratory & expiratory pressure levels separately thus reducing the need for mechanical ventilation. Inspiratory support is given by pressure support ventilation/ PSV and expiratory support is given by PEEP.

mandatory minute ventilation (mmv) :

Newer mode, calculates the minute ventilation of the patient based on body weight and will monitor whether minute ventilation is achieved. It is also a **weaning mode**. High end mode used in elderly recovery.

Adaptive Support Ventilation (ASV) :

Here, after entering body weight and minute ventilation of the patient the system calculates and adapts to everything including tidal volume, respiratory rate etc.

Proportional Assist ventilation (PAV) :

This mode changes the pressure support depending on elastance, compliance, volume, air flow etc.

Volume Assured Pressure Supported (VAPS) :

Not useful in airway obstruction.

Pressure Regulated volume Control (PRVC) : Regulates the PIP and controls the flow accordingly.

Volume ventilation + (VV +) : volume control with volume support.

Airway Pressure Release Ventilation (APRV) :

Helps relieve excessive pressure within the body, very useful in preventing barotrauma.

Automatic Tube Compensation (ATC) :

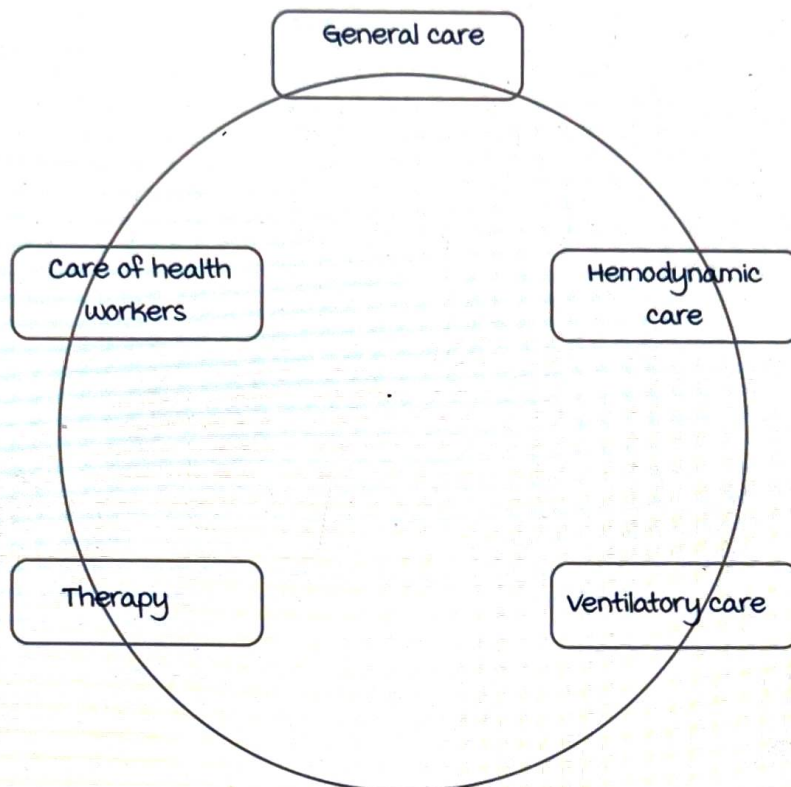
Compliance and obstruction of tubes is verified and compensation is made as required. Used in children.
KumarAnkitIndia@gmail.com

Neurally Adjusted Ventilator Assist (NAVA) :

Senses phrenic nerve movements and assists in ventilation.

Care of patient on ventilator

01:18:14



General care of ventilated patient :

- Care of endotracheal tube : ^{2nd} hourly suctioning of the tube.
kumarankitindia1@gmail.com
- Good chest physiotherapy.
- Adequate sedation & analgesics.
- **Humidified gases** are provided so as to not disturb airway mucociliary function.
- Nutrition.
- Bed sores.
- Central and intravenous line care.
- **Psychological support** as ICU psychosis is very common.
- Keeping updated medical records.

Hemodynamic care :

Chances of hypotension are very high in these patients due to disease condition or even initiation of therapy.

Therefore, must initiate IV fluids and monitor to **avoid volume overload** the patient.

Initiate vasopressors & inotropes if BP not improving.

Ventilatory care :

It is different from patient to patient, asthma patient, COPD

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patient and pulmonary oedema patient all have different needs.

Care of a covid patient would be as follows :

- Non invasive ventilation preferred over invasive.
- In non invasive ventilation, HFNC > NIPPV.
HFNC : High flow Nasal Cannula, NIPPV : Non invasive positive pressure ventilation like CPAP.
- Low V_T .
- Target P Plateau pressure : < 30cms (as the compliance of the lung is affected in ARDS).
60c6b3eeaa8ded0e4e7e5ea7
- Higher PEEP (>10cms watch for barotrauma).
- Avoid neuromuscular blockers (as prolonged usage of NM blockers can lead to atrophy).
- moderate to severe cases : **Prone ventilation** for 12 - 16 hours.
- Lung recruitment manoeuvres.
- **ECMO**.

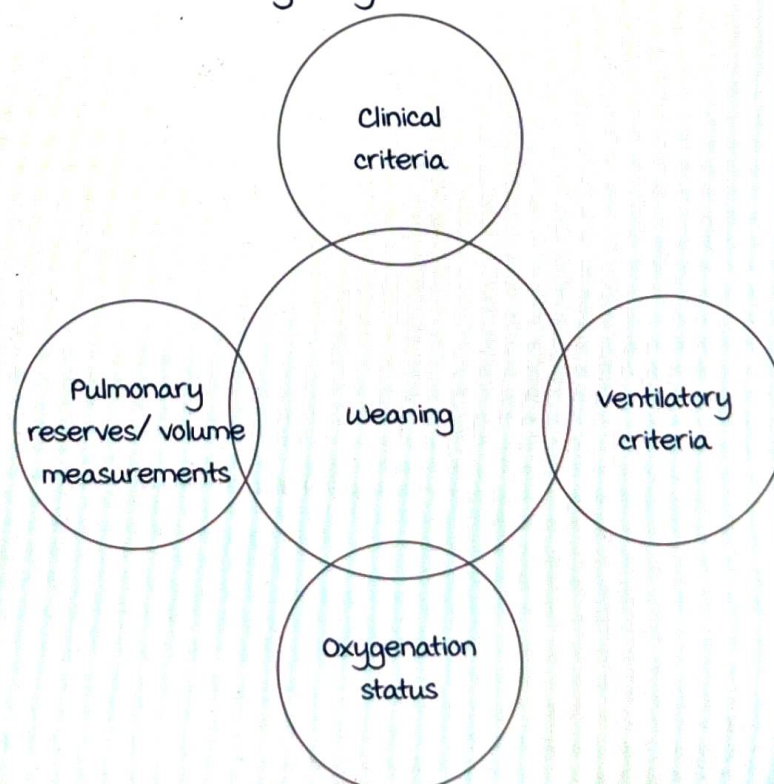
Therapy : Target the **primary illness**.

Health care worker protection :
Usage of PPE, N 95 masks etc.

Weaning from ventilator

01:23:40

Weaning is a very gentle process, not an emergency process. The modes must be changed regularly and patient condition has to be assessed regularly.



Active space

Clinical criteria :

The **main problem** should be resolved.

The patient must be conscious, alert and able to obey commands.

Patient should have a good cough reflex.

Patient must be hemodynamically stable.

Should have minimal secretions.

Ventilatory criteria :

Clinically ~~stable patient~~ **spontaneous breath trial (SBT)**.

Here, patient is on the ventilator and an alarm is kept for 20 - 30 minutes, during which the patient should maintain $\text{PaCO}_a < 50 \text{ mmHg}$ and generate a V_T of 5 - 10 ml/kg with $\text{RR} < 35/\text{min}$ i.e., minute ventilation (mv) should be $< 10 \text{ L}$.

If patient is shallow breathing or fast breathing, chances of failure are high.

Rapid Shallow Breathing Index (RSBI) is the ratio of $\text{RR} : V_T$, and it should be < 100 to plan **extubation**.

Oxygenation criteria :

Target $\text{PaO}_2 > 60 \text{ mmHg}$ (without PEEP) and $> 100 \text{ mmHg}$ (with PEEP).

$\text{SpO}_2 > 90\%$.

$\text{PaO}_2 : \text{FiO}_2 > 150$.

Pulmonary reserves :

vital capacity (VC) $> 10 \text{ L}$.

If VC is less, the patient cannot cough leading to pooling of secretions, aspiration etc.

$\text{Pip} < 30 \text{ cm}$ with good compliance of the lung tissue ($> 30 \text{ ml/cm}$).

If all the conditions are met, **patient may be extubated after gentle suctioning**.

CARDIO PULMONARY RESUSCITATION

Introduction

00:04:40

The modern method of Cardio-Pulmonary Resuscitation (CPR) was started less than 50 years back by James Elam and Peter Safar (Father of emergency medicine).

William Kouwenhoven is credited for teaching CPR in an organized fashion.

Zoll has introduced the use of defibrillator in CPR.

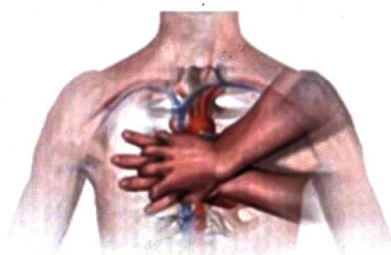
Physiology of sudden cardiac arrest and compressions

00:08:30

In a cardiac arrest, after the last beat of heart, the blood in aorta moves forward until the pressure of aorta becomes equal to pressure in right atrium.

The blood flow in pulmonary circulation will continue until its pressure becomes equal to pressure in left atrium.

Due to these pressure differences there will be forward flow of blood for 5 minutes approximately after the heart stops.



Position Hands Over sternum

OHCA



Active space

How CPR works?

Thoracic pump theory: Chest compressions → intrathoracic pressure exceeds extra thoracic pressure → forward flow resumes.

Cardiac pump theory: On compressing the sternum, the heart gets compressed between sternum and vertebral column. The tricuspid & mitral valve closes, left and right ventricular volume decreases and blood propels forward. During decompression phase the blood fills back due to pressure gradient created between pulmonary and systemic circulation.

Not only compressions but **adequate recoil** is also important.

You are walking in a park, early morning, a 52 year old male patient, who was walking ahead of you, suddenly collapsed. What will you do?

Sequence/action	Technical description
Safety	Ensure scene is safe
Response	Shake gently, ask loudly
Call for help	Call 108, get AED
Check for breathing and pulse	Gasping/ abnormal breath, check pulse for 10 seconds

3 scenarios :

- **Scene 1**: Normal breathing and pulse felt :
monitor patient until ambulance comes.
- **Scene 2**: No breathing but definitive pulse felt :
Give **rescue breaths** (1 breath per 6 seconds) and continue checking the pulse.
Consider opioid poisoning.
- **Scene 3**: No normal breathing/gasping for normal pulse
Start CPR.

Procedure :

method of compressions : Interlock fingers with hands palm to dorsum, place hands on lower 1/3rd of sternum, bend over the patient without bending your elbow and give compressions

with pressure coming from the shoulder girdles.

- 30 compressions, 2 breaths.
- make sure chest recoils properly.
- Avoid interruption < 10 sec.
- Chest compression fraction ratio (CCF) 80%, depth must be 2 inches or 5 cm.
- Do in a coordinated manner.
- Application of AED : Remove the clothes, apply pads and follow instructions.
- Shockable rhythm (VF/VT) : AED delivers shock, resume CPR for 2 minutes until AED prompts to check the pulse.
- Non shockable rhythm : Continue CPR, check pulse every 2 minutes.

New addition in 2020 guidelines :

- 6th link in chain of survival is recovery.
- Recovery : Initiating function and rehabilitation.
- 1 breath for every 6 seconds.
- Compressions should be minimum 120/min.

When to stop CPR?

00:26:43

After 20 mins of no return of spontaneous circulation (ROSC),
Outcome is not very good.

For BLS provider :

- Unwitnessed arrest.
- No ROSC obtained.
- No AED/no shock.

For ALS provider :

- Unwitnessed arrest.
- No ROSC obtained.
- No AED/ No shock given.
- NO bystander CPR.

Events following arrival of ALS team :

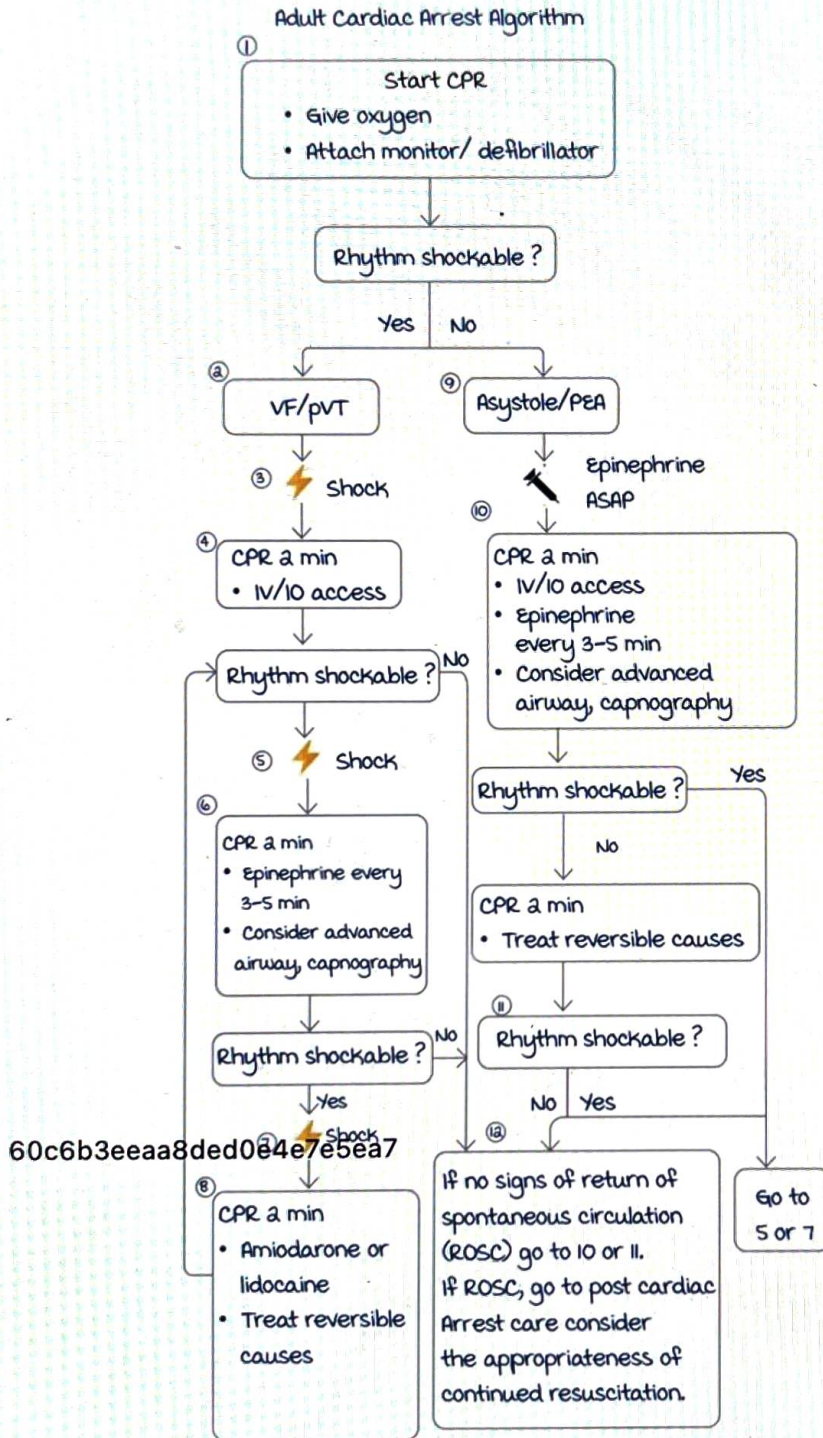
1. Give shock : Biphasic : 120-200J. monophasic : 360J.

Follow the manufacturer's recommendation.

The 2nd shock should be equal or more than the first shock.

2. Continue CPR for 5 cycles upto 2 minutes.

3. Start IV line and give IV epinephrine 1 mg every 4 minutes.
4. After 3rd shock is delivered, consider anti-arrhythmic infusion (Amiodarone/Lignocaine). Identify reversible causes
5. Advanced airway forms.



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CPR quality

- Push hard at least 2 inches (5 cm) and fast (100-120/min) and allow complete chest recoil. minimize interruptions in compressions.
- Avoid excessive ventilation.
- Change compressor every 2 minutes, or sooner if fatigued.
- If no advanced airway, 30 : 2 compression-ventilation ratio.
- Quantitative waveform capnography :
 - If $PETCO_2$ is low or decreasing reassess CPR Quality.

Shock energy for defibrillation

- Biphasic : manufacturer recommendation (eg, an initial dose of 120-200J) ; if unknown, use maximum available. Second and subsequent doses should be equivalent, and higher doses may be considered.
- monophasic : 360 J.

Drug therapy

- Epinephrine IV/IO dose : 1 mg every 3-5 minutes
- Amiodarone IV/IO doses :
 - First dose : 300 mg bolus.
 - Second dose : 150 mg or
- Lidocaine IV/IO doses
 - First dose : 1-1.5 mg.

Advanced airway

- Endotracheal intubation or supraglottic advanced airway.
- Waveform capnography or capnometry to confirm and monitor ET tube placement.
- Once an advanced airway is in place, Give 1 breath every 6 seconds (10 breaths/min) with continuous chest compressions.

Return of Spontaneous Circulation (ROSC)
<ul style="list-style-type: none"> • Pulse and blood pressure • Abrupt sustained increase in PETCO₂ (typically 40 mm Hg) • Spontaneous arterial pressure waves with intra-arterial monitoring
Reversible causes (SH & ST)
<ul style="list-style-type: none"> • Hypovolemia • Hypoxia • Hydrogen ion (acidosis) • Hypo/hyperkalemia • Hypothermia • Tension pneumothorax • Cardiac tamponade • Toxins • Pulmonary thrombosis • Coronary thrombosis

Non shockable rhythms

00:34:45

What are non shockable rhythms?	Asystole/Pulseless Electrical Activity (PEA)
What is the first step to do?	CPR kumarankitindia1@gmail.com
What is immediate step?	IV Inj Epinephrine
What is next step to instruct?	Continue CPR, check pulse for 2 mins

Return Of Spontaneous Circulation (ROSC)

00:36:08

Stop CPR.

I. Initial stabilisation phase :

Airway management : Position of ETT, connect to ventilator at 10 breaths per minute.

ABG :

maintain PaCO₂ at 35-45 mmHg and SPO₂ at 92-98 mmHg.

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maintenance of hemodynamics :

SBP > 90 mmHg,

MAP > 65 mmHg

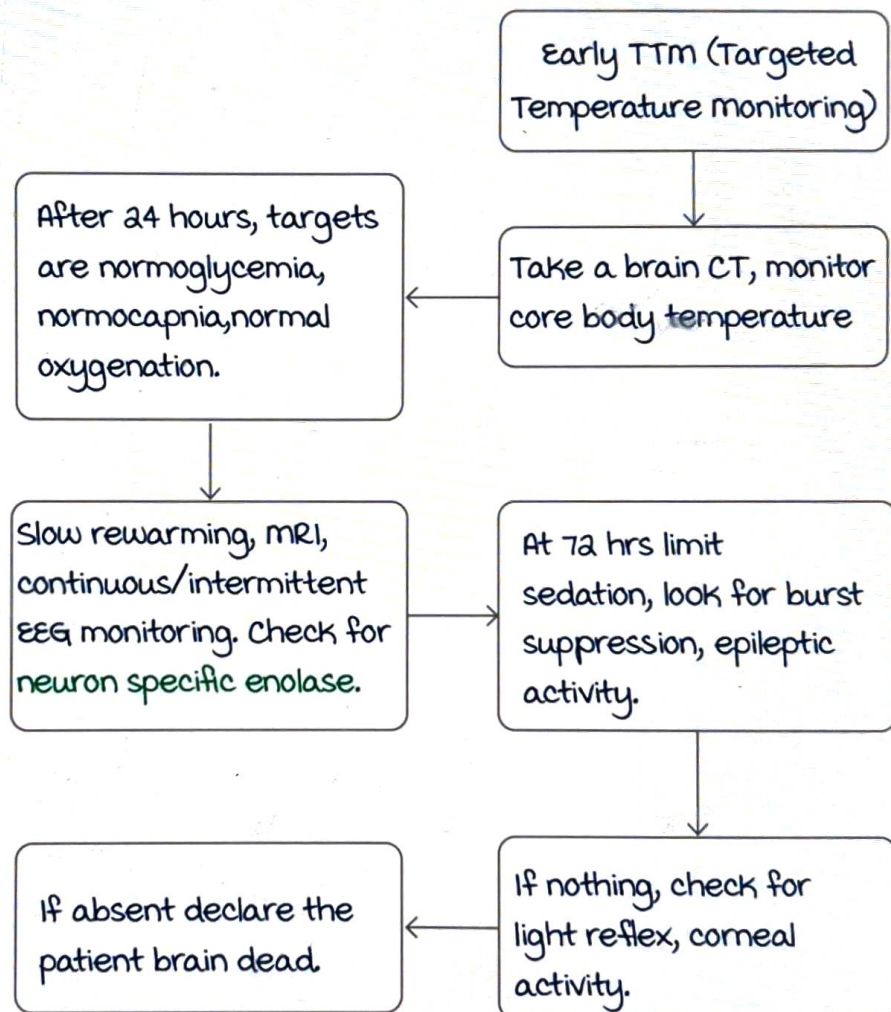
Get a 12 lead ECG- check for cardiac problems.

2. Continued management :

Patient is obeying verbal commands : Continue monitoring.

If patient is comatose : Suspect ischemic insult.

Start early Targeted Temperature monitoring at 32-36°C for 24 hrs. Hypothermia can lower BMR and improve survival.



New addition in 2020 guidelines :

- Intravenous access > Intraosseous access.
- Early Epinephrine on PEA and asystole.
- Post cardiac arrest evaluation.
- SpO₂ to be maintained between 92 - 98%

Adult tachycardia

00:44:10

You are working in an ICU. In the mid night the nursing staff called you to evaluate a 40 year old male patient who has been operated for some gastro-jejunostomy yesterday. The main issue was constant alarm from the monitor. You saw the patient and noticed that heart rate is 162/minute. How will you proceed?

- Assess the situation.
- Check the monitor for values and check if its properly connected.
- Insert an IV line and supplement oxygen.
- 12 lead ECG to be taken.
- Check for reversible causes like pain, fever, hypovolemia.
- Determine whether the patient is stable or unstable (altered mental status, hypotension, hypoperfusion, nausea).

Narrow complex QRS (unstable) :

Sedate with 1 mg midazolam and give synchronized cardioversion (shock will be delivered on R wave) 75J → 125J → 150J → 200J.

Narrow complex QRS (Stable) :

Vagal manoeuvres / carotid massage.

Adenosine : 6mg - 12mg IV

Rate control with Ca^{2+} channel blocker like Diltiazem or betablocker.

Wide complex QRS (unstable, regular)

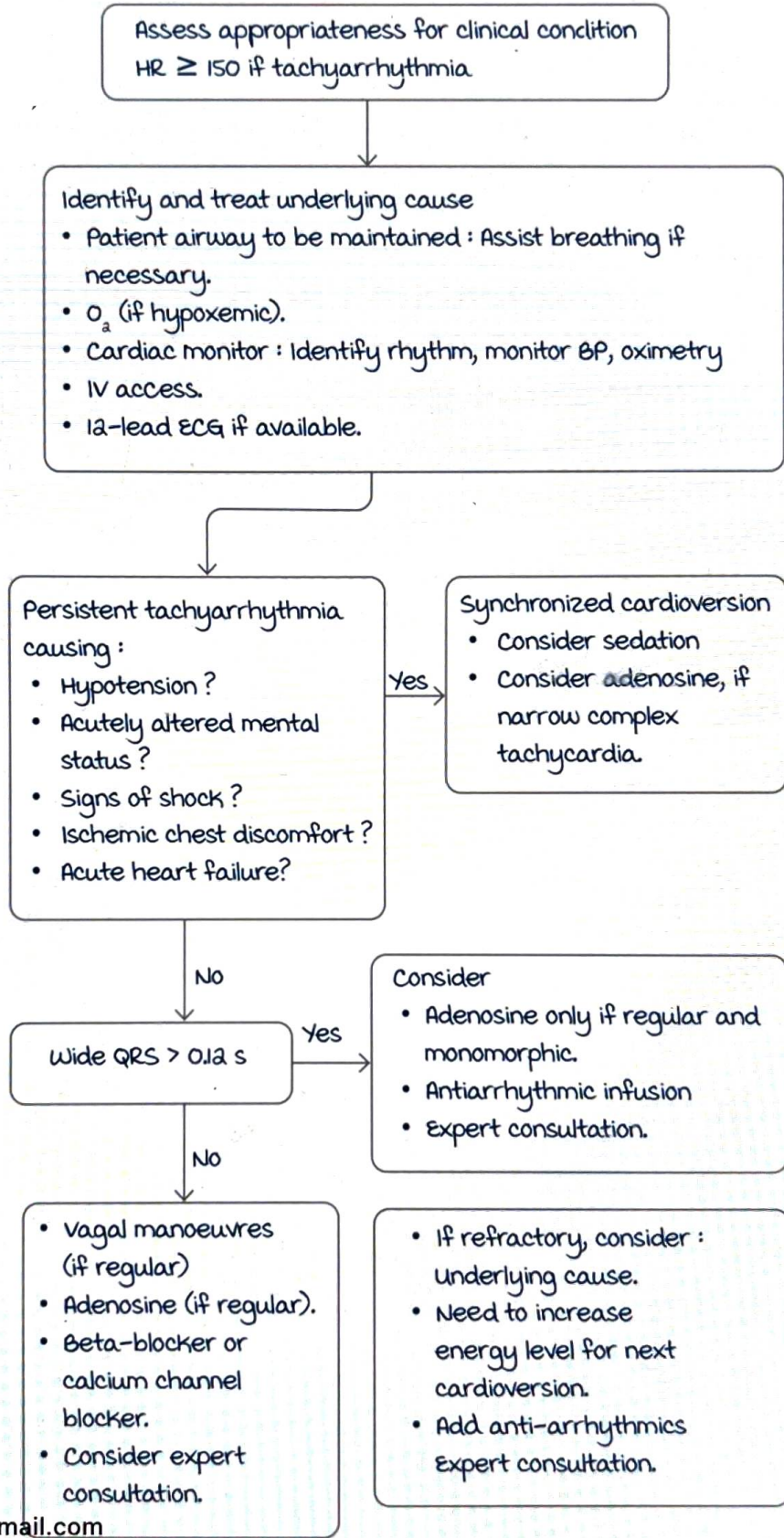
Immediately cardioversion with 100J. Consider Adenosine/ antiarrhythmic infusion like Procainamide if it is monomorphic.

Wide complex QRS (irregular)

Patient is unconscious : Defibrillate.

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Adult tachycardia with a pulse algorithm



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Doses/Details

Synchronized cardioversion : Refer to your specific device's recommended energy level to maximize first shock success.

Adenosine IV dose :

First dose : 6 mg rapid IV push; follow with NS flush.

Second dose : 12 mg if required.

Antiarrhythmic Infusions for Stable Wide-QRS Tachycardia

Procainamide IV dose :

20-50 mg/min until arrhythmia is suppressed, hypotension ensues, QRS duration increases >50%, or a maximum dose of 17 mg/kg is given. maintenance infusion : 1-4 mg/min.

Avoid if prolonged QT or CHF.

Amiodarone IV dose : First dose : 150 mg over 10 minutes.

Repeat as needed if VT recurs. Follow by a maintenance infusion of 1 mg/min for the first 6 hours.
kumarankitindia1@gmail.com

Sotalol IV dose :

100 mg (1.5 mg/kg) over 5 minutes. Avoid if prolonged QT.

Adult bradycardia

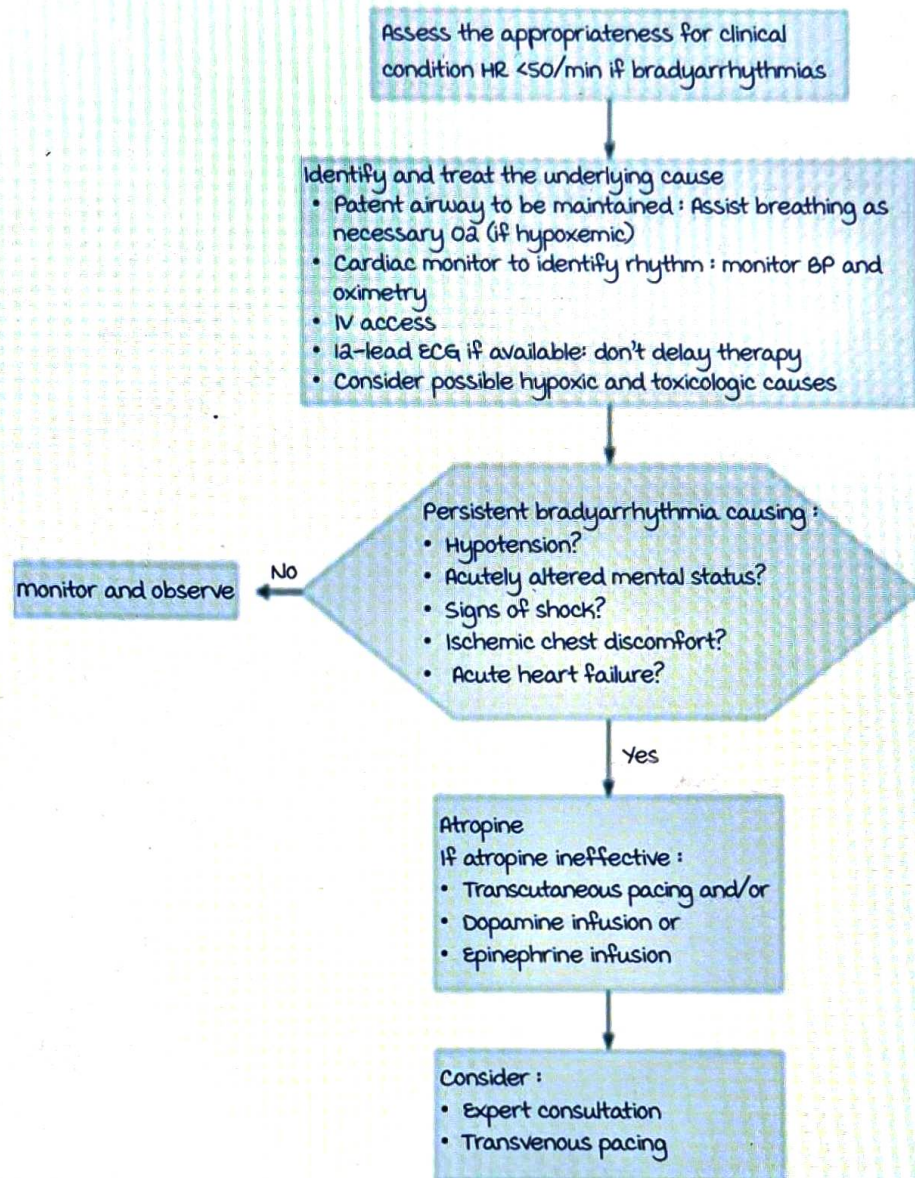
00:51:26

You are working in ER, in the late afternoon a 60 year old male patient with a history of cardiac problem was rushed into hospital for being somnolent since morning, you saw the patient and noticed that heart rate is 42/minute. How will you proceed?

Adult bradycardia algorithm to be followed starting from assessment of the patient.

Active space

Adult bradycardia algorithm



Doses/Details

Atropine IV dose:

First dose: 1 mg bolus.

Repeat every 3–5 min.

Max: 3 mg.

Dopamine IV infusion:

The usual infusion rate is 5–20 mcg/kg per minute.

Titrate to patient response, taper slowly.

Epinephrine IV infusion:

2–10 mcg per minute infusion

Titrate to patient response.

Causes:

- Myocardial ischemia/infarction.
- Drugs/toxicologic (e.g. calcium-channel blockers, beta-blockers, digoxin)
- Hypoxia.
- Electrolyte abnormality. (e.g. hyperkalemia)