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Volume 2

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# Contents

## Anesthesia


1. Anesthesia Trolly, Instruments, Circuits, Ventilation and Preanaesthetic Medication 3
2. Neuromuscular Blockers 22
3. Intravenous and Inhalational Anaesthetics 28
4. Clinical Anesthesia 43
5. Anaesthetic Complication & Management 56
6. Local Anaesthetics & Blocks 65
7. Spinal, Epidural and Caudal Anaesthesia 73
8. Review Notes 81


## Orthopedics


1. Bone Histology, Fracture: Pattern, Healing & Non-Union 147
2. Polytrauma 152
3. Injuries of Upper Limb 156
4. Injuries of Lower Limb 182
5. Spinal Injuries 201
6. Sports Injury/Ligamentous Injury 211
7. Advanced Orthopaedics and Managements 218
8. Nerve Injuries 226
9. Paediatric Orthopaedics 237
   - 9.1 Fractures in Children
   - 9.2 Paediatric Limb Anomaly
   - 9.3 Paediatric Hip Problem
   - 9.4 Paediatric Knee and Foot Problem
   - 9.5 CTEV
   - 9.6 Paediatric Spinal Problem
   - 9.7 Genetic & Developmental Disorders of Bones
10. Metabolic Bone Diseases 253
11. Avascular Necrosis of Bone & Osteochondritis 264
12. Arthritis 268
13. Regional Pain Syndromes 281
14. Infective Bone Diseases 286
15. Bone Tumors 294
16. Review Notes 311

# 1

# ANESTHESIA TROLLY, INSTRUMENTS, CIRCUITS, VENTILATION AND PREANAESTHETIC MEDICATION

## Respirometer (Spirometer / Ventilometer / Respiratory flow meter / Ventilation or respiratory meter or monitor / Volume measuring device)

- Respirometer is a device that *measures the volume of gas passing during a period of time* through a location in flow pathway.
- ***Monitoring respiratory volumes and flows*** can help in detecting breathing system obstruction, disconnections, leaks, apnea, ventilator failure, and high or low volumes in spontaneously breathing patients as well as in those whose ventilation is controlled. A discrepancy between expired & inspired tidal volume suggest a leak or incompetent unidirectional valve / reversed flow.
- ASA recommended *monitoring of volumes of expired gases*. So anesthesia workstation standard requires a device *to monitor the patient's exhaled tidal or minute volume or both.*
- **Possible locations for spirometer** in the circle system may be 1) in ***exhalation limb*** upstream or downstream of unidirectional valve (most common); 2) ***between breathing system and patient*** (most desirable from the standpoint of accuracy); 3) ***downstream of $CO_2$ absorber*** (volume of gas measured is decreased d/t absorption); 4) ***on inspiratory limb*** (show high readings as the gas that does not inflate patient's lung will also pass; but disconnection may not be detected during controlled ventilation). *Pressure flow sensors are located at expiratory downstream & inspiratory positions.*
- Measurement of exhaled tidal volumes in expiratory limb includes gas that had been lost to the circuit (& not delivered to the patient).
- The difference b/w the volume of gas delivered to circuit & volume of gas actually reaching the patient becomes very significant with *long compliant breathing tubes, rapid respiratory rates & high airway pressures*. These problems (of position 4) are particularly overcome by measuring the tidal volume at Y connector to the patient's airway (position 2).
- Flow of gas across respirometer is measured *mechanically (Wright's R.)*, electronically/ electro-magnetically (spiromed), photoelectrically, or by measuring *differential pressure* (flow sensor & D-lite gas sampler, novametrics side stream sensor), *thermal dissipation* (heated wire anemometer), and *discontinuities in gas flow* (ultrasonic flow sensor). A **pneumotachograph** is a fixed orifice flow meter that can function as spirometer.

## Hypoxia Preventation Safety Devices

- **Item no. 1** on the FDA checklist is that an **alternative means to ventilate the patients lung should be present and functioning.** Therefore, if a problem arises with the machine, the **patient's lungs can be ventilated manually using a self inflating resuscitation bag (eg AMBU bag = Artificial Manual Breathing Unit).** If a machine problem arises and the cause/remedy is not immediately obvious, one should instinctively reach for the **resuscitation bag and start manual ventilation**Q and call for help.
- One of the most serious mishaps that occurred with early mahines, was *depletion of $O_2$ supply (usually from a cylinder) without the user's awareness resulting in delivery of 100% anesthetic gas.* ***Oxygen pressure failure devices****, to prevent this problem, include*

### Oxygen Failure Safety Device (Valve)/ Low Pressure Guardian System/Oxygen Failure Protection Device/ Pressor Sensor Shut or Cut off Valve/$N_2O$ Shut off System/Fail Safe Device or Valve.

- **Oxygen can pass directly to its flow control valve , whereas, *$N_2O$, other gases & air (in some machine) must pass through a safety device – fail safe valve* before reaching their respective flow control valve. *So fail safe valve is located down stream from $N_2O$ supply source*Q.**
- These valves permit the flow of other gases only if there is sufficient $O_2$ pressure in safety device. Safety devices sense $O_2$ pressure via a small piloting pressure line and *if pressure falls below a threshold eg* 20 psig, **shut off / cut off / fail safety** valve close, preventing the administration of any other gas.

### Oxygen Supply Failure Alarm

- Acoording to (1998 ASTM F1850-00) standard specification, **whenever the $O_2$ supply pressure** (at inlet) **falls below a manufacture specified threshold** ~20-35 psig (usually 30 psig=205 KPa) **low pressure $O_2$ supply sensor, activate at least a medium priority alarm (gas whistle, electrical alarm) within 5 second**. It shall not be possible to disable this alarm. So that the delivered $O_2$ *concentration shall not decrease below 19% at the common gas outlet.*

- **Both the $O_2$ failure safety device and alarm depends on pressure and not flow.** They **aid in preventing hypoxia caused by problems occurring**

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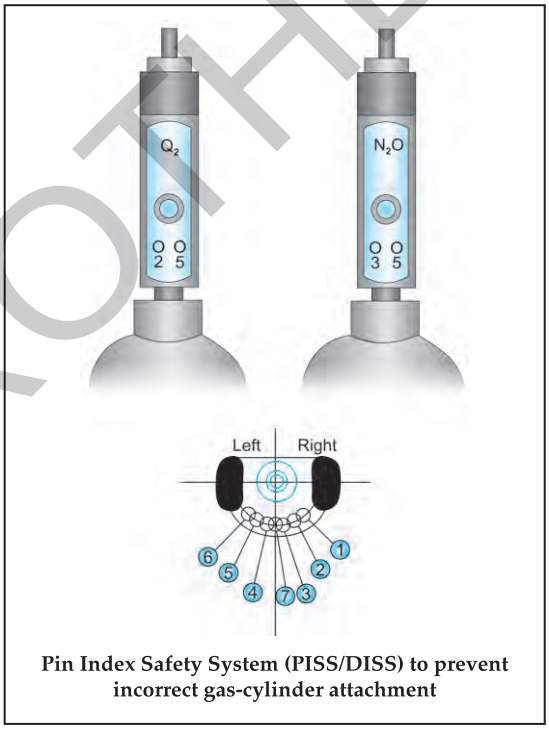
### Proportioning Safety Device

Most modern (Datex Ohmeda) machines use a *proportioning safety device* instead of threshold cutt off fail safe valve system. These devices *proportionately reduce the pressure of $N_2O$ & other gases except* air. Nitrous oxide & other gases are completely shut off only below a set minimum $O_2$ pressure (eg 0.5 psig for $N_2O$ & 10 psig for other gases).

**upstream in the machine circuits (disconnected $O_2$ hose, low $O_2$ pressure in pipeline,** and **depletion of $O_2$ cylinders).** These devices **do not offer total protection against a hypoxic mixture being delivered**, because they do not prevent anesthetic gas from flowing **if there is no flow of oxygen.**

## Pressure and Storage of Gases

- High pressure (H) gas cylinders are made up of ***steel alloy of molybdenum***Q **(molybdenum - steel) and gas pipes** are made of *seamless copper tubing*. **Height, size** and **volume** of cylinder increases from A onwards with **smallest available size AA and biggest H. So A<B<C<D<E<G<H<J**.
- E cylinders of $O_2$, $N_2O$ and air attach, directly to anesthesia machine.
- ***Nitrous oxide ($N_2O$), carbondioxide ($CO_2$) and cyclopropane are stored in liquid form***Q in equilibrium with saturated vapours, whereas, oxygen, nitrogen, helium, air, xenon, nitric oxide & carbon monooxide are stored as gases.
- **$N_2O$ can be kept in liquid form without refrigeration system, because its *critical temperature 36.5°C* is above room temperature (in cold countries).** Upto 80% of full $N_2O$ cylinder volume contains liquid. *Filling ratio* of $N_2O$ (i.e., ratio of weight of $N_2O$ to weight of water that would fill the cylinder) is *0.67 in tropical & 0.75 in temperature countries.*
- ***Pressue gauge of $N_2O$ cylinder should not exceed 745 psig at 20°C***Q. A higher reading implies gauge *malfunction*, tank over fill (liquid fill), ***or a cylinder containing a gas other than nitrous oxide***Q.
- If liquid $N_2O$ is kept at a constant temperature (20°C) it will vaporize at a same rate at which it is consumed & will maintain a constant pressure (745 psig) until the liquid is exhausted.
- Because energy is consumed in conversion of *liquid to gas, the liquid nitrous oxide cools.* And at high flow rates, pressure regulators may freeze
- *As oxygen is expanded, the cylinder's pressure falls in proportion to its content.*
- **$N_2O$ is neither flammable nor explosive, but supports combustion even in absence of $O_2$, if high temperature (> 450°C) is provided to initiate decomposition into $N_2$ & $O_2$**Q.




**Pin Index Safety System (PISS/DISS) to prevent incorrect gas-cylinder attachment**

### Coding of Gas Cylinders

| Gas | UK Code / Australian Code | | U S Code | Pin index position | Pressure at 15°C | |
|---|---|---|---|---|---|---|
| | **Body** | **Shoulder** | | | Ib $in^{-2}$ | Bar |
| **Oxygen** | Black | White | Green | **2, 5** | 1987 | 137 |
| **Nitrous oxide** | Blue | Blue | Blue | **3, 5** | ***638***Q | 44 |
| **$CO_2$** | Gray | Gray | Gray | 1, 6 | 725 | 50 |
| **Helium** | Brown | Brown | Brown | - | 1987 | 137 |
| **Air** | Grey | White / black quartered | Yellow | 1, 5 | 1987 | 137 |
| **$O_2$ /$CO_2$** | Black | White / grey quartered | - | $CO_2$ < 7.5% = 2,6<br>$CO_2$ > 7.5%=1,6 | 1987 | 137 |
| **$O_2$ / Helium** | Black | White /brown quartered | - | He > 80.5% = 4, 6<br>He < 80.5% = 2, 4 | 1987 | 137 |
| **$N_2O$ / $O_2$ (Entonox)** | Black | White / blue quartered | - | $N_2O$ 47.5-52.5% = 7 (single central) | 1987 | 137 |
| **$N_2$** | Black | Black | Black | 1, 4 | | |

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## Airway Management

**Total dead space (Physiological dead space) = Anatomical dead space + Alveolar dead space**

| Anatomical Dead Space is increased by | Anatomical Dead Space is decreased by | Alveolar Dead Space is increased by |
|---|---|---|
| - Old age<br>- *Standing (upright) posture*Q<br>- **Neck extension**Q<br>- Jaw protrusion<br>- *Bronchodilators anticholinergic e.g. (Atropine), halothane*Q<br>- *Increase lung volume*<br>- Anasthesia mask & Circuits<br>- IPPV (Intermittent positive pressure ventilation)<br>- **PEEP (Positive end expiratory pressure)**Q<br>- Pulmonary embolism, hypotension, *emphysema*Q | - *Supine position*Q<br>- *Neck flexion*Q<br>- *Artificial airways eg intubation*Q<br>- *Tracheostomy*Q<br>- Hyperventilation<br>- *Bronchoconstrictiors*Q<br>- *Massive pleural effusion*Q | - IPPV<br>- PEEP<br>- General anesthesia<br>- Hypotension<br>- Lung pathologies affecting diffusion membrane like interstitial lung disease, pulmonary embolism, pulmonary edema, ARDS. |

**Dead Space**

| Anatomical | Physiological |
|---|---|
| Area in the tracheobronchial tree where the gaseous exchange between the lung and capillaries is not possible. It starts from nasal cavity, includes larynx trachea, bronchi and end of terminal bronchiole | Space where gaseous exchange is occurring (alveoli) |

**Factors affecting Dead Space**

| Factor | Effect |
|---|---|
| **Posture**<br>*Upright*Q<br>*Supine*Q | ↑<br>↓ |
| **Position of airway**<br>*Neck extension*Q<br>*Neck flexion*Q | ↑<br>↓ |
| Age<br>Artificial airway | ↑<br>↓ |
| ***Positive pressure ventilation***Q<br>***Drug-anticholinergic***Q | ↑<br>↑ |
| Pulmonary perfusion<br>Pulmonary embolism<br>Hypotension | <br>↑<br>↑ |
| Pulmonary vascular disease<br>*Emphysema*Q | <br>↑ |

## Rebreathing System

**Rebreathing** system are systems, in which some gas is rebreathed by the patient were designed originally to economize in the use of cyclopropane. In addition, they *reduce the risk of atmospheric pollution* and *increase the humidity of inspired gases*, there by *reducing heat loss from patient*. They may be used as close systems in which fresh gas is introduce only to replace oxygen & anesthetic agents absorbed by the patient. More commonly, the system is used with a small leak through a spill valve, and fresh gas supply exceeds basal oxygen requirements. Because rebreathing occurs these systems *must incorporate a means of obsorbing $CO_2$ from exhaled alveolar gas*. Examples are – ***To and fro (Waters's / Mapleson C) system***Q ***and Circle system***Q.

### $CO_2$ Absorption

-
- Heat & humidity conserving rebreathing systems eliminate exhaled $CO_2$ by using $CO_2$ absorbent (eg. Soda / bara lime).
- *Hydroxide salts* of sodalime are *irritating to mucosa* & skin; thats why *adding silica increases hardness and minimizes the risk* of inhaling sodium hydroxide dust. As barium hydroxide (in baraline) incorporates water of crystalization in its structure, its sufficiently hard & safe without silica.
- Water is essential, as the chemical reaction only takes place in presence of water. So water is aded to both soda & bara lime to provide optional condition for carbonic acid formation. It is exothermic reaction resulting in drop of pH (d/t $CaCO_3$) and water formation. If sodalime canister is not felt warm it is not functioning)

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$CO_2 + 2NaOH \rightarrow Na_2CO_3 + H_2O$ (fast)
$Na_2CO_3 + Ca(OH)_2 \rightarrow 2NaOH + CaCO_3$ (slow). Note that initially required $H_2O$ & NaOH are regenerated.

- **Delayed induction or emergence** may occur as **dry *absorbent granules*** can absorb & latter release large amounts of volatile anesthetics
- The generated heat inside the sodaline can break ***trichloroethylene to dichloroacetylene, which is potent neurotoxin***Q. Sodalime may also decompose **sevoflurane**, so it is *not used for periods > 3 hours* in a closed system without flushing the system. If soda lime is allowed to dry (by leaving fresh gas flowing through canister), then its subsequent use ***with desflurane, isoflurane & enflurane***Q has been associated with carbon monoxide production (Clinical insignifcant). However ***dry barium hydroxide can cause clinically significant carbon monoxide poisoning***Q
- Efficiency of sodialime depends on its *physical structure* such as granule size. Too **large granules cause channeling** of gas so that it fails to come in contact with sodalime and results in **less absorpition** whereas, smaller granules provide high absorptive area but pack too tightly leading to excessive resistance to flow of gas. So **$CO_2$ absorption is:** →

| Increased by | Decreased by |
|---|---|
| - ***Resistance in circuit***Q | - ***High flow rate & tidal volume***Q |
| - ***Small granule size***Q | - ***Dead space***Q |
| - **Low flow rate**Q | - ***Channeling***Q |
| | - Too large granule size |

## Ambient $O_2$ Therapy Equipments

### High Flow/Fixed Performance Equipments

- $O_2$ is supplied at *predetermined rate* & at *fixed concentration*, inspite of patients respiratory, pattern (i.e. flow rate is not affected by respiratory pattern). This is achieved by delivering $O_2$ at a flow rate greater than the peak inspiratory flow rate. A flow of more than 20l/min. is adequate because a normal inspiratory flow rate is 20-30l/min for an adult. Because of high flow rate expired gases are rapidly flushed out and thus, there is no rebreatning & no increase in dead space.
- ***Venturi mask*** Q is ***colour coded*** and marked with *recommended oxygen flow rate*. ***Maximum $O_2$ that can be delivered by venturimask is 60%***Q. Indications of ventimask (fixed performance device) are Consistent $FiO_2$ & /or Large inspiratory flow of gas (>40l/min).

### Low flow or Variable Performance Equipments

- Provides a fraction of inspired $O_2$. Here the $FiO_2$, the patient is getting is uncertain. It is only used when it is not critical to deliver a fixed oxygen concentration.
- The final conc. of inspired $O_2$ depends upon *$O_2$ supply flow rate*, how *tight the mask* fits on the face, the *pattern of ventilation*, patients *inspiratory flow rate.*
- Low flow devices are ***nasal cannula (maximum $O_2$ delivered is 44%)***Q, ***Mary-carterall mask, nasal mask, oxygen tents***Q, simple mask, ***BLB Mask***, rebreathing & non rebreathing masks.

## Laryngeal Mask Airway (LMA)

1. It's a reusable (upto 40 times) *supra glottic airway device* providing ***an airway intermediate between the face-mask and tracheal tube in terms of anatomical position, invasiveness, security to protect the airway***Q, and facilitate gas exchange.
2. Also known as **Brain mask** (after the name of its inventor **Archies Brain**). It consists of 3 components: an inflatable mask, mask inflation line and airway tube. Mask is placed blindly in oropharynx and cuff is inflated until no air leak is detected. It is important to ensure that the *maximum inflation volume is not exceeded*. Cuffed mask is designated to fit closely over laryngeal aperture forming a *low pressure seal* around it. An ideally positioned cuff is boardered by the base of tongue (superiorly), pyriform sinus (laterally) and upper esophageal sphincter (inferiorly).

| Size | Length | Volume of cuff (mL) upto | Largest size tracheal tube that fits into LMA | Size of patient |
|---|---|---|---|---|
| **1** | 8 | 4 | 3.5 | ***Neonates & infants upto 6.5 kg***Q |
| 1.5 | 10 | 7 | 4 | Infants 5 – 10 kg |
| 2 | 11 | 10 | 4.5 | Infants & children 10-20 kg |
| 2.5 | 12.5 | 14 | 5 | Children 20–30 kg |
| **3** | 16 | 20 | 6 | ***Children & small adults 30 – 50 kg***Q |
| **4** | 16 | 30 | 6 | **Normal adults 50 – 70 kg**Q |
| 5 | 18 | 40 | 7 | Large adult > 70 kg |

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3. It is very effective in maintaining a patent airway in spontaneously breathing patient. Positive pressure ventilation may be applied if necessary. It is used ***in place of a face mask or ETT during administration of an anesthetic to facilitate ventilation & passage of ETT in a patient with difficult airway***Q and to aid in ventilation during fiberoptic bronchoscopy (FOB) as well as placement of bronchoscope.
4. LMA partially **protects the larynx from pharyngeal secretions but not gastric regurgitation.** The mask is **not suitable** for patients who are at *risk from regurgitation of gastric content (emergency surgery, hiatus hernia, or h/o reflux, and obesity).*
5. It is avoided in bronchospasm or high airway resistance (but not C/I)
6. It is available in ***7 different sizes***Q (i.e. 1, 1.5, 2, 2.5, 3, 4, 5). The **flexible LMA** differs from standard LMA in that it has a flexible wire reinforced tube available in sizes 2, 2.5, 3, 4, and 5. The size of the cuff is similar but the *tube is longer and narrower*; and therefore offering *more resistance* to breathing. Because of wire, it is unsuitable for MRI.
7. **Intubating LMA** is an advanced form with a *shorter tube* and a *metal handle* permitting *single handed insertion* without moving the head and neck and without placing fingers in the mouth. It is available in sizes *3, 4 and 5*; and may be passed through an interdental gap as narrow as *20 mm*. ***It allows a tracheal tube to be passed in order to intubate trachea***Q.
8. **LMA PRO-SEAL** is another advanced form of classic LMA that has a *double lumen*. The airway tube is wire reinforced to prevent collapse and has *built in bite block* (to reduce airway obstruction d/t bitting). The *drainage tube* passes lateral to the airway tube and allows passage of orogastric tube, drainage of gastric content and prevents gastric insufflation. The cuff allows a higher seal than classical LMA.

| Indications | Contraindications | Advantage |
|---|---|---|
| - ***To facilitate ventilation & passage of ETT in patient with a difficult airway***Q & to aid in ventilation during fiberoptic bronchoscopy as well as placement of bronchoscope<br>- ***Difficult airway management during cardiopulmonary resuscitation.***Q<br>- ***Difficult intubation***Q is anticipated<br>- In emergency where intubation & mask ventilation is not possible<br>- For minor surgeries, where anaesthetist wants to avoid intubation<br>- As a conduit for bronchoscopes, small size tubes, gum elastic bougies.<br>- For extra & intra-ocular surgeries including retinopathy surgery in ex-premature infants (better access the surgical field and does not affect the IOT)<br>- LMA have little effect on intraocular pressure. Therefore they may be useful for airway management of patient undergoing examination of eye under anesthesia : ***the absence of face mask may facilitate eye examination.***Q<br>- Mouth opening < 1.5 cm | • ***Oropharyngeal abscess or mass***Q<br>- **Conditions with high risk of aspiration eg full stomach,** Hiatus hernia, PregnancyQ<br>• ***Full stomach patients who are vulnerable to go in bronchospasm***Q<br>• Pharyngeal pathology (eg. abscess)<br>• Pharyngeal obstruction<br>• Low pulmonary compliance (eg. obesity)<br>• Peak inspiratory pressure > 20 cm of $H_2O$. | - Easy to insert<br>- ***Does not require any laryngoscope, visualization, & muscle relaxants***Q<br>- Does not require any specific position of cervical spine so *can be used in cervical injuries*<br>**Disadvantage**<br>- Does not prevent aspiration so should not be used for full stomach patients.<br>- High incidence of laryngospasm and bronchospasm. |

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# Endotracheal Intubation

## Process of Endotracheal Intubation

- Moderate head elevation and ***extension of atlanto occipital joint***[Q] places the patient in desired sniffing position. The ***lower portion of cervical spine is flexed***[Q] by resting the head on pillow.
- *Preoxygenation with 100% $O_2$* provides extra safety in difficult airways.
- The blade is intorduced into right side of oropharynx & tongue is swept to left
- ***The tip of curved blade is usually inserted into the vallecula while the straight blade tip covers the epiglottis***[Q]
- ***Trapping lip between teeth & blade and leverage on the teeth are avoided***[Q]
- The ETT *cuff* should lie in *upper tranchea but beyond the larynx*. The cuff is inflated with the *least amount of air necessary to create a seal* during positive pressure ventilation.

## Indications of Endotracheal Intubation

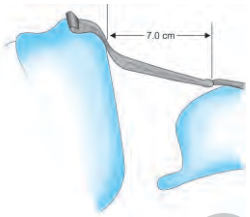
- ***To deliver positive pressure ventilation***[Q]
- Protection of the respiratory tract from aspiration of gastric contents
- Surgical procedures involving the head and neck or in non-supine positions that preclude manual airway support
- Almost all situations involving neuromuscular paralysis
- Surgical procedures involving the cranium, thorax, or abdomen
- Procedures that may involve intracranial hypertension
- ***To maintain patent airway***[Q]
- Profound disturbance in consciousness with the inability to protect the airway.
- ***Tracheobronchial toilet***[Q]
- Severe pulmonary or multisystem injury associated with respiratory failure, such as sepsis, airway obstruction, hypoxemia and hypercarbia.

## Difficult Airway

It means difficulty in tracheal intubation solely or problems with mask ventilation. Number of signs, scale & tests have been proposed and these are-

- ***Mallampati oropharyngeal Scale***[Q]
- **Patil Thyromental Distance Test**
  If it is < *7 cm* there is an increased likelihood of a difficult intubation.

chin
Thyroid




✶ The ***cricoid cartilage***[Q] is the narrowest point of airway in **children younger than 5 years of age**; in **adults**, the narrowest point is the ***glottis***[Q].

### Signs Of Difficult Laryngoscopy

| | |
|---|---|
| - **Micrognathia with acute mandibular angle** | 5 |
| - **Glossoptosis or Basal macroglossia** | 4 |
| - Difficulty with prior laryngoscopy | 3 |
| - Long, high arched palate with long, narrow dental arch | 2 |
| - **Temporomandibular joint limitation** | 4 |
| - Short muscular neck with full dentition | 2 |
| - Protuding maxillary dentition with premaxillary over growth | 2 |
| - Increased alveolomental depth | 1 |
| - **Limited extension of upper cervical vertebrae** | 2 |
| - **Limited motion of lower cervical vertebrae** | 3 |
| - Pathological signs of airway obstruction | 3 |
| - Decreased distance between hyoid & thyroid | 2 |
| - Decreased distance of epiglottis from posterior wall of pharynx | 3 |
| - **Miller sign** | 3 |
| - Skill of anesthesiologist, planning for endoscopy | 1-5 |

## Mallampati Oropharyngeal Scale

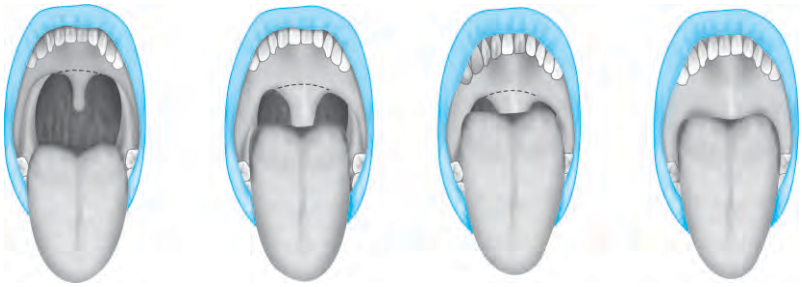
The view of posterior wall of pharynx, obtained after asking patient to open mouth widely and protuding the tongue, may be divided into *four grades of increasing difficulty in tracheal intubation.*

**Class I**
- ***Soft palate, uvula, faucial pillars & posterior pharngeal wall are visible***[Q]

**Class II**
- Lower part of faucial pillar & uvula masked by base of tongue
- Upper part of faucial pillars & soft palate are visible

**Class III**
- ***Only soft palate is visible***[Q]

**Class IV**
- All of these structures masked
- ***Only hard palate visible***[Q]



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## Nasal (Nasotracheal) Intubation (NTI)

Nasal intubation (ie placement of endotracheal tube through nose and nosopharynx) is necessary when oral route is not possible (eg limited mouth opening) or would impede surgical access (eg intraoral surgery). NTI was formely considered the **technique of choice for resuscitation**, but **orotracheal intubation using the rapid sequence technique** is now **usually the first choice. Rapid sequence induction (RSI)** is indicated when there is significant *risk of airway soiling from gastro-oesophageal* contents (eg pregnancy, intestinal obstruction, oesophageal dilatation, inadequate starvation, trauma, emergency). RSI involves *preoxygenation (at least 3 min or $E_TO_2$ > 90%), intravenous induction (thiopental and suxamethonium) and cricoid pressure.*

### Advantages and Disadvantages

- NTI tubes are longer and narrower than oral tracheal or tracheostomy tubes so the *airway resistance is greater and therapeutic aspiration of pulmonary secretions is more difficult.*
- NTI has been used in critical care as an alternative to tracheostomy because it is *better tolerated than oral intubation* (Miller 1586). NTI is less popular then formerly in ICU b/o increased recognition of the risk of sepsis from sinusitis (Aitkenhead 739).
- Both nasal & oral (translaryngeal) tracheal intubation are safe at least for 2-3 weeks. When compared with oral intubation;

**Benifits of nasal intubation are**

- ***Good oral hygiene***Q
- More comfortable for patient
- ***More secure (less extubation /displacement incidences)***Q
- *Less* likely to cause laryngeal damage

**Adverse events** associated with nasal intubation

- ***Significant mucosal damage & nasal bleeding***Q
- ***Transient bacteremia (infection)***Q
- Submucosal dissection of nasopharynx and oropharynx
- ***Sinusitis & otitis media***Q (d/t obstruction of auditory tubes)

- When used for more than 2 –3 weeks, both oral & nasal translaryngeal- tracheal tubes predispose to *subglottic stenosis*. So if longer periods (> 1 week for some institution) of mechanical ventilation is required, tracheostomy is performed (within first few days) and *cuffed tracheostomy* tube is used.

### Indications

- Obstructing mass in oral cavity
- Abscess in oral cavity
- Oral surgery
- ***Fracture mandible (no mouth opening)***Q
- TM joint dysfunction (inadequate mouth opening)
- Cervical spine injury
- ***Awake intubation***Q
- Tube is to be kept for long periods

### Contraindications

- ***Old or new base of skull (eg cribiform plate) fracture and surgery and severe mid facial trauma b/o risk of intracranial tube placement***Q.
- ***CSF rihnorrhea***Q may l/t cerebral infection
- Nasal trauma & abnormalities like polyp, abscess, foreign body.
- Adenoids
- Coagulopathy of bleeding disorder
- Previous nasal surgery is relative contraindication

### Blind Nasal Intubation

Nasal intubation may be accomplished under vision to guide the tube into larynx or by **blind technique** (BNI). Distance b/w nares and crania in adult men is 32 cm and women is 27 cm. It is done in

- Where laryngoscopy is not possible due to inadequate mouth opening, like in:
- ***Temporomandibular joint ankylosis***Q
- Trismus (d/t , tetanus, quinsy)
- Neck contracture

## Helium (He) and Heliox (He – $O_2$) Therapy

- **Helium (He)** isolated by Sir W. Ramsey is an ***inert (nobel), colorless, odourless gas with high diffusibility and low mass, density, solubility and density to viscosity ratio***Q. *Low solubility* of He enables it to be used in *measurement of lung volumes by gas dilution*. Whereas, *combination of high diffusibility and low solubility* make (He) *less* likely than nitrogen to be *responsible for decompression sickness*. Its high thermal capacity encourages loss of body heat.
- *Helium has a significantly lower density but a similar viscosity to air*. So He has *low Reynold's number* (b/o low density) and *significantly lower density /viscosity ratio*. Low Reynold's number (< 1000) is associated with laminar flow whereas high value (>1500) produces turbulent flow. Laminar flow normally occurs distal to small bronchioles (< 1mm). Flow in upper air way is usually turbulent. During **turbulent flow (i.e. in upper large airways)** airway resistance depends on **gas density** whereas, during **laminar flow** (i.e. in ***small distal airways)*** resistance depends on **gas viscosity**. So a **gas (He)** or a **gas mixture (Heliox)** with **low density** leads to a *dramatic decrease in airway resistance and turbulent in upper large airways*; *lower Reynold's number will encourage laminar flow in larger airways*; but because its *viscosity is very similar to air (He)/$O_2$ (heliox)* it will make *no difference to laminar flow in small airways*.
- **Heliox** is a ***mixture of helium with oxygen***Q in several blends (80-20% He to 20-80% $O_2$). However, most popular mixtures are *80%/20% and 70%/30% helium-oxygen*. However, the higher the concentration of helium in mixture, the *lower the $F_{IO2}$ (oxygenation)*. So heliox can be used in

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1) Patients with *acute distress (& stridor) from upper airway obstruction*.
2) *Pressure needed to ventilate patients with small diameter endo-tracheal tubes is substantially reduced* (halved with 80/20 He-$O_2$) in anesthesia.
3) ***Inspiratory driving pressure and work of breathing can be reduced***$^{Q}$.
4) May also be used as a *driving gas for small volume nebulizers* for bronchodilator therapy in asthma. However, the 80/20 heliox flow needs to be increased to 11 lit/min versus the usual 6-8 L/min with $O_2$.
5) *For deep sea diving (> 50 meters)*, nitrogen (air) should be avoided and replaced with a helium – oxygen mixture to reduce chances of decompression sickness. Whereas *risk of high pressure nervous syndrome (HPNS)*, at depths of > 500 m (very high pressure > 70 atmospheric) or during rapid compression (> 1m/min) is reduced by adding *low concentrations (5%) of nitrogen to heliox (trimixes)*.

- *At higher partial pressure* (produced by hyperbaric exposure *eg during hyperbaric $O_2$ therapy or underwater diving)* most inert gases *produce CNS depression (anesthetic potency)* which approximately follows their *lipid solubility*. **Increasing order of lipid solubility, anesthetic/narcotic potency and CNS depression** and **decreasing order of MAC** is: **He < Ne < H2 < N2 < Ar < Kr < Xe.** MAC is in reverse order except Kr > Ar. *At high partial pressures, the blood and tissue content of dissolved inert gas is also increased*, the magnitude of which depends upon the pressure, duration and solubility of gas. So less soluble gas like helium are less likely to produce decompression sickness. And similarly b/o very low solubility, He has such a low anesthetic potency (chances of CNS depression) that the pressure required to produce CNS depression exceeds those required to produce HPNS (i.e. CNS depression has not been observed).

## Ventilators Modes & Stettings

**Ventilators may cycle from inspiration (I) to expiration (E) after a fixed** (1) time (time cycled V); (2) **volume is delivered (volume cycled V);** (3) airway pressure is reached **(pressure cycled V)**; or (4) flow is reached usually 25% of initial peak flow rate **(flow cycled V)**

| Adult Ventilation | Paediatric Ventilation |
|---|---|
| - Tidal Volume = 100 ml to 2000 ml<br>- Inspiratory Flow Rate = ***6 lit/min to 120 L/min***$^{Q}$ | - Tidal Volume 20 ml to 300 ml<br>- Inspiratory Flow Rate = ***6 L/min to 30 L/min***$^{Q}$ |

**Ventilator Settings Principles** are as follows.

- Tidal volume and respiratory rate set the minute ventilation. Too high a volume risks overinflation; too low a volume allows for atelectasis. Too high a rate risks hyperventilation and respiratory alkalosis along with inadequate expiratory time and autoPEEP; too low a rate risks inadequate minute ventilation and respiratory acidosis. A tidal volume of 8 to 10 mL/kg ideal body weight is usually appropriate
- Level of negative pressure required to trigger the ventilator is **–2 cm $H_2O$**. Too high a setting (eg, more negative than –2 cm $H_2O$) causes weak patients to be unable to trigger a breath. Too low a setting may lead to overventilation by causing the machine to auto-cycle.
- The ratio of time spent in inhalation versus that spent in exhalation **(I:E ratio)** for patients with normal mechanics is **1:3**. Patients with asthma or COPD exacerbations should have ratios of 1:4 or even more to limit the degree of autoPEEP.
- Either the flow rate or the I:E ratio can be adjusted, not both. The inspiratory flow should generally be set at about **60 L/min but can be increased up to 120 L/min** for patients with airflow limitation to facilitate having more time in exhalation, thereby limiting autoPEEP.
- $FIO_2$ is initially set at **1.0** and is subsequently decreased to the lowest level necessary to maintain adequate oxygenation.

### Positive Airway Pressure Therapy (PEEP & CPAP)

Positive airway pressure therapy can be used in patients breathing spontaneously as well as those mechanically ventilated. The principal indication for PAPT is a **symptomatic decrease in FRC**, resulting in *absolute or relative hypoxemia*. By increasing transpulmonary distending prerssure, PAPT can *increase FRC and lung compliance*, and reverse V/P mismatching (reflected as decreased venous admixture & improved arterial $O_2$ tension).

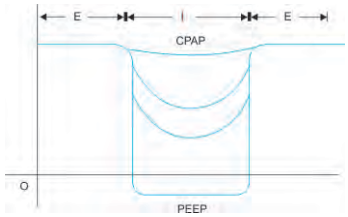
### Continuous Positive Airway Pressure (CPAP)

A constant level of positive pressure applied to a spontaneous breathing cycle is named CPAP. It is **indicated** in.

| Clinical Presentation | Conditions responsive to CPAP (with ≥1clinical presentations) |
|---|---|
| - On **examination –** the presence of increased work of breathing (i.e. **respiratory distress)** as indicated by increase in | - ***Very preterm infants***$^{Q}$ (born at < 28 weeks |

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When *positive pressure* is applied *during expiration* as an adjunct to a mechanically delivered breath (that allows expiratory flow to occur only when airway pressure exceeds or equals the PEEP level), the therapy is referred to as **positive end-expiratory pressure** & while, *positive pressure* is applied *during both inspiration & expiration* during spontaneous breathing therapy is k/a **continuous positive airway pressure.**




So pure PEEP is a ventilator cycled breath, while CPAP provides only sufficient continuous or on demand gas flows **(60-90 L/min)** to prevent inspiratory pressure from falling below the expiratory level during spontaneous breaths. ***By increasing inspiratory gas flow, PEEP progressively becomes CPAP.***Q

**Pulmonary Effects**

- ***Useful in situations where $PO_2$ is low***Q
- ***Increase FRC, tidal ventilation, compliance***Q
- Correct ventilation-perfusion abnormalities
- ***Improve arterial oxygenation***Q by decreasing intrapulmonary shunting, reexpanding functionally collapsed alveoli, redistributing lung water, & thereby reducing V/Q mismatch
- Side effects due to excessive PEEP/CPAP l/t over distension of alveoli & bronchi
- **Alkalosis**Q d/t $CO_2$ washout.
- **Increase dead space** because gas flows to more compliant, non dependent areas & blood flows to dependent areas.
- ***Decrease lung compliance***Q
- Increase in pulmonary vascular resistance & right ventricular after load
- ***Barotrauma (Pneumothorax, Pneumopericardium, Pneumoperitoneum, Subcutaneous emphysema)***Q***, pulmonary air embolism***Q.

**Extra pulmonary effects**

- ***Decrease cardiac output***Q (due to rise in mean airway pressure & intrathoracic pressure l/t ↓ venous return.
- ***Decrease in hepatic & renal blood flow***Q (due to decrease in CO & increase in central venous pressure)
- ***GFR, urinary output, free water clearance decreases & ADH and angiotensin levels are increased (i.e. renal functions are impaired***Q.
- ***Raised ICT***Q

E = Expiration &
I = Inspiration

respiratory rate >30% of normal, grunting, nasal flaring, and suprasternal & substernal retractions; the presence of pale or cyanotic skin colour, and agitation
- **On chest x-ray** presence of poorly expanded &/or infiltrated lung fields.
- Inadequate **arterial blood gas** values i.e **inability to maintain $PaO_2$ >50 mmHg** with

1. $FiO_2 \leq 0.60$ (provided $V_E$ is adequate as indicated by a $PaCO_2$ 50 mmHg & a pH ≥ 7.25) i.e. patient is breathing 60% of oxygen in moderate to severe respiratory distress or recurrent apnea
2. $FiO_2$ of 0.40 in newborns with RDS

## Guidelines for CPAP use

**Start at pressure of 5 cm of $H_2O$ and $FiO_2$ of 40-50%**Q

↓ No improvement Worsening

Pressure is increased by 1 – 2 cm $H_2O$ to maximum of 8-12 cm of water.

↓ Still impaired oxygenation

**Increase $FiO_2$ by 5% to maximum of 80%**Q

gestation age, weight **<1kg**) = nasal CPAP + surfactant therapy.
- **Apnea of prematurity** (prolonged & recurrent attacks)
- ***Respiratory distress syndrome***Q (in both term and preterm infants)
- **Weaning of chronically ventilator dependent infants.**
- Recent extubation (following mechan-ical ventilation)
- Post operative thoracotomy care
- Conditions associated with atelactasis, decreased functional residual capacity, right to left shunts, V/Q mismatch, alveolar edema and airway instability
- Atelactasis & one lung ventilation
- Pulmonary edema
- Tracheal malacia or other similar abnormalities of lower airway
- *Sleep apnea*
- For administration of NO in spontaneously breathing infants

## Devices providing CPAP

Nasal prong (6–15mm)
Nasopharyngeal CPAP (40-90 mm)
Endotracheal tube CPAP

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# Monitoring of Patient

## BIS/Bispectral Index

- ***Bispectral imaging analyses EEG* data and quantitates anesthetic effects on the brain, specifically the *hypnotic component*.** It is a *composite numerical index*, which represents a dimensionless numerical value that has been correlated with the patient's current hypnotic state or depth of anaesthesia and provides some assurance that paralyzed (anesthetized) patient is also asleep (unaware).
- BIS analysis may *reduce chances of patient awareness during anesthesia*. It may *also reduce resource utilization* because less drug is required to ensure amnesia, facilitating a faster wake up time and a shorter stay in recovery room. The **BIS number** decreases with increasing hypnosis.
- To perform BIS, data measured by EEG are taken through a number of steps. BIS estimates *phase coupling* between different frequency components in EEF signal. The BIS is derived from complex EEG analysis incorporating weighted information derived from the **degree of burst suppression, spectral (β band) power and the bispectrum coherance**. To make the EEG signals easier to interpret it uses 2 principles which are, which are, **spectral analysis (power)** (ie any complex wave may broken down into a series of sine waves) and **fast fourier analysis** (ie an analysis in terms of proportion of each frequency that contributes to total signal). BIS analysis uses the phase and power of different frequencies within the original signal.
- BIS identifies EEG patterns with 30 second periods, by first *excluding (filtering)* episodes likely to be produced by *artifact (diathermy or muscle activity)* and periods of burst suppression (burst suppression ratio and QUAZI). The remaining activity is subjected to bispectral analysis with the final result adjusted to take account of the proportion of suppressed EEG.

| BIS | Awareness level and Depth of anesthesia |
|---|---|
| 100 | **Awake** (memory intact, respond to verbal command) |
| 85-65 | **Sedation** |
| 65-40 | **General anesthesia** (no awareness, deep hypnosis, memory function lost) |
| <40 | Cortical suppression becomes discernible, increasing burst suppression |
| 0 | **Cortical silence (isoelectric), deeply anesthetised** |

- Although it is FDA approved for assessing the depth of anesthesia in paediatric and adult patients, it has not yet become a standard monitor *b/o high cost and inaccuracy*. BIS values had *better response with hypnotic drugs (eg isoflurane, propofol) than with opiates*. BIS values *decrease in patients receiving NM blocker*, while fully conscious. BIS value remains *unchanged or even elevated during $N_2O$ anesthesia*, and elevated during IV ketamine (both acting through NMDA glutamate receptor).

## ☆ Assessing Consciousness Intraoperative

1. **Bispectral index (BIS) analysis**
2. **Narcotrend monitor** (Monitor Technik)
3. **Patient state index (PSI, Physiometrix)** is based on quantitative EEG signal relationship b/w frontal and occipital brain regions
4. **Entropy monitors** measure *state entropy* (response over the rangeof 0.8 – 32 Hz, reflecting EEG dominant spectrum and *response entropy* (response over range of 0.8 – 47 Hz, reflecting both EEG and EMG spectra)
5. **Stimulus – response technique of auditory evoked potential.**

# Neurophysiological Monitoring

## Electroencephalography (EEG)

- EEG are most useful for **assessing the adequacy of *cerebral perfusion* during *carotid endarterectomy (CEA) & controlled hypoventilation* and for *assessing anesthetic depth*Q.**
- EEG activation (i.e. predominantly *high frequency & low voltage* activity) is seen with *light anesthesia*, and surgical stimulation, whereas EEG depression (i.e. predominantly *low frequency & high voltage activity*) occurs with *deep anesthesia or cerebral compromise*. Most anesthetics produce a **biphasic pattern** consisting of an *initial activation* (at subanesthetic low doses) *f/b dose dependent depression*.
- IV agents: Opioids produce monophasic, dose dependent depression whereas ketamine produces unusual activation consisting of rhythmic high amplitude theta activity f/b very high

## Evoked Potentials (EP)

- **Somatosensory evoked potentials (SSEPs)** test the integrity of *dorsal spinal column & sensory cortex* and may be useful during spinal tumor resection, spine instrumentation, CEA & aortic surgery. Adequacy of spinal cord perfusion is better assessed by *motor evoked potential*.
- **Brain stem auditory evoked potential or response (BAER)** test the integrity of 8th cranial nerve and auditory pathways above pons & are used for surgery in posterior fossa. **Visual evoked response (VER)**

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