Life Saving Anaesthetic Skills for Emergency Obstetric Care

Training Programme for MBBS Doctors
Under the RCH Programme, a number of initiatives have been taken to strengthen Emergency Obstetric Care services at the first referral units. Emergency Obstetric Care drug kits are being supplied to selected first referral units. The Drug and Cosmetics Act has been amended and it has now become possible to provide storage facilities for blood at first referral units. A scheme for engaging Anesthetists from private sector has also been in operation. However, due to acute shortage of anesthetists in sub-district areas, it has not been possible to get their services. The States were also offered financial and technical assistance in case they would choose to increase the number of seats in Anesthesia at Diploma level in their Medical Colleges and depute the Medical Officers of State Health Services for such training with provision that after training the Medical Officer would serve in the State for some years. However, this scheme has not been taken up by any State for a number of reasons.

After detailed deliberations with experts in Anesthesia, Obst. & Gynae, Medical specialists, public health experts and legal councils on Consumer Protection Act and taking into account the experience of other countries, it was felt that it would be desirable to institute a training programme of appropriate duration to train MBBS doctors in Life Saving Anesthesia skills for emergency obstetric care.

A core group of experts was constituted under the chairmanship of Dr. Ravi Saksena, Professor of Anesthesia and Head of Casualty, Emergency Medicine and Trauma Centre, All India Institute of Medical Sciences, New Delhi with Dr. V.K. Manchanda, Deputy Director General (Maternal Health/Training) as Convenor, in order to draw up the curriculum, prepare the training material and finalise other requirements of the training programme.

I am happy to note that, the training material has since been prepared and the first training programme of 18 weeks is being held at the All India Institute of Medical Sciences, The programme
focuses primarily on skill development leading to competencies for anesthesia management of Obstetrical emergencies in first referral unit settings. After the completion of the first training programme, it would be extended to other Medical Colleges in the States where there is adequate case-load.

I would like to acknowledge here, the efforts put in by Dr. Ravi Saksena and other members of the core group and also thank the Director, All India Institute of Medical Sciences for agreeing to host the training programme in the Institute.

New Delhi
10th March, 2003

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Module-X  Neonatal and adult resuscitation  
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Module-XI  Ethical and legal issues and consumer protection  
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Log book for trainees & guidelines for trainers  
(Dr. A.K. Sood, National Institute of Health & Family Welfare, New Delhi)
## CONTENTS

<table>
<thead>
<tr>
<th>Module-I</th>
<th>Anatomy as relevant to anesthesia for emergency obstetric care</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module-II</td>
<td>Physiological changes during pregnancy as relevant to anesthesiologist</td>
<td>15</td>
</tr>
<tr>
<td>Module-III</td>
<td>Pharmacology</td>
<td>45</td>
</tr>
<tr>
<td>Module-IV</td>
<td>Anesthesia machine</td>
<td>77</td>
</tr>
<tr>
<td>Module-V</td>
<td>Patient preparation, pre-medication and theatre preparation</td>
<td>101</td>
</tr>
<tr>
<td>Module-VI</td>
<td>General and regional anesthesia</td>
<td>113</td>
</tr>
<tr>
<td>Module-VII</td>
<td>The parturient with systemic disease</td>
<td>139</td>
</tr>
<tr>
<td>Module-VIII</td>
<td>Trauma and pregnancy</td>
<td>169</td>
</tr>
<tr>
<td>Module-IX</td>
<td>Difficult air way in obstetrics</td>
<td>183</td>
</tr>
<tr>
<td>Module-X</td>
<td>Neonatal and adult resuscitation</td>
<td>205</td>
</tr>
<tr>
<td>Module-XI</td>
<td>Ethical and legal issues and consumer protection</td>
<td>229</td>
</tr>
</tbody>
</table>
LIFE SAVING ANAESTHETIC
SKILLS FOR EMERGENCY
OBSTETRIC CARE

Training Programme
for
MBBS Doctors
Module - I
Anatomy as Relevant to Anaesthesia for Emergency Obstetric Care
<table>
<thead>
<tr>
<th>1.1 Introduction</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 Objectives</td>
<td>5</td>
</tr>
<tr>
<td>1.3 Contents</td>
<td></td>
</tr>
<tr>
<td>1.3.1 Anatomy of larynx</td>
<td>5</td>
</tr>
<tr>
<td>1.3.2 Airway assessment by physical examination</td>
<td>6</td>
</tr>
<tr>
<td>1.3.3 Changes in the respiratory system during pregnancy</td>
<td>8</td>
</tr>
<tr>
<td>1.3.4 Anatomy for spinal anaesthesia</td>
<td>9</td>
</tr>
<tr>
<td>1.3.5 Anatomy of epidural space</td>
<td>12</td>
</tr>
<tr>
<td>1.4 Salient points to remember</td>
<td>12</td>
</tr>
<tr>
<td>1.5 Check your progress</td>
<td>13</td>
</tr>
<tr>
<td>1.6 Further readings</td>
<td>13</td>
</tr>
</tbody>
</table>
1.1 Introduction
We will discuss in this module anatomy as relevant in context of your role as the anesthesia care provider in emergency obstetric situations. It gives an overall idea about certain anatomical facts, which you should have at the back of your mind while proceeding to provide anesthesia. Do keep any standard textbook of anatomy for ready reference.

1.2 Objectives
After going through this module you should be able to:
- Describe anatomy of upper airway and spine.
- The knowledge while performing endotracheal intubation, spinal and epidural blocks.
- Discuss how to reassess and retry if encountering difficulty during the above procedures.
- To describe the anatomical differences between pregnant and non-pregnant patient.

1.3 Contents
1.3.1 Anatomy of larynx
The larynx, also known as the voice box, routes the food and air to their proper destination. The larynx is made up of eight hyaline cartilages and a flap of elastic cartilage, the epiglottis. The epiglottis’ job is to prevent food from entering the upper opening of the larynx, and traveling down the trachea. Breathing opens the epiglottis and allows free passage of air to the lungs. The larynx is pulled in an upward direction while swallowing, causing the epiglottis to “tip” and close over the opening of the larynx. When the epiglottis is closed, it directs food to be pushed down the esophagus. If something besides air enters the larynx, a cough occurs. A coughs’ purpose is to repel any foreign substance, besides air, from entering the trachea. The mucous membrane of the larynx forms the vocal folds. The vocal folds vibrate by the expelled air. This vibration allows human’s the ability of speech. The glottis is the thin passageway between the vocal folds. The largest of the hyaline cartilages is the thyroid cartilage. The thyroid cartilage, also called the Adams apple, protrudes anteriorly. Larynx’s vertical extent corresponds to the fourth and sixth cervical vertebrae, but it is placed somewhat higher in the females and also during childhood.

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>44 mm.</td>
<td>36 mm.</td>
</tr>
<tr>
<td>Transverse diameter</td>
<td>43 mm.</td>
<td>41 mm.</td>
</tr>
<tr>
<td>Antero-posterior diameter</td>
<td>36 mm.</td>
<td>26 mm.</td>
</tr>
<tr>
<td>Circumference</td>
<td>136 mm.</td>
<td>112 mm.</td>
</tr>
</tbody>
</table>
Innervation

The sensory innervation of the airway is divided among three areas:

- The nose and nasopharynx are innervated by maxillary branches of the trigeminal nerve.
- The posterior one third of the tongue and oropharynx are innervated by branches of the glossopharyngeal nerve. This nerve exits the skull through the jugular foramen and travels in the carotid sheath.
- The larynx and trachea are innervated by branches of the vagus nerve. The superior laryngeal nerve carries sensation from the base of the tongue and the inferior epiglottis to the vocal cords. The recurrent laryngeal nerve carries sensation distal to the vocal cords.
- The superior laryngeal nerve travels inferior to the greater cornu of the hyoid bone and divides into internal and external branches. The internal branch pierces the thyrohyoid membrane with laryngeal branch of the superior thyroid artery. The muscles of the larynx are supplied by branches of the vagus nerve. The cricothyroid muscle is supplied by the external branch of the superior laryngeal nerve. All of the other intrinsic muscles of the larynx are supplied by the inferior laryngeal nerve, a continuation of the recurrent laryngeal nerve.

1.3.2 Airway assessment by physical examination:

Oral Cavity

- **Mouth opening:** note symmetry and extent of opening (3 finger breadths optimal).
- **Dentition:** ascertain the presence of loose, cracked, or missing teeth, dental prostheses and co-existing dental abnormalities.
- **Macroglossia:** will increase difficulty of intubation.

Neck

- **Anterior mandibular space:** evaluated by asking the supine patient to maximally extend the head and measuring the distance between the hyoid bone and the inside of the mentum or between
the notch of the thyroid cartilage to the mentum. An inadequate mandibular space is associated with a hyomental distance of 6cm or a thyromental distance of 6.5cm.

- **Cervical spine mobility** (Atlantooccipital joint extension): $80^\circ$ extension is normal at the atlantooccipital joint. Decreases in extension are associated with increased difficulty of intubation. Evaluate for presence of a healed or patent tracheostomy stoma, prior surgeries or pathology of the head and neck (laryngeal cancer).

### Predictors of difficult intubation

#### Anatomic variations

Micrognathia, prognathism, large tongue, arched palate, short neck, prominent upper incisors, buckteeth, decreased jaw movement, receding mandible or anterior larynx, short stout neck.

#### Mallampati classification

The Mallampati classification relates tongue size to pharyngeal cavity. Test is performed with the patient in the sitting position, the head held in a neutral position, the mouth wide open, and the tongue protruding to the maximum. The subsequent classification is assigned based upon the pharyngeal structures that are visible.

**Mallampati classification (classification of tongue size vs pharynx)**

- **Class 1**: able to visualize the soft palate, fauces, uvula, anterior and posterior tonsillar pillars.
- **Class 2**: able to visualize the soft palate, fauces and uvula. *The anterior and posterior tonsillar pillars are hidden by the tongue.*
- **Class 3**: only the soft palate and base of uvula are visible
- **Class 4**: only the soft palate can be seen (no uvula seen)

The classification assigned by the clinician may vary if the patient is in the supine position instead of sitting. If the patients phonate, this falsely improves the view. If the patient arches his or her tongue, the uvula is falsely obscured. A class 1 view suggests ease of intubation and correlates with a laryngoscopscopic view grade-1 in 99 to 100% of the cases. Beware of the intermediate classes, which may result in all degrees of difficulty in laryngoscoposcopic visualization.
Grades of laryngoscopic view

- Grade 1: full view of the entire glottic opening.
- Grade 2: posterior portion of the glottic opening is visible.
- Grade 3: only tip of epiglottis is visible.
- Grade 4: only soft palate is visible (no part of glottis or epiglottis visible)

Grade II or III laryngoscopic views are relatively common and occur in 1% to 18% of surgical patients. The Grade III view occurs in about 1-4% of patients. A severe grade III or grade IV view with failed endotracheal intubation occurs in 0.05 of 0.35% of patients. It may be helpful for the subsequent anesthesiologist if you record the grade of laryngoscopic view achieved along with the patient position and the technique used.

1.3.3 Changes in the respiratory system during pregnancy

Hormonal changes to the mucosal vasculature of the respiratory tract lead to capillary engorgement and swelling of the lining in the nose, oropharynx, larynx, and trachea. Symptoms of nasal congestion, voice change and upper respiratory tract infection may prevail throughout
gestation. These symptoms can be exacerbated by fluid overload or oedema associated with pregnancy induced hypertension (PIH) or pre-eclampsia. In such cases, manipulation of the airway can result in profuse bleeding from the nose or oropharynx: endotracheal intubation can be difficult: and only a smaller than usual endotracheal tube may fit through the larynx. Airway resistance is reduced; probably due to the progesterone mediated relaxation of the bronchial musculature. So the pregnant airway is different from normal airway.

Suctioning of oropharynx, insertion of airways, and laryngoscopy may further lead to edema and bleeding. The false cords may be swollen; hence a small cuffed endotracheal tube (6.5-7.0mm) is recommended for use when trachea is intubated. Repeated attempts at laryngoscopy during management of a difficult airway must be minimized to prevent occurrence of airway edema.

The problem of difficult laryngoscopy is often encountered at intubation. This is largely due to the engorged breast that makes the insertion of handle of laryngoscope difficult. This can be solved by using a shorter handle, inserting the blade first and then attaching the handle, using a pillow under the shoulder, and in some cases by separating the breast laterally by using adhesive tapes.

### 1.3.4 Anatomy for spinal anaesthesia

The spinal cord usually ends at the level of L.2 in adults and L.3 in children. Dural puncture above these levels is associated with a slight risk of damaging the spinal cord and is best avoided. An important landmark to remember is that a line joining the top of the iliac crests is at L4 spine or L4/5 space. Remember the structures that the needle will pierce before reaching the CSF.

**The skin:** It is wise to inject a small dose of local anesthetic intradermally before inserting the spinal needle.

**Subcutaneous fat:** This is of variable thickness. Identifying the intervertebral spaces is far easier in thin patients.

**Supraspinous ligament:** Joins the tips of the spinous processes together.

**Interspinous ligament:** Is a thin flat band of ligament running between the spinous processes.

**Ligamentum flavum:** Is quite thick, up to about 1cm in the midline and is mostly composed of elastic tissue. It runs vertically from lamina to lamina. When the needle is within this ligament it
will feel gripped and a distinct “give” can often be felt as it passes through this into the epidural space. The epidural space contains fat and blood vessels. If blood comes out of the spinal needle instead of CSF when the stylet is removed, it is likely that an epidural vein has been punctured. The needle should simply be advanced a little further. A similar ‘give’ may be felt when the needle is advanced a short distance further and pierces the dural sac.

*Subarachnoid space:* This contains the spinal cord and nerve roots surrounded by CSF. An injection of local anesthetic will mix with the CSF and rapidly block the nerve roots with which it comes in contact.
Positioning the patient for lumbar puncture

Lumbar puncture is most easily performed when there is maximum flexion of the lumbar spine. This can best be achieved by sitting on the operating table and keeping the feet on a stool. The patients then rest their forearms on their thighs, they can maintain a stable and comfortable position. Alternatively, the procedure can be performed with the patient lying on their side with their hips and knees maximally flexed. An assistant may help to maintain the patient in a comfortable curled position. The sitting position is preferable in the obese whereas the lateral is
better for uncooperative or sedated patients. The anesthetist can either sit or kneel whilst performing the block.

1.3.5 Anatomy of the epidural space

The epidural space is that part of the vertebral canal not occupied by the duramater and its contents. It is a potential space that lies between the dura and the periosteum lining the inside of the vertebral canal. It extends from the foramen magnum to the sacral hiatus. The anterior and posterior nerve roots in their dural covering pass across this potential space to unite in the inter-vertebral foramen to form segmental nerves. The anterior border consists of the posterior longitudinal ligament covering the vertebral bodies, and the inter-vertebral discs. Laterally, the epidural space is bordered by the periosteum of the vertebral pedicles, and the inter-vertebral foraminae. Posteriorly, the bordering stuctures are the periosteum of the anterior surface of the laminae and articular processes and their connecting ligaments and the inter-laminar spaces filled by the ligamentum flavum. The space contains venous plexuses and fatty tissue, which is continuous with fat in the para-vertebral space.

1.4 Salient points to remember

- Position for intubation is extension at atlanto-occipital joint and flexion of cervical spine.
- Pre-operative airway assessment is essential
- In pregnancy, you are likely to encounter an edematous airway, especially in presence of pregnancy induced hypertension use smaller tube.
- It is safe to give a spinal or epidural below L2 level, L2-L3 space or L3-L4 space.
- Due to vena caval compression by the gravid uterus, there is distension of the epidural venous plexus, increasing the chances of intravascular injection while attempting an epidural injection.

1.5 Check your progress

i. What is the nerve supply of larynx?

ii. Pregnant airway is more vascular than the normal airway. True/False

iii. The toughest structure you encounter in giving spinal is
   a) skin b) duramater c) ligamentum flavum d) supra spinous ligament

iv. The extent of epidural space is from foremen magnum to____

v. The Mallampati classification is done while a) the patient lies down – T/F, b) the patient protrudes the tongue – T/F

1.6 Further readings

- Snell’s clinical anatomy

- Essential anatomy for anesthesia by Sue M. Black
Module - X
Neonatal Resuscitation and Cardio-pulmonary Resuscitation in Adult
Module Structure

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1</td>
<td>Introduction</td>
<td>209</td>
</tr>
<tr>
<td>10.2</td>
<td>Objectives</td>
<td>209</td>
</tr>
<tr>
<td>10.3</td>
<td>Contents</td>
<td></td>
</tr>
<tr>
<td>10.3.1</td>
<td>Pathophysiology of Asphyxia</td>
<td>209</td>
</tr>
<tr>
<td>10.3.2</td>
<td>Resuscitation</td>
<td>212</td>
</tr>
<tr>
<td>10.3.3</td>
<td>Cardio-pulmonary resuscitation adults</td>
<td>216</td>
</tr>
<tr>
<td>10.4</td>
<td>Salient points to remember</td>
<td>225</td>
</tr>
<tr>
<td>10.5</td>
<td>Check your progress</td>
<td>225</td>
</tr>
<tr>
<td>10.6</td>
<td>Further readings</td>
<td>227</td>
</tr>
</tbody>
</table>
10.1 Introduction

The Latin word “Resuscitate” means to arouse again. Every new born has a right to have proper resuscitation performed because the management in the first few minutes of life can have consequences over an entire life time, directly affecting the quality of the individual’s life.

The circumstances in which you people will be working will have more number of asphyxiated infants. Anticipation is the key to good care. Most episodes of newborn asphyxia can be anticipated but surprises are not uncommon. In spite of being at risk for asphyxia, infants will do well following delivery and require no resuscitative assistance. We will briefly discuss the causes of asphyxia, its pathophysiology and management.

10.2 Objectives

After going through the module the trainees should be able to

- Describe how to diagnose at the earliest an asphyxiated infant- APGAR Score
- Describe steps for immediate resuscitative measures to minimize the damage
- Describe what further consultations are required
- Describe steps in diagnosis and management of cardiopulmonary resuscitation in adult

10.3 Contents

10.3.1. Pathophysiology of asphyxia

The predominant changes with asphyxia are

- Hypoxemia
- Hypercarbia
- Secondary metabolic acidosis

Asphyxia is a progressive process that is potentially reversible in the early stages, however, once the asphyxia progresses to a very severe stage spontaneous corrective reversal is unlikely because of the circulatory and neurological changes that accompany it.

Causes of Asphyxia

Basic causes of asphyxia during labor and delivery are

- Interruption of umbilical blood flow (e.g., cord compression).
- Failure of gas exchange across the placenta (e.g., placental abruption)
- Inadequate perfusion of the maternal side of the placenta (e.g., severe maternal hypertension)
- An otherwise compromised fetus who cannot further tolerate the transient, intermittent hypoxia of normal labor (e.g., the anaemic or growth-retarded fetus)
- Failure to inflate the lungs and complete the change in ventilation and lung perfusion that must occur at birth.

**Biochemical and hormonal changes in asphyxia**

- Metabolic acidosis suggests asphyxia; although some of the increased lactic acid in blood may be due to reduced uptake by the asphyxiated liver
- Increased Plasma hypoxanthine due to lack of aerobic metabolism
- Increased Plasma erythropoietin in response to hypoxia
- Elevation of plasma corticotrophin, glucocorticoids, catecholamines, arginine vasopressin, renin and atrial natriuretic factors
- Decreased insulin levels
- Increased catecholamines serve to maintain myocardial function in spite of asphyxia, thereby increasing survival
- Hepatic glycogenolysis helps maintain plasma glucose level
- The physiology of resuscitation is essentially a reversal of the pathophysiology of asphyxia.

**Primary apnoea**

When a fetus or infant is deprived of oxygen, an initial period of rapid breathing occurs. If the asphyxia continues, the respiratory movement ceases, the heart rate begins to fall, and the infant enters a period of apnoea known as primary apnoea. Exposure to oxygen and stimulation during this period in most instances will induce respiration.

**Secondary apnoea**

If the asphyxia continues, the infant develops deep gasping respiration, the heart rate continues to increase and the blood pressure begins to fall. The respiration become weaker and weaker until the infant takes a last gasp and enters a period of apnoea called secondary apnoea.
During secondary apnoea, heart rate, blood pressure and PaO2 continue to fall further. The infant then become unresponsive to stimulation and artificial ventilation with oxygen must be initiated immediately. In practice primary and secondary apnoea are indistinguishable as the infant may go through both the phases while in utero as a result of fetal hypoxia. A newborn infant in primary apnoea will re-establish a breathing pattern (although irregular and possibly ineffective) without intervention. An infant in secondary apnoea will not resume breathing of his/her own accord.

**Initiation of respiration**

The most important adaptation that occurs at birth is the entry of air into previously fluid filled lungs and the transfer within seconds of primary gas exchange site from placenta to lung. In normal delivery human fetus goes through a period of transient hypoxemia, hypercapnia and acidemia. To inhale air into the fluid-filled lungs, the newborn baby must overcome large surface forces with the first few breaths. Usually pressure of 15-25 cm of water is necessary to introduce air into lungs but even in some normal infants a force as much as 70 cm of water must be exerted.

About one-third of fetal lung fluid is removed during vaginal delivery, as the chest is squeezed and lining fluid exits through the nose and mouth (the ‘vaginal squeeze’). The remaining fluid in the alveoli is absorbed by lymphatics. When an infant has never taken an initial breath, the lungs remain filled with fluid and an additional pressure is often required to expand the alveoli and clear the fluid.

**Mechanism of establishment of continuous neonatal breathing**

- The onset of breathing activities occurs in-utero, as a part of normal fetal development.
- Clamping of umbilical cord initiates rhythmic breathing.
- Relative hyperoxia with air breathing compared to low fetal PaO2 augments and maintains the rhythmic breathing.
- Continuous breathing is independent of the level PaCO2.
- Breathing is unaffected by carotid denervation.
- Hypoxia depresses or abolishes continuous breathing.

**Changes in pulmonary circulation**

Asphyxia results in low oxygen content of blood resulting in a fall in pH. In the presence of these
factors the arterioles of the newborn lungs remain constricted and the ductus remains open. Fetal circulation is maintained with no increase in pulmonary perfusion. In the fetus, gas exchange occurs at the placenta. The transition from intrauterine to extrauterine life requires the successful management of a series of well-synchronized cardio-pulmonary manoeuvres.

The placenta separates with clamping of the umbilical cord, ventilation and pulmonary blood flow begins, then circulation changes from parallel to a series system, intra-cardiac and extra-cardiac shunts close. Pulmonary vascular resistance falls drastically, increasing the pulmonary blood flow leading to rise in the left atrial pressure and the closure of the foramen ovale. Functional closure of the ductus arteriosus occurs with the removal of the placenta and a consequent decrease in the levels of circulating prostaglandins and increasing PaO2.

10.3.2 Resuscitation

A successful resuscitation depends on the immediate recognition of the infant in need of resuscitation, initiating the procedure promptly and performing the procedures skillfully.

ABC’s of Resuscitation

A) Establish an open Airway
   • Position the infant appropriately
   • Suction mouth, nose and trachea in some instances (never suck nose first)
   • If necessary, insert an endotracheal tube to assure open airway

B) Initiate Breathing
   • Use tactile stimulation
   • Employ IPPV either with bag and mask or via endotracheal tube

C) Maintain Circulation
   • Stimulate and maintain circulation of blood with chest compression and medications if required
   • Volume expanders if required
Equipment for resuscitation

- Radiant Warmer with canopy heater

- Suction equipment
  - Bulb Syringe
  - Mechanical suction or DeLee mucous trap with 10 Fr catheter
  - Suction catheters 5 Fr to 10 Fr
  - 8 Fr feeding tube

- Bag and mask and intubation equipment
  - Self inflating resuscitation bag or 500 ml reservoir bag
  - Endo-tracheal tubes with connectors 2, 2.5, 3, 3.5.
  - Infant laryngoscopes 0, 1 sizes
  - Oropharyngeal airway 000, 00
  - Humidified warmed oxygen source

- Umbilical vessel catheterisation tray
  - 3 way stop cock umbilical catheters 3 1/2 and 5 Fr
  - Sterile syringe for flushing and heparinised syringe for blood gas sampling

- ECG, Pulse oximeter, pressure transducer and monitors for vascular pressure

- Medications

Evaluation

The Quantitative assessment of neonate described by Virginia Apgar remains the simplest method of evaluation of the condition at birth.
Assessment is done at 1 minute and 5 minutes with this score.

### Table 10.1 Apgar score

<table>
<thead>
<tr>
<th>Sign</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate</td>
<td></td>
</tr>
<tr>
<td>(Beat/min)</td>
<td>Absent</td>
</tr>
<tr>
<td></td>
<td>&lt; 100</td>
</tr>
<tr>
<td></td>
<td>&gt; 100</td>
</tr>
<tr>
<td>Respiratory effort</td>
<td>Absent</td>
</tr>
<tr>
<td></td>
<td>Slow, irregular</td>
</tr>
<tr>
<td></td>
<td>Good crying</td>
</tr>
<tr>
<td>Muscle tone</td>
<td>Flaccid</td>
</tr>
<tr>
<td></td>
<td>Some flexion</td>
</tr>
<tr>
<td></td>
<td>Active motion</td>
</tr>
<tr>
<td>Reflex</td>
<td>No response</td>
</tr>
<tr>
<td></td>
<td>Grimace</td>
</tr>
<tr>
<td></td>
<td>Crying</td>
</tr>
<tr>
<td>Color</td>
<td>Blue or pale</td>
</tr>
<tr>
<td></td>
<td>Body pink</td>
</tr>
<tr>
<td></td>
<td>Extremeties blue</td>
</tr>
<tr>
<td></td>
<td>All pink</td>
</tr>
</tbody>
</table>

It is not advisable to wait for 1 minute to initiate resuscitation. The scoring is meant for assessing the effectiveness of resuscitation but not the need for resuscitation. When the 5 minute Apgar score is less than 7, additional scores should be obtained every 5 minutes upto 20 minutes unless 2 successive scores are 8 or more.

**Phases of resuscitation**

**Phase-I**

- Keep the infant under radiant heat source and dry the baby. Cold stress increases the metabolic rate, which increases the oxygen demand in the already asphyxiated new born.
- Head down, slightly extended and if needed turn head to one side. A roll, about 1 inch high, is placed under the shoulders to elevate the large occiput, accentuated by moulding.
- First do suction of the mouth then nose. Initial nasal suction results in a gasp and the baby aspirates the fluid already present in the mouth.

**Caution:** Do not introduce the bulb syringe too far into the mouth of the baby. It may result in bradycardia, apnoea due to vagal response. Negative pressure should not exceed 100 mmHg. If meconium is seen in the amniotic fluid and appears watery no special action may be necessary. If thick, immediate endotracheal suction should be done.
- Slapping the sole of the foot, flicking the heel and rubbing the infant's back are the forms of tactile stimulation that may be used to help initiate respiration. If the infant does not respond to tactile stimulation within 30 seconds abandon these manoeuvres.

- If the heart rate is > 100 per minute, inadequate respiratory effort, cyanosis then free flow of oxygen over the face should be provided. Oxygen therapy after acute resuscitation should be guided by PaO2 values. If the above manoeuvres fail and the heart rate continues to be below 100 bpm then positive pressure ventilation either with bag and mask or endotracheal intubation and chest compressions may be needed.

**Bag and mask ventilation**

Adequate size mask should be used as too large masks cause injury to the eyes and too small masks do not cover the mouth but on the other hand, may occlude the nose. A 500 ml reservoir bag or self inflating bag may be used to provide IPPV. Initial lung inflation may need a pressure up to 30 to 40 cms of water but subsequently a pressure of 15 to 20 cms of water is adequate during IPPV. A respiratory rate of about 40 per minute is used to provide ventilation. An orogastric catheter may be placed in-situ to prevent distention of stomach leading to pressure on the diaphragm preventing full expansion of lungs and also prevents regurgitation of gastric contents, which may lead to aspiration.

NOTE: Bag and mask ventilation is contraindicated in diaphragmatic hernia.

Airways may be needed if the tongue is blocking the airway, or if there is bilateral choanal atresia. Within 15 to 30 seconds after ventilation if heart rate is not above 100 beats per minute or does not attain effective spontaneous respirations or rate is below 80 beats per minute, endotracheal intubation and chest compressions along with medication are initiated. Check carotids and or femoral to assess effectiveness of compressions. Continue IPPV with 100% oxygen during the procedure. Chest compressions: breath ratio, 3:1.

If the heart rate > 100 discontinue chest compressions, continue ventilation till spontaneous respiration is established. If the heart rate is below 80 and the child is already not intubated, intubate the child and continue the ventilation. Any attempt at intubation should not last longer than 30 seconds.

**Drugs for resuscitation:** If the infant’s heart beat is below 80 beats per minute despite adequate ventilation and chest compression for 30 seconds or if the heart rate is 0 the use of drug is indicated.
Epinephrine
1 in 10,000 Solution at the dose of 0.1 -0.3 ml per kg i.v, which may be repeated every 5 minutes. The heart rate should rise within 30 seconds to 100 or above.

Sodium bicarbonate
Is indicated only when there is documented metabolic acidosis (pH <7.05, base deficit equal to or greater than 15 mEq/L) 4.2% solution should be used. Dose 2 mEq per kg. Effective ventilation should precede and accompany soda bicarb administration.

Naloxone hydrochloride
It is indicated in severe respiratory depression as a result of maternal narcotic administration within the past 4-hours. Dose- 0.01 mg per kg. Duration of action: 1 to 4 hours. It’s administration may result in seizures.

Dopamine
It is indicated in patients with poor peripheral pulses at the dose of 5 mcg/kg/min which may be gradually increased.

Phase II
As soon as the patient’s general condition is stabilized, look for congenital anomalies. Recheck and fix the endotracheal tube properly after auscultation over the lungs.

Phase III
Severely asphyxiated infants may manifest failure of various organ systems. Transient consumption of coagulation factors may complicate severe asphyxia. Thrombocytopenia is the most common finding.

Meconium aspirations, multiple births, extremely low birth weight babies, birth injuries and hydrops babies present distinct challenges to resuscitators.

10.3.3. Cardiopulmonary resuscitation in adult
Cardiopulmonary resuscitation (CPR) is symptomatic treatment, aimed at sustaining vital organ function till spontaneous cardiac function is restored. However the search for a reversible cause of arrest is essential. Cardiac arrest is defined as an apnoeic, unresponsive and unconscious patient with absent central pulses. The cerebral ATP stores get depleted within 4-8 minutes of arrest. Best
outcomes are seen when ventilation and chest-compression are commenced within 4 minutes and defibrillation applied within 8 minutes. When effective resuscitation efforts are instituted rapidly, backed up by an efficient medical emergency response system, initial resuscitation rates of about 40% and survival to hospital discharge of 10-15% are reported.

CPR techniques are broadly divided into two: Basic life support (BLS) and Advanced cardiac life support (ACLS).

Basic life support

Basic life support refers to the elements of CPR, which may be performed without additional equipment. It essentially comprises three elements: airway management, ventilation or breathing, and chest compressions.

Table 10.2. Approach to an unconscious patient.

- Assess responsiveness.
- If unresponsive, activate Emergency Medical Services.
- Open airway.
- Look, listen, and feel for respiration.
- If apnoeic, provide two rescue breaths.
- Check carotid pulse.
- If pulseless, start chest compressions.
- Continue chest compression and mouth-to-mouth ventilation at 15:2.

Airway management

The commonest cause of airway obstruction in an unconscious patient is the tongue or epiglottis falling back upon the posterior pharyngeal wall. The primary method to counter this is the ‘head tilt-chin lift’ manoeuvre. In a scenario where cervical spine injury is a possibility, only the ‘jaw thrust’ is to be applied, with minimal or no movement of the head and neck. It is desirable to obtain a definitive airway as early as possible, which includes endotracheal intubation or tracheostomy. Other intermediate alternative available to us includes the LMA, Combitube and Cricothyrotomy.

Breathing

After opening or establishment of the airway assessment for spontaneous breathing should be made. After apnoea is confirmed by lack of chest movements, air flow and breath sounds, two rescue breaths are slowly administered taking two seconds per breath. If these breaths are ineffective,
the head and neck need repositioning, and any obstruction by a foreign body must be relieved by removal.

The rescue breaths are provided by mouth-to-mouth by obtaining an airtight seal with the victim’s lips and pinching the nose simultaneously. The tidal volume provided in each breath should be about 700-1000 ml and the effectiveness of the rescue breaths is judged by observing the chest rising and falling with each breath. When available, a self-inflating bag-valve-mask may be used to provide more effective ventilation. Of course, the best method of ventilation would ideally be a bag-valve-endotracheal tube with oxygen.

**Circulation**

As soon as two successful rescue breaths are provided, the circulation is rapidly assessed by a carotid pulse check. If adequate central pulses are present, ventilation alone is continued. If the patient is pulseless, the circulation is supported by a combination of chest-compressions, intravenous drugs (inotropes, antiarrhythmics etc.) and defibrillation. The ratio of chest-compressions to mouth-to-mouth breaths should be 15:2.

The heel of rescuer’s hand is placed over the lower half of the victim’s sternum and the other hand is placed over the first hand. The rescuer’s shoulders are positioned directly over the hands with elbows locked. With a straight downward thrust the sternum is depressed 1.5-2 inches. The cardiac compression rate should be 100 per minute. Assessment of adequacy of circulation during CPR may be judged by palpation of carotid or femoral pulse or end-tidal CO2.

**Advanced cardiac life support**

It includes the skills necessary to restore spontaneous circulation when BLS does not result in resuscitation. In addition to BLS skill, it includes the use of adjunctive equipment and techniques for assisting ventilation and circulation, ECG monitoring, defibrillation, establishment of i.v. access and pharmacologic therapy.

**Defibrillation**

Ventricular fibrillation is the commonest cause of arrest in the adult non-trauma victim and the only consistently effective treatment is electrical defibrillation, which should be provided as early as possible, preferably within 3 minutes of arrest. The current recommendations are to use 200 J for the initial shock followed by a second at 200-300 J if the first is unsuccessful. If both fail, additional shocks are given at 300-360 J.

**Pharmacologic Therapy**

Drug therapy is always secondary to other interventions like chest-compressions, airway
management, ventilation and defibrillation in cardiac arrest. The route of administration preferred is intravenous. The most rapid drug levels are achieved by administration into a central vein, however peripheral vein administration is also effective. It is to be noted that CPR should not be interrupted just in order to establish a central venous access. Alternatively, the intrasosseous and intratracheal routes may be used for drug administration. Doses 2-2.5 times higher than the intravenous values are to be used for intratracheal administration.

**Epinephrine**

Epinephrine acts by producing peripheral vasoconstriction by its α-adrenergic properties, thus increasing the aortic diastolic pressure and coronary perfusion. Epinephrine remains the vasopressor of choice in CPR. The recommended standard dose is 1 mg i.v, repeated as required every 3-5 minutes. Other dose schedules described include the escalating dose (1, 3, 5 mg) and the high dose regimes (0.1 mg/kg). Unfortunately outcome studies have not yet conclusively proven the most effective dose schedule.

**Atropine**

Atropine enhances sinus node automaticity and atrioventricular conduction through its vagolytic properties. Atropine is often given during arrest with asystole, bradycardia or slow pulseless electrical activity. The dose is 1 mg i.v. repeated every 3-5 minutes upto a total full vagolytic dose of 40 µg/kg is given.

**Sodium Bi-carbonate**

Sodium Bi-carbonate needs to be administered judiciously according to standard recommendation to prevent metabolic abnormalities like hypernatremia, hyperosmolarity and metabolic alkalosis developing from its administration. It is recommended to use Sodium Bi-carbonate primarily in arrests associated with hyperkalaemia, severe metabolic acidosis and tricyclic or barbiturate overdose. Dose 1 mEq/kg, additional doses of 0.5 mEq/kg every 10 minutes if required.

**Calcium**

Calcium increases myocardial contractility and automaticity. The specific indications for calcium administration are hyperkalaemia, hypocalcaemia and calcium channel blocker toxicity. The dose is 0.1-0.2 ml/kg of 10 % calcium chloride or 0.3-0.8 ml/kg of 10 % calcium gluconate.

**Amiodarone**

It is a complex drug with sodium calcium potassium and adrenergic blocking properties. It is indicated in SVT, unstable VT and VF, stable VT, AF and Flutter. Dose: 150 mg over 10 minutes followed by 1 mg per minute for 6 hours, than 0.5 mg/minute upto a total dose of 2 gm over 24 hours.
Universal Algorithm for Adult Emergency Cardiac Care

Person collapses
Possible cardiac arrest
Assess responsiveness

Unresponsive

Begin primary ABCD Survey
(Begin BLS Algorithm)
• Activate Emergency Response System
• Call for Defibrillator
• Assess breathing (open airway, look, listen, and feel)

Not Breathing

• B Give 2 slow breaths
• C Access pulse, if no pulse
• C Start chest compressions
• D Attach monitor/defibrillator when available

No pulse

• CPR continues
• Assess rhythm

VF/VT

Attempt defibrillator
(up to 3 shocks if VF persists)

Non-VF/VT

Non-VF/VT
(asystole or PEA)

SECONDARY ABCD SURVEY

• Airway: attempt to place airway device
• Breathing: confirm and secure airway device, ventilation, oxygenation
• Circulation: gain intravenous access; give adrenergic agent; consider antiarrhythmics, buffer agents, pacing

Non-VF/VT patients:
- Epinephrine 1 mg IV, repeat every 3 to 5 minutes

VF/VT patients:
- Vasopressin 40 U IV, single dose, 1 time only or
- Epinephrine 1 mg IV, repeat every 3 to 5 minutes (if no response after single dose of vasopressin, may resume epinephrine 1 mg IV push; repeat every 3 to 5 minutes)

CPR for 1 minute

CPR up to 3 minutes
Algorithm for Management of VF/Pulseless VT:

**PRIMARY ABCD SURVEY**
Focus: basic CPR and defibrillation
- Check responsiveness
- Activate Emergency Response System
- Call for Defibrillator
A Airway: open the airway
B Breathing: provide positive pressure ventilations
C Circulation: give chest compressions
D Defibrillation: assess for rhythm and shock VF/pulseless VT, up to 3 times (200 J, 200 to 300 J, 360 J, or equivalent biphasic) if necessary

- Rhythm after first 3

- Persistent or recurrent

**Secondary ABCD Survey**
Focus: more advanced assessments and treatments
A Airway: place airway device as soon as possible
B Breathing: confirm airway device placement by exam plus confirmation device
B Breathing: secure airway device; purpose-made tube holders preferred
B Breathing: confirm effective oxygenation and ventilation
C Circulation: establish IV access
C Circulation: identify rhythm ➔ monitor

- Epinephrine 1 mg IV push, repeat every 3 to 5 minutes
  or

**Resume Attempts To Defibrillate**
1 X 360 J (or equivalent biphasic) within 30 to 60 seconds
Algorithm for Management of Pulseless Electrical Activity:

**Pulseless Electrical Activity**
P EA = (rhythm on monitor, without detectable pulse)

**Primary ABCD Survey**
Focus: basic CPR and defibrillation
- Check responsiveness
- Activate Emergency Response System
- Call for Defibrillator
A Airway: open the airway
B Breathing: provide positive airway pressure ventilations
C Circulation: give chest compressions
D Defibrillation: assess for rhythm and shock VF/pulseless VT

**Secondary ABCD Survey**
Focus: more advanced assessments and treatments
A Airway: place airway device as soon as possible
B Breathing: confirm airway device placement by exam plus confirmation device
B Breathing: secure airway device: purpose-made tube holders preferred
B Breathing: confirm effective oxygenation and ventilation
C Circulation: establish IV access
C Circulation: identify rhythm monitor
C Circulation: administer drugs appropriate for rhythm and condition
Algorithm for Management of Asystole:

**Primary ABCD Survey**
Focus: basic CPR and defibrillation
- Check responsiveness
- Activate Emergency Response System
- Call for Defibrillator
A Airway: open the airway
B Breathing: provide positive - pressure ventilations
C Circulation: give chest compressions
C Confirm true asystole
D Defibrillation: assess for and shock VF/pulseless VT, shock if needed

Review For Most Frequent Causes
- Hypovolemia - “Tablets” (drug OD, accidents)
- Hypoxia - Tamponade, cardiac
- Hydrogen ion – acidosis - Tension pneumothorax
- Hyper-/hypokalemia - Thrombosis, coronary (ACS)
- Hypothermia - Thrombosis, pulmonary (embolism)

Epinephrine 1 mg IV push, repeat every 3 to 5 minutes

Atropine 1 mg IV (if PEA rate is slow), repeat every 3 to 5 minutes as needed, to a total dose of 0.04 mg/kg
Secondary ABCD Survey
Focus: more advanced assessments and treatments
A Airway: place airway device as soon as possible
B Breathing: confirm airway device placement by exam plus confirmation device
B Breathing: secure airway device; purpose-made tube holders preferred
B Breathing: confirm effective oxygenation and ventilation
C Circulation: confirm true asystole
C Circulation: establish IV access
C Circulation: identify rhythm monitor

Transcutaneous Pacing
If considered, perform immediately

Epinephrine 1 mg IV push,
Repeat every 3 to 5 minutes

Atropine 1 mg IV
repeat every 3 to 5 minutes as needed, to a total dose of 0.04 mg/kg

Asystole persists
Withhold or cease resuscitation efforts?
• Consider quality of resuscitation?
• Atypical clinical features present?
• Support for cease-efforts protocols in place?
10.4 **Salient points to remember**

- Asphyxia is a progressive process that is reversible in the early stages, but may cause a permanent neurologic damage if not corrected in time.
- Always remember the ABC’s of resuscitations in order Airway, breathing & circulation.
- APGAR score at 1 minute is an index of survival, and that at 5 minutes is indicative of neurologic outcome.
- Naloxone is indicated only in respiratory depression as a result of material narcotic administration.
- The ‘head tice chin lift’ manouevre is the most effective way of relieving airway obstruction in an unconscious patient.
- In adult resuscitation, the ratio of chest compressions to verification should be 15:2.
- Assessment of adequacy of CPR may be judged by palpation of the cantid/femoral pulse or by the ETCO$_2$.
- Distribution should be ideally applied within 3 minutes of collapse.

10.5 **Check your progress**

i. True or False
   
i.a. During the first suction of the neonate, the nose should be sucked first

   i.b. Assessment of APGAR score is done at 1 min & 5 min.

   i.c. Adrenaline is available as a 1:2,00,000 solution.

   i.d. Sodabicarb is administered as a 7.5% solution to the neonate.

ii. Fill in the blanks
   
   ii.a. Cardiac compression rate in the adult is ______ /min.

   ii.b. The first step in approach to unconscious patient is ______

   ii.c. If the arrest is due to VF, the first shock delivered is of ______ J.
iiid. Best outcome is seen when CPR is started within ____ min & distribution within _______ min.

iii. The neonate has blue extremities, heart rate of 110, restrivation slow & irregular, grimaces to stimuli, and flaccid muscle tone H3 APGAR score B
   a. 9
   b. 7
   c. 4
   d. 3

div. The recommended dose of 1:10,000 adrenaline in neonate is
   a. 0.1-0.3 ml/kg
   b. 0.5-1 ml/kg
   c. 1-2 ml/kg
   d. 2-4 ml/kg

dv. If the patient is unresponsive, the first step is
   a. Cardiac compression
   b. Rescue breath
   c. Distribution
   d. Activate EMS

dvi. During chest compressions in adult, the sternum should be depressed by ______ inches:
   a. 1-1½
   b. 1½ – 2
   c. 2 – 3
   d. 3 – 4
Answers

ia-F; ib-T, ic-F; id-F; iiia-100; iib-200; iiid-4, 8; iii-c; iv-a; v-d; vi-b

10.6 Further findings

- Anaesthesia – Miller
- Paediatric anaesthesia - Smith
Module - XI
Anesthesia for Emergency Obstetric Care Ethical and Legal Issues and Consumer Protection
## Module Structure

11.1 Introduction 233

11.2 Objective 233

11.3 Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.3.1</td>
<td>Ethical Considerations</td>
<td>233</td>
</tr>
<tr>
<td>11.3.2</td>
<td>Legal Considerations and the Consumer Protection Act</td>
<td>236</td>
</tr>
<tr>
<td>11.3.3</td>
<td>Duties of an Anesthetist</td>
<td>242</td>
</tr>
<tr>
<td>11.3.4</td>
<td>Legal Protection to Medical Practitioners</td>
<td>248</td>
</tr>
<tr>
<td>11.3.5</td>
<td>Negligence in Medical Practice</td>
<td>249</td>
</tr>
<tr>
<td>11.3.6</td>
<td>Death on Operation Table (DOT)</td>
<td>254</td>
</tr>
</tbody>
</table>
11.1 Introduction

Prior to enactment of the Consumer Protection Act 1986, cases of professional negligence against doctors were only rarely filed before civil courts. Men in medical profession, therefore, hardly ever tried to make themselves aware of legal aspect of the profession. But with the establishment of Consumer Disputes Redressal Agencies under the Act, it has become very easy for a consumer to get a speedy, economical and effective relief through these agencies. The Supreme Court in *Indian Medical Association vs. V.P. Shantha & Ors.*, III(1995) CPJ 1 (SC) has maintained that medical men do not enjoy immunity against claims of compensation in case of negligence, and that medical service is a ‘service’ under the Act and the patient is a consumer with certain exceptions. There is growing awareness amongst people and they have now high expectations from doctors. Cases of medical negligence are, therefore, being filed before Consumer Forums in large numbers. On the other hand, doctors, particularly in government employment, do not appear to be adequately conversant with their accountability in the profession as well as their rights. Consequently they have undue fears in their minds, which prevent them from discharging their duties to the full extent. Such fears can be removed only by an adequate knowledge of the legal aspect of the profession.

11.2 Objective

After going through the module you should be able to

- Describe ethical and legal aspects of anaesthetic practice
- Describe medical negligence and legal protection of medical practitioner

11.3 Contents

11.3.1 Ethical considerations

The earliest code of medical ethics was ‘The Hippocratic Oath’. It was modified by the World Medical Association as ‘Declaration of Geneva’. It is followed by the Medical Council of India as ‘Code of Medical Ethics’. Every doctor, at the time of registration with the medical council, has to sign a pledge that he agrees to abide by the same. The Code of Medical Ethics it not a legislation but a self-imposed code of conduct evolved by the Medical Council of India.

i. Salient features of the code of medical ethics

*Character of the physician* - The prime object of the medical profession is to render service to humanity; reward of financial gain is a subordinate consideration. Who-so-ever chooses this profession, assumes the obligation to conduct himself in accord with its ideals. “A physician
should be an upright man, instructed in the art of healing”. He must keep himself pure in character and be diligent in caring for the sick. He should be modest, sober, patient, prompt to do whole duty without anxiety; pious without going so far as superstition conducting himself with propriety in his profession and in all the actions of his life.

**The physician’s responsibility** - The principal objective of the medical profession is to render service to humanity with full respect for the dignity of man. Physician should merit the confidence of patients entrusted to his care, rendering to each a full measure of service and devotion.

**Payment of professional services** - The ethical physician, engaged in the practice of medicine, limits the sources of his income received from professional activities to service rendered to the patient. Remunerations received for such services should be in the form and amount specifically announced to the patient at the time the service is rendered. It is unethical to enter into a contract of “no cure no payment”.

**Patience, delicacy and secrecy** - Patience and delicacy should characterize the physician. Confidence concerning individual or domestic life entrusted by patients to a physician and defects in the disposition or character of patients observed during medical attendance should never be revealed unless their revelation is required by the laws of the State.

**Prognosis** - The physician should neither exaggerate nor minimize the gravity of a patient’s condition. He should assure himself that the patient, his relatives or his responsible friends have such knowledge of the patient’s condition as will serve the best interests of the patient and the family.

**The patient must not be neglected** - A physician is free to choose whom he will serve. He should, however, respond to any request for his assistance in an emergency or whenever temperate public opinion expects the service. Once having undertaken a case, the physician should not neglect the patient, nor should he withdraw from the case without giving notice to the patient, his relatives or his responsible friends sufficiently long in advance of his withdrawal to allow them to secure another medical attendant. No provisionally or fully registered medical practitioner shall willfully commit an act of negligence that may deprive his patient or patients from necessary medical care.

**Upholding the honour of the profession** - A physician is expected to uphold the dignity and honour of his profession.

**Membership in medical society** - For the advancement of his profession, a physician should affiliate with medical societies and contribute his time, energy and means so that these societies may represent the ideals of the profession.
Safeguarding the profession - Every physician should aid in safeguarding the profession against admission to it of those who are deficient in moral character or education.

Exposure of unethical conduct - A physician should expose, without fear or favour, incompetent or corrupt, dishonest or unethical conduct on the part of members of the profession. Questions of such conduct should be considered, first before proper medical tribunals in executive sessions or by special or duly appointed committees on ethical relations, provided such a course is possible and provided also that the law is not hampered thereby. If doubt should arise as to the legality of the physician’s conduct, the situation under investigation may be placed before officers of the law, and the physician investigators may take the necessary steps to enlist the interest of the proper authority.

Consultation should be encouraged - In case of serious illness, especially in doubtful or difficult conditions the physician should request consultation.

Consultation for Patient’s Benefit - In every consultation, the benefit to the patient is first importance. All physicians’ interest in the case should be candid with the patient, a member of his family or responsible friend.

Appointment of substitute - Whenever a physician requests another physician to attend his patients during his temporary absence from his practice, professional courtesy requires the acceptance of such appointment in consistent with his other duties, the physician acting under such an appointment should give the utmost consideration to the interests and reputation of the absent physician. All such patients should be restored to the care of the latter upon his return.

Engagement for an obstetric case - If a physician agrees to attend a woman during her confinement, he must do so. Inability to do so on an excuse of any other engagement is not tenable except when he is already engaged on a similar or other serious case. When a physician who has been engaged to attend an obstetric case is absent and another is sent for and delivery accomplished, the acting physician is, entitled to his professional fees, but should secure the patient’s consent to resign on the arrival of the physician engaged.

ii Disciplinary action

- The Medical Council of India desire to bring to the notice of the registered medical practitioners the following statement upon offences and form of professional misconduct, which may be brought before the appropriate Medical Council for disciplinary action in view of the authority conferred upon the Medical Council of India and/or State Medical Councils as provided
under Indian Medical Council Act, 1956, or State Medical Councils Acts as may be subsequently amended.

- The appropriate Medical Council may award such punishment as deemed necessary or may direct the removal altogether or for a specified period from the Register, the name of any registered practitioner who has been convicted of any such offences as implies in the opinion of the Medical Council of India and/or State Medical Councils, a defect of character or who after an enquiry at which opportunity has been given to such registered practitioner to be heard in person or by pleader, has been held by the appropriate Medical Council to have been guilty of serious professional misconduct. The appropriate Medical Council may also direct that any name so removed shall be restored.

- It must be clearly understood that the instances of offences and of professional misconduct which are given do not constitute and are not intended to constitute a complete list of the infamous acts which may be punished by erasure from the Register, and that by issuing this notice the Medical Council of India and/or State Medical Councils are in no way precluded from considering and dealing with any form of professional misconduct on the part of a registered practitioner. Circumstances may and do arise from time to time in relation to which there may occur questions of professional misconduct which do not come within any of these categories. Every care should be taken that the code is not violated in letter or spirit. In such instances as in all others, the Medical Council of India and/or State Medical Councils have to consider and decide upon the facts brought before the Medical Council of India and/or State Medical Councils.

For the ‘list’, please refer to the ‘Code of Medical Ethics’.

11.3.2 Legal considerations and the consumer protection act

Under the Consumer Protection Act, quasi-judicial tribunals have been established to settle the disputes of consumers and to provide them speedy relief of a specific nature. The tribunals viz., the District Consumer Disputes Redressal Forum at the district, the State Consumer Disputes Redressal Commission at the state and the National Consumer Disputes Redressal Commission at the national level, are empowered to grant relief only to those who are ‘consumers’ as defined in the Act. Literally speaking a person who buys goods or uses services is a consumer. But every such person has not been included in the definition in the Act, and those who are not included in the definition of ‘consumer’ are not entitled to seek relief before the Consumer Forum. Consumers fall in two categories: consumer of goods and consumer of services.
i. Is a patient consumer of his doctor/hospital?

Earlier it was disputed as to whether a patient is a consumer of his doctor or not. The Supreme Court, in its well-known judgment in Indian Medical Association vs. V.P. Shantha & Ors. III(1995) CPJ 1(SC) has held that medical service in the form of consultation, diagnosis and treatment is a service unless rendered to everyone free of charge. The Supreme Court, on the liability and accountability of the medical profession, has arrived at the following conclusions:

- Service rendered to a patient by a medical practitioner (except where the doctor renders service free of charge to every patient or under a contract of personal service) by way of consultation, diagnosis and treatment, both medicinal and surgical, would fall within the ambit of ‘service’ as defined in Section 2(1) (o) of the Act.

- The fact that medical practitioners belong to the medical profession and are subject to the disciplinary control of the Medical Council of India and/or State Medical Councils constituted under the provisions of the Indian Medical Council Act would not exclude the services rendered by them from the ambit of the Act.

- A ‘contract of personal service’ has to be distinguished from a ‘contract for personal services’. In the absence of the relationship of master and servant between the patient and medical practitioner, the service rendered by a medical practitioner to the patient cannot be regarded as service rendered under a ‘contract of personal service’. Such service is service rendered under a ‘contract for personal service’ and is not covered by exclusionary clause of the definition of ‘service’ contained in Section 2(1) (o) of the Act.

- The expression ‘contract of personal service’ in Section 2(1) (o) of the Act cannot be confined to contracts for employment of domestic servants only and the said expression would include the employment of a medical officer for the purpose of rendering medical service to the employer. The service rendered by a medical officer to his employer under the contract of employment would be outside the purview of ‘service’ as defined in Section 2(1) (o) of the Act.

- Service rendered free of charge by a medical practitioner attached to a hospital/nursing home or a medical officer employed in a hospital/nursing home where such services are rendered free of charge to everybody, would not be “service” as defined in Section 2(1) (o) of the Act. The payment of a token amount for registration purpose only at the hospital/nursing home would not alter the position.
Module-XI

- Service rendered at a non-Government hospital/nursing home where no charge whatsoever is made from any person availing the service and all patients (rich and poor) are given free service – is outside the purview of the expression ‘service’ as defined in Section 2(1) (o) of the Act. The payment of a token amount for registration purpose only at the hospital/Nursing home would not alter the position.

- Service rendered at a non-Government hospital/nursing home where charges are required to be paid by the persons availing such services falls within the purview of the expression ‘service’ as defined in Section 2(1) (o) of the Act.

- Service rendered at a non-Government hospital/nursing home where charges are required to be paid by persons who are in the position to pay and persons who cannot afford to pay are rendered service free of charge would fall within the ambit of the expression ‘service’ as defined in Section 2(1) (o) of the Act, irrespective of the fact that the service is rendered free of charge to persons who are not in a position to pay for such services. Free services would also be ‘service’ and the recipient a “consumer” under the Act.

- Service rendered at a Government hospital/health centre/dispensary where no charge whatsoever is made from any person availing the services and all patients (rich and poor) are given free service is outside the purview of the expression ‘service’ as defined in Section 2(1) (o) of the Act. The payment of a token amount for registration purpose only at the hospital/nursing home would not alter the position.

- Service rendered at a Government hospital/health centre/dispensary where services are rendered on payment of charges and also rendered free of charge to other persons availing such services would fall within the ambit of the expression ‘service’ as defined in Section 2(1) (o) of the Act irrespective of the fact that the service is rendered free of charge to persons who do not pay for such service. Free service would also be “service” and the recipient a “consumer” under the Act.

- Service rendered by a medical practitioner or hospital/nursing home cannot be regarded as service rendered free of charge, if the person availing the service has taken an insurance policy for medical care where under the charges for consultation, diagnosis and medical treatment are borne by the insurance company and such service would fall within the ambit of ‘service’ as defined in Section 2(1) (o) of the Act.
Similarly, where, as a part of the conditions of service, the employer bears the expenses of medical treatment of an employee and his family members dependent on him, the service rendered to such an employee and his family members by a medical practitioner or a hospital/nursing home would not be free of charge and would constitute service under Section 2(1)(o) of the Act.

Some of the salient features of the judgment on the question whether medical service is a ‘service’ and whether patient is a ‘consumer’ under the Act:

- Medical service rendered to a patient by a medical practitioner is a ‘service’ under the Act, except where the service is rendered free of charge to every patient or is rendered under a contract of personal service.

- As there is no relationship of master and servant between the patient and the medical practitioner, service rendered to the patient cannot be regarded as service under a contract of personal service. Therefore, it is not excluded from the definition of ‘service’ under the Act. Only in case of service rendered by a medical man to his employer under the contract of employment, the service would be outside the purview of ‘service’ under the Act.

- Where service is rendered free of charge to all patients, rich and poor alike, such a service is outside the definition of ‘service’ under the Act. The token amount paid for registration purpose only would not alter the position.

- Service rendered free of charge to those persons who cannot afford to pay where other persons who are in a position to pay are treated on payment of charges, is included in the definition of ‘service’.

- Service rendered at a Government hospital/health centre/dispensary where services are rendered on payment of charges and also rendered free of charge to other persons, the free service would also fall within the ambit of ‘service’ under the Act.

- Service rendered where charges are borne by the insurance company or by the employer would also constitute ‘service’ under the Act.

ii. **Under what conditions is a patient consumer of his doctor?**

A patient is a consumer of his doctor, where –

- He pays consideration i.e. price or money for the medical service.
• He is rendered medical service free of charge as he cannot afford to pay at a non-government hospital/nursing home where charges are required to be paid by persons who are in a position to pay.

• He is rendered free medical service at a government hospital, health centre or dispensary where services are rendered on payment of charges and also rendered free of charge to other persons availing such services.

• The patient availing the services has taken an insurance policy for medical care where under the charges for consultation, diagnosis and treatment are paid by the Insurance Company.

• An employee and his family members avail of medical services where the employer bears the expenses of the services.

iii Under what conditions is a patient not a consumer of his doctor?

A patient is not a consumer of his doctor, where –

• The medical service is rendered free of charge at the hospital, health centre or dispensary where such services are rendered free to every person, though a token amount for registration purpose may have been paid.

• A person undergoes sterilization operation at a government hospital or undergoes an operation in a free eye camp.

• A government servant receives medical services under CGHS.

• Doctor-patient relationship is not established.

iv How is medical negligence determined under the Act?

Under the CPA, ‘negligence’ is covered under ‘deficiency in service’ as defined in Section 2(1)(g) of the Act. The principles of determination of negligence which apply before the Civil Court would equally apply before the Consumer Forum. The Supreme Court in Indian Medical Association v. V.P. Shantha & Ors. has held that no change is brought about in the substantive law governing claims for compensation on the ground of negligence and the principles which apply to determination of such a claim before the Civil Court would equally apply to consumer disputes before the Consumer Disputes Redressal Agencies under the Act. The Act only provides an inexpensive and a speedy remedy for adjudication of such claims.
v Which types of cases of negligence should be adjudicated by the Consumer Fora?

In the same judgment, the Supreme Court has held that in cases which do not raise complicated questions and the deficiency in service may be due to obvious faults which can be easily established such as removal of the wrong limb or the performance of an operation on the wrong patient or giving injection of a drug to which the patient is allergic without looking into the outpatient card containing the warning or use of wrong gas during the course of an anesthetic or leaving inside the patient swabs or other items of operating equipment after surgery. The issues arising in the complaints in such cases can be speedily disposed of by the procedure that is being followed by the Consumer Disputes Redressal Agencies and there is no reason why complaints regarding deficiency in service in such cases should not be adjudicated by the Agencies under the Act.

The Court has further held that in complaints involving complicated issues requiring recording of evidence of experts, the complainant can be asked to approach the Civil Court for appropriate relief.

vi The legal aspect of doctor-patient relationship

As soon as a doctor agrees to treat a patient, the doctor-patient relationship is established. Since the same moment the duty of the doctor towards the patient starts. There is no legal obligation on a doctor who treats the patients on payment of charges to accept any and every patient that happens to go to him. He may refuse to treat any patient without any rhyme or reason. But a doctor in government employment cannot refuse to see a case that is brought to the hospital or health centre. The doctor-patient relationship may be in the form of an implied contract or without a contract.

The relationship of contract

The relationship is contractual when a patient goes to a private practitioner. Here the relationship is substantially a matter of contract between the two. While a private practitioner cannot be forced to treat any person, he has certain duties and responsibilities towards those whom he accepts as patients. Under the contract, the doctor is bound to fulfill his promise of service and cannot resile or withdraw from the commitment. He owes a civil obligation to render those services.

The relationship beyond contract: gratuitous service

In hospitals or health centres run by government, municipal bodies or charitable institutions where patients are treated free of charge, the direct contract between the doctor and the patient...
does not exist. However, the doctor-patient relationship does exist but for the monetary considerations. The doctor’s duties to such patients are equally onerous irrespective of whether or not payment has been made for such a service. Once the patient is taken for treatment by the doctor, he has to act with reasonable care and skill. The Code of Medical Ethics, too, calls for the doctor to fulfill his obligations towards such patients with reasonable care and skill.

It may be mentioned here that patients availing medical services of a hospital where all patients are treated free cannot agitate their grievance before a Consumer Forum as they are not included in the definition of ‘consumer’ under the Act. They can, however, file a suit, in tort, before a Civil Court.

**Situations in which a doctor-patient relationship is not established:**

- The doctor performs an examination for life insurance purposes.
- He makes a pre-employment medical examination for a prospective employer.
- He is appointed by trial Court to examine the accused for any reason.
- Assessment of injuries in case of assaults.
- Assessing drunkenness in prohibition and vehicular accident cases.
- Evaluation of disabilities for purposes like compensation, retirement benefits, etc.

In these cases the doctor examines the person in his official capacity at the instance of police, a court or the organisation employing the doctor.

### 10.3.3 Duties of an anaesthetist

The professional duties of an anaesthetist are of complex nature and entail a high degree of knowledge, skill and experience. The duty starts as soon as the anaesthetist agrees to take up the case and continues till complete recovery from anaesthesia and its after-effects. The duties may be enumerated as below:

**To decide whether to undertake the case**

The anaesthetist has to decide– (a) whether he is competent to administer anaesthesia to the case, and (b) whether he has an adequately equipped and staffed operation theatre to administer anaesthesia and to deal with any complication or emergency that may arise.
To carry out pre-anaesthetic check-up

A proper assessment of the case regarding the anesthetic risks should be made. Poor risk cases should be identified and dealt with properly.

To obtain consent for anaesthesia *vide infra.*

Identification of the patient before anaesthesia

It is the duty of the anesthetist to ensure that a wrong man is not taken for anaesthesia. He cannot escape his liability if a wrong person is anaesthetized.

To ensure proper recovery from anaesthesia

He should take necessary precautions to ensure a smooth recovery. Any post-anaesthetic complication should be anticipated, detected without undue delay and treated adequately.

To exercise reasonable degree of knowledge, skill and care

It is the settled principle that a medical practitioner is expected to exercise not the highest but the reasonable degree of skill, knowledge and care in the treatment of his patient. The word ‘reasonable’ is vague and not precise, and several facts have to be taken into consideration to decide what is ‘reasonable’. It has to be judged from the qualification and experience of the doctor and from the given set of circumstances in which he treats the patient. A general practitioner is expected to possess the skill that is required of a general practitioner and cannot be compared to that of a specialist. A specialist is expected to exercise a higher degree of skill that is expected of a specialist, and he, too, is expected to exercise the reasonable degree of skill of a specialist. A different standard of reasonable care and skill would be adopted in the case of a new entrant in the profession as compared to an experienced man having the same qualification. The degree of skill and knowledge to be expected of an anaesthetist practicing in a remote area would not be the same as expected of a consultant anaesthetist in a teaching hospital.

Maintenance of records

A record of all the administrations of anaesthesia must be maintained by the anaesthetist. The purpose is manifold

- It contributes to the care of the patient.
- It helps a second anaesthetist who may take charge of the case.
Module-XI

- **For medico-legal purpose.** For this purpose the record must be complete, accurate, legible, contemporaneous and duly signed. Events should be recorded as soon after as they take place. Any correction made in the record should be made in such a way that it does not create any doubts in the minds of one who examines it. It must not be tampered. A record is the most important weapon of defence of the anaesthetist in case of litigation. Once it is concluded that the record has been tampered with, it loses all its importance as an effective document.

The document should contain:
- The name, age, sex and address of the patient.
- Date of operation.
- Names of surgeons and anaesthetist.
- The operation.
- The summary of pre-operative assessment.
- Anaesthesia administered: the technique and the drugs used.
- Record of vital signs: e.g. pulse, blood pressure, respiration and other details. They should be recorded as frequently as required.
- I.V. fluids/blood given.
- Any complication during anaesthesia: how managed.
- Recovery from anaesthesia.
- After-effects, if any.

**To attend an injured or critically ill person to preserve life**

The role of an anaesthetist in managing a critically ill person cannot be overemphasised.

In a public interest litigation, *Pt. Parmanand Katara v. Union of India & Ors*, AIR 1989 SC 2039, the Supreme Court has held that medico-legal formalities should not come in the way of preserving life of an injured person, and it is the duty of every medical practitioner to attend such a case when temperate public opinion urges upon him to do so. The Court held:

“There can be no second opinion that preservation of human life is of paramount importance. That is so on account of the fact that once life is lost, the *status quo ante* cannot be restored as resurrection is beyond the capacity of man”.

“Article 21 of the Constitution casts the obligation on the State to preserve life. The provision as explained by this Court in scores of decisions has emphasised and reiterated with gradually increasing emphasis that position. A doctor at the government hospital positioned to meet this State obligation is, therefore, duty-bound to extend medical assistance for preserving life. Every doctor whether at a government hospital or otherwise has the professional obligation to extend his services with due expertise for protecting life. No law or State action can intervene to avoid/delay the discharge of the paramount obligation cast upon members of the medical profession. The obligation being total, absolute and paramount, laws of procedure whether in statutes or otherwise which would interfere with the discharge of this obligation cannot be sustained and must, therefore, give way...... the matter is extremely urgent and in our view, brooks no delay to remind every doctor of his total obligation and assure him of the position that he does not contravene the law of the land by proceeding to treat the injured victim on his appearance before him either by himself or being carried by others”.

The Supreme Court desired that wide publicity should be given about the relevant aspect so that every practising doctor would soon become aware of the position.

“It could not be forgotten that seeing an injured man in a miserable condition the human instinct of every citizen moves him to rush for help and do all that an be done to save the life. It could not be disputed that inspite of development economical, political and cultural, still citizens are human beings and all the more when a man in such a miserable state hanging between life and death reaches the medical practitioner either in a hospital (run or managed by the State) public authority or a private person or a medical professional doing only private practice he is always called upon to rush to help such an injured person and to do all that is within his power to save life. So far as this duty of medical professional is concerned its duty coupled with human instinct, it needs no decision nor any code of ethics nor any rule or law”.

Regarding the fears in the minds of doctors about interrogation by the police and attending the courts, the Supreme Court held,

“It is clear that there is no legal impediment for a medical professional when he is called upon or requested to attend to an injured person needing his medical assistance immediately. There is also no doubt that the effort to save the person should be the top priority not only of the medical professional but even of the police or any other citizen who happens to be connected with the matter or who happens to notice such an incident or a situation. But on behalf of the medical profession there is one more apprehension which sometimes prevents a medical professional in
spite of his desire to help the person, as he apprehends that he will be a witness and may have to face the police interrogation which sometimes may need going to the police station repeatedly and waiting and also to be a witness in a court of law where also he apprehends that he may have to go on number of days and may have to wait for a long time and may have to face sometimes long unnecessary cross-examination which sometimes may even be humiliating for a man in the medical profession and in our opinion it is this apprehension which prevents a medical professional who is not entrusted with the duty of handling medico-legal cases to do the needful, he always tries to avoid and even if approached directs the person concerned to go to a State hospital and particularly to the person who is in-charge of the medico-legal cases. We therefore, have no hesitation in assuring the persons in the medical profession that these apprehensions, even if have some foundation, should not prevent them from discharging their duty as a medical professional to save a human life and to do all that is necessary but at the same time we hope and trust that with this expectation from the members of the medical profession, the police, the members of the legal profession, our law courts and everyone concerned will also keep in mind that a man in the medical profession should not be unnecessarily harassed for purposes of interrogation or for any other formalities and should not be dragged during investigations at the police station and it should be avoided as far as possible”.

“We also hope and trust that our law courts will not summon a medical professional to give evidence unless the evidence is necessary and even if he is summoned attempt should be made to see that the men in this profession are not made to wait and waste time unnecessarily, and it is known that our law courts always have respect for the men in the medical profession and they are called to give evidence when necessary and attempts are made so that they may not have to wait for long”.

“We have no hesitation in saying that it is expected of the members of the legal profession which is the other honorable profession to honor the persons in the medical profession and see that they are not called to give evidence so long as it is not necessary. It is also expected that where the facts are so clear it is expected that unnecessary harassment of the members of the medical profession either by way of request for adjournments or by cross-examination should be avoided so that the apprehension that the men in the medical profession have which prevents them from discharging their duty to a suffering person who needs their assistance utmost, is removed and a citizen needing the assistance of a man in the medical profession received it”.
Consent in Anaesthesia

Under section 13 of Indian Contract Act 1872, two or more persons are said to consent when they agree upon the same thing in the same sense. Consent must always be obtained by the anaesthetist for anaesthesia since administration of anaesthesia without the consent of the patient is assault in law, even if it is beneficial to the patient and done in good faith. Consent is necessary for every medical examination and treatment. The consent must be freely given. Under section 14 of the Indian Contract Act, 1872, consent is said to be free when it is not caused by coercion, undue influence, fraud, misrepresentation, or mistake. Consent obtained in these situations does not amount to a valid consent.

The consent should be an ‘informed consent’ which means that the consent of the patient has been obtained after the patient has been informed and made to understand about, the nature of his condition,

- the nature of the proposed procedure of treatment or anaesthesia,
- any alternative procedure, and
- the risks involved in both the proposed and the alternative procedures or treatment,
- the relative chances of success or failure of both the procedures so that the patient may accept or reject the procedure.

All disclosures must be in language the patient can understand. When such a consent is obtained from the patient in writing and in the presence of a disinterested witness, it will minimize the chances of litigation. However, it should be remembered that obtaining a consent does not give protection to a doctor from being proceeded against in a case of negligence in treatment.

The consent should refer to one specific procedure and should be broad enough to cover everything contemplated and should be in proper form and suitably drafted for the circumstances. It should be obtained before the patient is pre-medicated. The patient should be informed that he has a right to refuse the treatment and that the result may go against him. If the patient refuses he cannot be given that treatment. However, this should be brought in the record and the patient’s signature should be obtained.

Though an oral consent is legally valid, a written consent should always be preferred as it obviates any problem arising later. A person who gave only oral consent may file a complaint at a later date.
that no consent was ever given by him. A written consent, which is a permanent document, must be preserved as a part of the record.

10.3.4 Legal protection to medical practitioners

Certain provisions of the Indian Penal Code provide protection from liability for unfortunate consequences where medical men are not at fault and have exercised their utmost care and attention and acted with the best intentions:

i. Unintentional causing of grievous hurt or death is justifiable.

**Section 88, I.P.C. – Act not intended to cause death, done by consent in good faith for person’s benefit** – Nothing, which is not intended to cause death, is an offence by reason to any harm which it may cause, or be intended by the doer to cause, or be known by the doer to be likely to cause, to any person for whose benefit it is done in good faith, and who has given a consent, whether express or implied, to suffer that harm, or to take the risk of that harm.

**Illustration**

A, a surgeon, knowing that a particular operation is likely to cause the death of Z, who suffers under a painful complaint, but not intending to cause Z’s death, and intending, in good faith Z’s benefit, performs that operation on Z, with Z’s consent, A has committed no offence.

ii. Any harm caused to a person in good faith, even without that person’s consent is not an offence, if the circumstances are such that it is impossible for that person to signify consent, and has no guardian or other person in lawful charge of him from whom it is possible to obtain consent in time for the thing to be done in benefit.

**Sec. 92, I.P.C. Act done in good faith for benefit of a person without consent.** Nothing is an offence by reason of any harm which it may cause to a person for whose benefit it is done in good faith, even without that person’s consent, if the circumstances are such that it is impossible for that person to signify consent, or if that person is incapable of giving consent, and has no guardian or other person in lawful charge of him from whom it is possible obtain consent in time for the thing to be done with benefit:

**Provided –**

**Firstly** – That this exception shall not extend to the intentional causing of death, or the attempting to cause death.
Secondly – That this exception shall not extend to the doing of anything which the person doing it knows to be likely to cause death, for any purpose other than the preventing of death or grievous hurt, or the curing of any grievous disease or infirmity.

Thirdly – That this exception shall not extend to the voluntary causing of hurt, or to the attempting to cause hurt, for any purpose other than the preventing of death or hurt.

Fourthly – That this exception shall not extend to the abetment of any offence, to the committing of which offence it would not extend.

Illustrations

(a) Z is thrown from his horse, and is insensible. A, a surgeon, finds that Z requires to be trepanned. A not intending Z’s death, but in good faith, for Z’s benefit, performs the trepan before Z recovers his power of judging for himself. A has committed no offence.

(b) Z is carried off by a tiger. A fires at the tiger knowing it to be likely that the shot may kill Z, but not intending to kill Z, and in good faith intending Z’s benefit. A’s ball gives Z a mortal wound. A has committed no offence.

(c) A, a surgeon sees a child suffer an accident, which is likely to prove fatal unless an operation be immediately performed. There is no time to apply to the child’s guardian. A performs the operation inspite of the entreaties of the child, intending, in good faith, the child’s benefit. A has committed no offence.

(d) A, is in a house which is on fire, with Z, a child. People below hold out a blanket. A drops the child from the housetop, knowing it to be likely that the fall may kill the child, but not intending to kill the child, and intending, in good faith, the child’s benefit. Here, even if the child is killed by the fall, A has committed no offence.

10.3.5 Negligence in medical practice

These days, cases relating to doctors’ professional negligence are on the increase in consumer jurisdiction. Therefore, a medical man should not only be aware of his professional duties, but should also know what constitutes ‘medical negligence’ and should keep away from any act or omission that may make him liable for an action against him.

Definition: Negligence, in general, is the breach of a duty to take care which results in damage to the person receiving service. It is want of proper care or attention in rendering service judged form
the standards of performance by a reasonable man. The Supreme Court, in *Poonam Verma v. Ashwin Patel & Ors*, II(1996) CPJ I (SC), has defined ‘negligence’ as thus: “Negligence as tort is the breach of a duty caused by omission to do something which a reasonable man would do, or doing something which a prudent and reasonable man would not do”.

**Constituents of negligence**

There are three constituents of negligence – (i) a legal duty to exercise due care; (ii) breach of the duty, and (iii) damage as a consequence.

i. **Legal Duty To Exercise Due Care**

The foremost question to be considered is whether the doctor had a legal duty to exercise due care to the patient; in other words, whether the doctor had entered into a doctor-patient relationship with the patient. A doctor does not have a legal duty towards a patient with whom he has no such relationship. Where such a relationship exists, the doctor has a legal duty to render medical service to the patient, irrespective of whether the relationship is contractual or the service is rendered gratuitously.

ii. **Breach of the duty**

Once a medical practitioner has undertaken to render medical service to a patient there should not be any breach of the duty as long as the doctor-patient relationship exists. The question whether a medical practitioner has committed any breach of his duty in care of his patient is not always simple to decide. Breach of the duty and liability of the doctor will always depend upon the circumstances of the particular case. The Supreme Court, in the case of negligence against a surgeon, in *Laxman Balakrishna Joshi v. Trimbak Bapu Godbole & Anr*, (1969) I SCR 206 at 213; AIR 1969 SC 128, has held:

“The duties which a doctor owes to his patient are clear. A person who holds himself out ready to give medical advice and treatment impliedly undertakes that he is possessed of skill and knowledge for the purpose. Such a person when consulted by a patient owes him certain duties, viz., a duty of care in deciding whether to undertake the case, a duty of care in deciding what treatment to give or a duty of care in the administration of that treatment. A breach of any of these duties gives a right of action for negligence to the patient. The practitioner must bring to his task a reasonable degree of skill and knowledge and must exercise a reasonable degree of care. Neither the very highest nor a very low degree of care and competence judged in the light of the particular circumstances of each case is what the law require”.
Doctors are not liable for everything that happens to go wrong

In the well-known case of A.S. Mittal & Ors v. State of U.P. & Ors, AIR 1989 SC 1570, the Supreme Court has observed, “But the law recognises the danger which are inherent in surgical operations. Mistakes will occur on occasions despite exercise of reasonable skill and care”.

Lord Justice Denning in Roe v. Minister of Health (1954-2 All England Reporter 181) said that we should be doing a disservice to the community at large if we were to impose liability on hospitals and doctors for everything that happens to go wrong....... We must insist on due care for the patient at every point, but we must not condemn as negligence that which is only a misadventure.

Where there are two different schools of thought

In the treatment of a patient including administration of anaesthesia if there are two different schools of thought, a doctor can take recourse to any of them he believes in, and he cannot be held guilty of negligence only because some persons have a contrary view.

iii. Damage done to the patient as a result of breach of duty

In order to hold a doctor negligent, the finding of damage in the shape of a complication or death must be present. A doctor cannot be held negligent simply because he has committed an act or omission he ought not to have done, if there is no damage done to the patient. A doctor is negligent only when the damage is done to the patient as a consequence of the breach of the doctor’s duty. There must be a direct and proximate relationship between the breach of the duty and the damage. If a patient suffers a complication which is not related to the breach of the duty of the doctor, the latter cannot be held responsible merely because the patient was under his treatment when the complication developed. In such cases, it is the duty of the doctor to be adequately prepared to face the situation where it can be anticipated. When a complication arises he should manage it with reasonable degree of skill, knowledge and care, and should not do or omit to do anything that a reasonable counterpart would have done in the given situation. Further, if a complication develops in spite of the reasonable care taken by the doctor, he cannot be held liable.

Some examples of negligence in Anaesthesia

- Improper pre-anesthetic assessment so that some serious illness is missed.
- Failure to check the equipments and gas cylinders.
Module-XI

- Failure to recognize misplacement of end tracheal tube leading to hypoxia or anoxia.
- Damage to soft tissues.
- Administration of wrong drug or anaesthetic.
- Over dosage.
- Wrong technique.
- Cautery burn during anaesthesia.
- Early extubation leading to complications.
- Intra-arterial injection of thiopentone leading to ischaemia/necrosis of fingers.
- Local anaesthetic entering circulation, leading to convulsions, cardiac depression and death.
- Use of large-bore needle in spinal anaesthesia.

Cases against negligence may be brought against a medical practitioner in a Civil Court or a Criminal Court, and accordingly the negligence is known as Civil or Criminal negligence. It can also be a subject of enquiry by the Medical Council. An action for negligence can now be brought in consumer jurisdiction before a Consumer Forum, by a patient if he happens to be a consumer of the medical service under Section 2(1)(d)(ii) of the Act.

Civil Negligence

This is the usual form of negligence, as described above, in which a patient or his legal heirs bring an action of damages in Civil Court against the medical practitioner, who had a legal duty to take care of the patient, and the practitioner committed breach in his duty with consequent damage to the patient. The patient may bring a complaint alleging negligence of the practitioner before the Consumer Forum, if the patient is a ‘Consumer’ under the Act. If the patient is able to establish negligence on the part of the practitioner, he is entitled to compensation for the sufferings due to the complication. The patient has a choice either to file a civil suit in a Civil Court or to file a complaint before the Consumer Forum, but he cannot take recourse to both of them. It is seen that almost every patient prefers to take the shelter of the Consumer Forum because of the speedy and inexpensive nature of the relief provided by the Fora.

Criminal Negligence

Here the negligence is more grave than the civil negligence. When a doctor, whether qualified or unqualified, has committed an act or made an omission which is extremely or grossly rash or
grossly negligent, and the grossly negligent act is proved to be the direct and proximate cause of the patient’s death, it is an act of criminal negligence. In such cases, the doctor may be prosecuted by the police and charged in a Criminal Court under Section 304-A of the Indian Penal Code and is punishable with imprisonment for a term which may extend up to two years, or with a fine, or with both. Here again, it is required that the grossly negligent act is proved to be the proximate and direct or substantive cause of death of the patient. Section 304-A of the Indian Penal Code reads as thus:

304-A I.P.C. Causing death by negligence. Whoever causes the death of any person by doing any act so rash or negligent not amounting to culpable homicide, shall be punishable with imprisonment of either description (i.e. rigorous or simple) for a term which may extend to two years, or with fine or with both”.

i. **What is a rash act.** Rashness is thoughtlessness, the tendency to rush headlong, with no eyes on the probable or possible consequences of the undertaken act. It is doing some positive act which no man in his senses or no prudent and reasonable man in his place, would ever do. For example, a doctor not conversant with surgical aspects of a problem, rushes to open the abdomen, thinking foolishly that God will help him and nothing untoward will happen. This is rashness.

ii. **Grossly negligent act.** If the act of the doctor is not ‘rash’, it must be a ‘negligent act’. Negligence has been described above, and such a negligence must be gross, resulting from gross carelessness or gross ignorance.

iii. **There should be absence of intention to cause death.** In a case of criminal negligence there is a presumption of absence of intention to cause death of the patient, and the want of knowledge that the act done will most probably result in death.

iv. **There is proximate causal relationship between the act and the death.** Direct and immediate relationship between the rash or negligent act of the doctor and the death of the patient must be established beyond doubt. As the charges are grave, the proof should be clear. It must be clear that but for the doctor’s alleged gross rashness and/or negligence, the patient would not have died in the ordinary course.

In the pursuit of his profession, a medical man may come across situation where due to some mishap he may apprehend that he could be charged under Section 304-A of the Indian Penal Code, viz., death of a patient during or immediately after the operation, administration of an injection or any minor procedure. It is, therefore, imperative for every medical practitioner to be conversant
with the Section 304-A I.P.C., and without getting unnerved, he should be able to take necessary steps to tackle the situation he is faced with. The practitioner should not allow the fears to overpower him, as unscrupulous heirs of the deceased may be tempted to exploit him.

The offence under Section 304-A I.P.C. is bailable i.e. the doctor is entitled to bail as a matter of right and he cannot be put under detention as soon as he has furnished the bail. As the offence is punishable at the most with two years’ imprisonment and/or with fine, the amount of bail that can be legitimately demanded by police cannot be any way high, particularly in the case of a doctor who has medical practice at his command for earning his livelihood. A police officer cannot act unreasonably and under the pretext of non-furnishing of bail, he cannot put him under arrest and detention. Any such act on the part of the police officer will expose him to being held up, tried and convicted of an offence of wrongful confinement punishable under Section 342 I.P.C. The fear of doctors in such cases is ill-founded and they should boldly and fearlessly face this sort of action of police.

10.3.6 Death on operation table (DOT)

An anaesthetist may come across a situation where patient may die on the operation table during anaesthesia or during recovery from anaesthesia. Such a grave incident may happen due to an act of negligence or omission by the anaesthetist, or it may be only a mishap where the anaesthetist is not liable. Death may also occur due to some lapse on the part of surgeon or due to some surgical cause.

Causes of death due to anaesthesia

i. Due to anaesthetic agent, causing
   - cardiac arrhythmia.
   - cardiac arrest.
   - respiratory arrest.
   - malignant hyperpyrexia due to muscle relaxants.

iii. Respiratory failure, due to depression of respiratory centre
   - overdose of anaesthetics.
   - overdose of muscle relaxants.
   - overdose of pre-anaesthetic medication.
iii. Cardio-respiratory failure
   - inadequate ventilation.
   - intubations in a light anaesthetic plane.
   - excess carbon dioxide inhalation.
   - too rapid induction.

iv. Laryngeal spasm

v. Obstruction of larynx or trachea by swab, blood or vomitus, etc.

vi. Equipment related
   - kinked pipes.
   - cross tubes.
   - malfunctioning of machine.
   - explosion, ignition or electric current injury.

vii. Fault of anaesthetist
   - aspiration of vomitus during intubation.
   - breathing circuit disconnection.
   - inadequate monitoring.
   - failure to detect an underlying disease.

viii. Lack of trained personnel, outdated equipment, lack of proper facilities.

**Causes of death related to surgery**

- poor risk case due to injury or disease.
- inadvertent cutting of a big vessel.
- surgical shock e.g. unduly prolonged surgery.
• patient’s poor general condition due to systemic disease e.g. diabetes, hypertension or hypotension, old age.

**Complications of anaesthesia**

• death
• hypoxia resulting in brain damage
• paraplegia
• blindness
• aspiration
• pneumonia
• atelectasis
• pulmonary oedema
• pneumothorax
• bronchospasm
• air embolism
• oxygen intoxication
• neurological disorders
• myelopathy, arachnoiditis after spinal anaesthesia

**Responsibility of anaesthetist or surgeon ?**

The dividing line of responsibility between the surgeon and the anaesthetist may not always be well-defined. The surgeon is responsible for his decision to undertake a case for surgery, the extent of surgery and whether to cut-short or extend a procedure. He is guided by the anaesthetist as to the pre-operative status of the patient and his condition during the operation. Intravenous fluid replacement and blood transfusion is a function of both the surgeon and the anaesthetist. The choice of anaesthesia is made by the anaesthetist in conjunction with the surgeon and the patient. Modern surgery is a team work with a joint responsibility.
In case of death

- The anaesthetist and his staff should not panic as it may create a misunderstanding in the minds of the onlookers. On the contrary, the situation should be explained to the relatives and assurance should be given that whatever best could be done under the circumstances has been provided.

- The hospital authorities and the police should be informed even if the relatives are not willing.

- The staff should not leave the theatre.

- Nothing should be removed from the operation theatre including the broken ampoules, empty bottles of I.V. fluids and blood, used syringes, etc. till the police arrives and permits to remove them.

- If the cause of death is clear, the postmortem examination may not be ordered by the police.

- If the cause of death is obscure, the team of the operation theatre should insist for a postmortem examination for their own safety and defense.

- If the relatives feel that some negligent act has been done, the doctor should not hesitate in explaining them the real facts.

- A complete, detailed, contemporaneous and signed record should be maintained.

- Copies of all correspondences with the patient’s relatives and the police should be preserved.
Module - II
Physiological Changes During Pregnancy
as Relevant to the Anaesthesiologist
Module Structure

2.1 Introduction 19
2.2 Objectives 19
2.3 Contents
   2.3.1 Body weight and composition 19
   2.3.2 Metabolism 20
   2.3.3 Respiration 20
   2.3.4 Heart and circulation 27
   2.3.5 Hematology and coagulation 32
   2.3.6 Gastrointestinal system 34
   2.3.7 Liver and gall bladder 35
   2.3.8 Renal system 35
   2.3.9 Nervous system 36
   2.3.10 Endocrine system 36
   2.3.11 Musculoskeletal system 37
   2.3.12 The immune system 38
   2.3.13 Anaesthetic implications 38
2.4 Salient points to remember 40
2.5 Check your progress 41
2.6 Further readings 44
2.1 Introduction

The obstetric anesthetist has the care of two lives in his hands; this responsibility is increased by the fact that Pregnancy is a Physiological State, so it is necessary to have a good understanding of how pregnancy and labor alter maternal physiology and ways in which these changes may have effect upon and be affected by anesthetic procedures and anesthetic agents.

Important issues when anaesthetizing a pregnant woman for labor, vaginal delivery or caesarean delivery are:

- Physiological changes of pregnancy
- The direct and indirect effects of anaesthetics on the foetus
- The benefits and risks of various anaesthetic techniques to the mother.
- In this module you will learn about these issues.

2.2 Objectives

After going through this module you should be able to

- Describe physiological changes in Pregnancy.
- Describe anesthetic implications of these changes

2.3 Contents

2.3.1 Body weight and composition

Increase in mean weight = 17% of Pre-pregnant weight or approx 12 kg.

- Amniotic fluid = 1kg.
- Uterus = 1kg
- Fetus and Placenta = 4kg.
- Blood volume = 2kg.
- Interstitial fluid = 2kg.
- Deposition of new fat and protein = 4kg
Normal weight gain (approximately) during
1st trimester = 1-2kg.
2nd trimester = 5-6kg.
3rd trimester = 5-6kg.

2.3.2 Metabolism

Oxygen consumption increases by 30% to 40%

Primarily due to increased
Metabolic needs of
a) foetus b) uterus
and c) placenta
Secondarily due to increased
a) Cardiac work
b) respiratory work

2.3.3 Respiration

i Lung Volumes
- Tidal volume (TV) is the volume of air inhaled or exhaled during normal quiet breathing
  Normal TV is 500ml
- Inspiratory reserve volume is the maximal volume of gas that can be inhaled following a
  normal inspiration while at rest.
  Normal IRV is 3000ml
- Expiratory reserve volume is the maximal volume of gas that can be exhaled following a
  normal expiration
  Normal ERV is 1000ml
- Residual volume is the volume of gas remaining in the lungs after a forced exhalation
  Normal RV is 1500ml
• Vital capacity is the maximal amount of gas that can be exhaled after a maximal inhalation

\[ VC = TV + IRV + ERV \]

Normal VC = 4500ml

• Inspiratory capacity is the maximal amount of gas that can be inhaled from the resting expiratory position after a normal exhalation

\[ IC = TV + IRV \]

Normal IC = 3500ml

• Functional residual capacity is the remaining lung volume at the end of a normal quiet expiration

\[ FRC = RV + ERV \]

Normal FRC = 2500ml

• Total lung capacity is the lung volume at the end of a maximal inspiration

\[ TLC = VC + RV \]

Normal TLC = 6000ml.

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>VC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRV</td>
<td>3.3</td>
<td>1.9</td>
</tr>
<tr>
<td>TV</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>ERV</td>
<td>1.0</td>
<td>0.7</td>
</tr>
<tr>
<td>RV</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>IC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FRC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ii  Mechanics

• Thoracic cage increases in circumference by 5 - 7cm in pregnancy because of increases in both the anteroposterior and transverse diameters.

• Capillary engorgement of the nasal and oropharyngeal mucosae and larynx begins early in the first trimester and increases progressively throughout pregnancy.
Module-II

Role of Hormones – progesterone, cortisone and relaxin on Airway?

Progestrone/Cortisone/Relaxin
Directly & Indirectly Via
↑-adrenergic activity
↓
Dilation of larger airway below larynx
↓
Airway conductance increases

Breathing is Diaphragmatic during pregnancy
↓
Enlarging uterus pushes the diaphragm anteriorly & to the left

Reduced O\textsubscript{2} reserve in the body
↓
RR and TV
↓
in minute volume
↓
Hypocapnia

Expected ↑ in airway resistance but compensated

Effects of pregnancy on Respiratory mechanics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diaphragmatic excursion</td>
<td>Increased</td>
</tr>
<tr>
<td>Chest wall excursion</td>
<td>Decreased</td>
</tr>
<tr>
<td>Pulmonary resistance</td>
<td>Decreased 50%</td>
</tr>
<tr>
<td>\text{FEV}_1</td>
<td>No change</td>
</tr>
<tr>
<td>\text{FEV}_1/FVC</td>
<td>No change</td>
</tr>
<tr>
<td>Flow volume loop</td>
<td>No change</td>
</tr>
<tr>
<td>Closing capacity</td>
<td>No change</td>
</tr>
</tbody>
</table>
iii Changes in Lung Volumes and Capacities

There are 4 basic lung volumes and 4 “derived capacities” which are combinations of these lung volumes.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRV</td>
<td>+ 5%</td>
</tr>
<tr>
<td>TV</td>
<td>+ 45%</td>
</tr>
<tr>
<td>ERV</td>
<td>- 25%</td>
</tr>
<tr>
<td>RV</td>
<td>- 15%</td>
</tr>
<tr>
<td>IC</td>
<td>+ 15%</td>
</tr>
<tr>
<td>FRC</td>
<td>- 20%</td>
</tr>
<tr>
<td>VC</td>
<td>No change</td>
</tr>
<tr>
<td>TLC</td>
<td>- 5%</td>
</tr>
<tr>
<td>Dead Space</td>
<td>+ 45%</td>
</tr>
<tr>
<td>Respiratory rate</td>
<td>No Change</td>
</tr>
</tbody>
</table>

iv Ventilation

Minute ventilation = increases by + 45%

Alveolar ventilation = increases by + 45%

- The increased ventilation during pregnancy results from hormonal changes and increased carbon dioxide production.
- Progesterone increases the sensitivity of the central respiratory center to carbon dioxide and acts as a Direct Respiratory Stimulant.
v Blood gases

### Blood Gases During Pregnancy

<table>
<thead>
<tr>
<th>Description</th>
<th>Non-pregnant</th>
<th>Trimester</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>First</td>
<td>Second</td>
<td>Third</td>
</tr>
<tr>
<td>PaCO₂</td>
<td>40</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>PaO₂</td>
<td>100</td>
<td>107</td>
<td>105</td>
<td>103</td>
</tr>
<tr>
<td>pH</td>
<td>7.40</td>
<td>7.44</td>
<td>7.44</td>
<td>7.44</td>
</tr>
<tr>
<td>HCO₃</td>
<td>24</td>
<td>21</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

**What happens to the Gradient between end-tidal carbon dioxide tension and arterial partial pressure of carbon dioxide (PaCO₂)?**

During early pregnancy, at term gestation and in the early postpartum period, the two measurements are equivalent (although a gradient exists in non-pregnant individuals) due to reduction of alveolar dead space (i.e. un-perfused alveoli), which results from a marked increase in cardiac output.

**How does moving a pregnant woman from supine to erect or lateral decubitus position improves arterial oxygenation and decreases the alveolar-to-arterial oxygen gradient?**

A PaO₂ below 100 mm Hg in supine position due to FRC < CC (Closing capacity) in up to 50% leads to hypoxemia in supine position.

- ↓ Cardiac output
- ↓ Mixed venous O₂ content
- ↑ arterio venous O₂ difference
- ↓ Aorto-caval compression

| PaO₂ below 100 mm Hg in supine position | Aorto-caval compression | FRC < CC (Closing capacity) in up to 50% | ↓ Cardiac output | ↓ Mixed venous O₂ content | ↑ arterio venous O₂ difference | Hypoxemia in supine position |
vi  Acid Base Balance

Increase in respiratory rate and tidal volume results in respiratory alkalosis and compensatory metabolic acidosis develops. Serum bicarbonate concentration becomes 20 meq/L.

vii  Metabolism and Respiration

<table>
<thead>
<tr>
<th>During Labor</th>
<th>During puerperium</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FRC returns to normal by 1 to 2 weeks</td>
</tr>
<tr>
<td></td>
<td>O₂ consumption, TV, MV elevated till 6-8 weeks postpartum</td>
</tr>
<tr>
<td>Hyperventilation (↑ MV)</td>
<td>Alveolar and mixed venous PCO₂ low till 6-8 weeks</td>
</tr>
<tr>
<td>↑Uterine Activity</td>
<td>↑ metabolic demands</td>
</tr>
<tr>
<td></td>
<td>maternal expulsive efforts during 2nd stage</td>
</tr>
<tr>
<td></td>
<td>↑ O₂ consumption</td>
</tr>
<tr>
<td></td>
<td>Progressive rise of Blood lactate levels</td>
</tr>
</tbody>
</table>

So, when opioid analgesia/epidural analgesia is administered during

First Stage: of labor,

- Minute ventilation
- O₂ Consumption
Lactate Concentration

PaCO₂ remain at near normal values. As normal physiology gets altered during pregnancy, we must note a few things regarding respiration during anesthesia in a pregnant woman

- Remember to “PRE-OXYGENATE”. Or else the arterial O₂ tension will fall rapidly
- Securing of the airway could be problematic!

How?

- There are increased chances of bleeding from nose or oropharynx due to congestion of airway.
- May encounter difficulty in intubation due to mucosal edema.

When a higher PO₂ is required for Hb to bind a given amount of oxygen, the O₂ -Dissociation curve shifts to the right

During the right shift: the affinity of Hb for O₂ ↓

Means, O₂ is easily given up to the tissues

P₅₀ is a convenient index of such shifts

What is P₅₀?

It is the PO₂ at which Hb is half saturated with O₂. The higher the P₅₀, the lower the affinity of Hb for O₂.

And when does this happen?

Right Shift occurs in

- ↑Temperature (as fever)
- ↑H⁺ (i.e. ↓pH): acidosis/shock/diabetic ketoacidosis/lactic acidosis
- ↑In 2, 3 DPG -
2.3.4 Heart and circulation

What is stroke volume?
It is the volume of blood pumped out by the heart in one beat.

What is Cardiac Output?
It is the volume of blood pumped out by the heart in one minute
CO = HR × SV.

i Examination of the heart

- Elevation of the diaphragm shifts the heart anteriorly and to the left during pregnancy.

Therefore look for Apical Impulse in the fourth intercostal space lateral to the mid-clavicular line

- S1 = accentuation with exaggerated splitting of mitral and tricuspid components
- S2 = Changes little
- S3 = heard easily during latter half of pregnancy
- S4 = Identified in up to 16% of pregnant women but disappears at term

- Murmurs = a grade I or II early systolic to mid-systolic at left sternal border due to dilatation of the Tricuspid Annulus resulting in regurgitation.
- ECG reveals
  - Sinus tachycardia
- Shortening of P-R interval
- QRS axis shifts to Right (During first trimester)  
  Left (During Third Trimester)
- T-wave axis shifted leftwards
- Depressed S-T segment

- Echocardiography
  Left ventricular hypertrophy by 12 weeks gestation (50% increase in mass)
  Aortic, pulmonary and mitral valve areas increase by 12-14%

ii Central Hemodynamics

Prerequisites for accurate determination of hemodynamic changes of pregnancy:

- Measurement to be made in subjects in resting state
- Measurement to be made in position minimizing compression of aorta and inferior vena cava by the gravid uterus

### Central Hemodynamics at Term Gestation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac Output</td>
<td>+ 50%</td>
</tr>
<tr>
<td>Stroke volume</td>
<td>+ 25%</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>+ 25%</td>
</tr>
<tr>
<td>Left ventricular end diastolic volume</td>
<td>Increased</td>
</tr>
<tr>
<td>Left ventricular end systolic volume</td>
<td>No change</td>
</tr>
<tr>
<td>Ejection Fraction</td>
<td>Increased</td>
</tr>
<tr>
<td>Pulmonary Capillary wedge pressure</td>
<td>No change</td>
</tr>
<tr>
<td>Central Venous pressure</td>
<td>No change</td>
</tr>
<tr>
<td>Systemic Vascular resistance</td>
<td>- 20%</td>
</tr>
</tbody>
</table>
iii Organ perfusion

- Uterus, kidneys and extremities (skin and skeletal muscles) receive more blood supply during pregnancy. Uterine blood flow increases to 700 – 800 ml/minute at term gestation.

- Blood flow to other major organs (e.g. Brain, liver) DOES NOT CHANGE.

iv Blood pressure

B.P. = CO x SVR (Systemic vascular resistance)

- Position/age/parity affect blood pressure measurement in pregnant women.

- Systolic B.P. minimally affected by pregnancy. Diastolic B.P. falls to a greater degree (than does systolic B.P.) i.e. may show a slight mid pregnancy dip.
A pregnant women should never lie flat on her back

On lying flat, the enlarged uterus compresses the inferior vena cava (IVC) and lower aorta.

**IVC Compression**

- Venous blood return through other routes

**Aorta compression**

- Venous return
- Compensation in BP by systemic vascular resistance

↓

Engorged epidural veins Decrease uterine flow

↓

Sympathetic block (SAB) causes drastic ↓ in BP

↓

**What if you forget?**

↓ Uterine blood flow on giving spinal Epidural veins get engorged as venous blood returns through them

↓↓↓ in BP

Fetal asphyxia Reduced kidney perfusion

Increased chances of damaging these engorged epidural veins, when giving a spinal block/epidural block

**SO, ALWAYS PUT A WEDGE UNDER THE RIGHT HIP!**
In pregnancy the requirements of local anesthetic drug to be injected in spinal or epidural block is reduced. This is because, within the rigid spinal canal the increased venous volume reduces the effective volume of the extradural space.

↓
So, the usual drug volume produces a greater height of block
↓
More hypotension.

**Blood Pressure** = C.O. x SVR
= SV x HR x SVR
= Venous return x m. contractility x HR x SVR

So, if there is hypotension, consider the following factors:

A. ↓ in venous return

1. This could be due to hypovolemia
   Hemorrhage or Dehydration

2. Due to ↑ intrathoracic pressure as in tension pneumothorax /IPPV/PEEP

3. Due to aortocaval compression as in intra-abdominal tumours
B. Reduced Myocardial Contractility

- This could be due to hypoxia, myocardial ischaemia or infarction, acidosis.
- Deep anesthesia like halothane, beta blockers
- Tachy arrhythmias
- Sepsis
- Beta blockers

C. Decrease in heart rate: Halothane

Beta-blockers

D. Decrease in systemic vascular resistance

- Spinal anaesthesia – due to sympathetic blockade
- Sepsis
- Histamine release due to drugs
- Anaphylaxis

When BP falls, the SYMPATHETIC SYSTEM gets activated, to counter the fall in BP

So, if contractility decreases → there is an increase in heart rate or ↑ in SVR to maintain BP. Similarly if SVR falls due to peripheral vasodilatation – the Heart rate increases.

2.3.5 Hematology and coagulation

Blood

PLASMA

↑ 55%

CELLS

-RBC (↑ by 30%)
-W.B.C.
-Platelets

Blood volume increases during pregnancy
→ The increase in plasma volume is much more than the increase in the cells.

↓

Leads to a state of RELATIVE HAEMODILUTION (physiologic anaemia)
- This haemodilution helps to compensate for the maternal blood loss at delivery which is 300 to 500ml in a normal vaginal delivery and 750 to 1000ml in a caesarean section

**Pregnancy represents state of accelerated but compensated intravascular coagulation**

**How**

<table>
<thead>
<tr>
<th>Changes in coagulation in fibrinolytic parameters at term gestation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Increased factor concentration:</td>
</tr>
<tr>
<td>- Factor I (Fibrinogen)</td>
</tr>
<tr>
<td>- Factor VII (Proconvertin)</td>
</tr>
<tr>
<td>- Factor VIII (Antihemophilic factors)</td>
</tr>
<tr>
<td>- Factor IX (Christmas factor)</td>
</tr>
<tr>
<td>- Factor X (Stuart Prower factor)</td>
</tr>
<tr>
<td>- Factor XII (Hageman factor)</td>
</tr>
<tr>
<td>• Unchanged factor concentrations</td>
</tr>
<tr>
<td>- Factor II (Prothrombin)</td>
</tr>
<tr>
<td>- Factor V (Proaccelerin)</td>
</tr>
<tr>
<td>• Decreased factor concentrations</td>
</tr>
<tr>
<td>- Factor XI (Thromboplastin antecedent)</td>
</tr>
<tr>
<td>- Factor XIII (Fibrin stabilizing factor)</td>
</tr>
<tr>
<td>• Prothrombin time = -20% (shortened)</td>
</tr>
<tr>
<td>• Partial thromboplastin time = -20% (shortened)</td>
</tr>
<tr>
<td>• Antithrombin III = decreased</td>
</tr>
<tr>
<td>• Platelet count = no change or decreased</td>
</tr>
<tr>
<td>• Bleeding time = -10% (shortened)</td>
</tr>
<tr>
<td>• Fibrin degradation product = increased</td>
</tr>
<tr>
<td>• Plasminogen = increased</td>
</tr>
</tbody>
</table>
2.3.6 Gastrointestinal System

Consider every pregnant woman to be full stomach so take adequate precautions

**GASTRIC EMPTYING DELAYED**

- Intra-gastric Pressure increased  \( \downarrow \)
  - Stasis of food  \( \rightarrow \)
  - Esophageal peristalsis and intestinal transit time slowed  \( \downarrow \)
  - Chance of aspiration of solids  \( \uparrow \)
  - Atelectasis, pneumonitis or lung abscess

**Aspiration is more common in pregnant women**

- Enlarging uterus pushes stomach upwards into left side of diaphragm  \( \downarrow \)
  - Displaces intra-abdominal segment of esophagus into thorax  \( \downarrow \)
  - Gastro esophageal angle changes  \( \downarrow \)
  - Prevents rise in lower esophageal tone, which normally accompanies an increase in intra-gastric pressure.

- Reduction in the tone of lower esophageal sphincter  \( \downarrow \)
  - All these factors increase the chances of reflux  \( \downarrow \)
  - The chances of acid aspiration increase  \( \downarrow \)
  - Chemical pneumonitis known as Mendelsion syndrome

**Effects of analgesia during labor on gastric function**

- Opioids  \( ++ \)
  - Impaired gastric emptying  \( \rightarrow \)
  - Reduced tone of Lower Esophageal pressure zone  \( \downarrow \)
  - Epidural local anesthetic  \( -- \)
2.3.7  *Liver and gall bladder*

Liver size/morphology/blood flow do not change during pregnancy.

- Serum bilirubin/SGPT/SGOT/lactic dehydrogenase to upper limits of normal range.
- Alkaline phosphatase activity increases 2–4 folds mostly from the production by the placenta.

**Pregnancy predisposes to gallstone formation**

| Fasting and residual volumes of gall bladder increases | Rate of gall bladder emptying slows | Bile stone formation | Bile tends to concentrate |

2.3.8  *Renal System*

- Kidneys enlarge in size
- Ureters and renal pelvis dilate

Filtration fraction decreases

+ Greater increase in Renal plasma flow (75 – 85%)

1. Blood urea nitrogen concentration falls by 8-9mg/dl
2. Serum creatinine falls to 0.5 – 0.6mg/dl

Glycosuria (1-10gm/24 hours) in 90%

because greater amount of glucose going to the renal tubules which exceeds their resorptive capacity.
2.3.9 **Nervous System**

i  **Pregnancy induced analgesia** - The analgesic requirement is reduced in pregnancy due to elevated threshold for pain during gestation; role of endorphins (Specially β-endorphin implicated).

ii **Vertebral Column**

Epidural space may be regarded as a rigid tube, which contains 2 fluid filled structures, the dural sac and the epidural venous plexus. When the volume within one distensible tube increases there is compensatory loss of fluid from the other.

<table>
<thead>
<tr>
<th>During pregnancy compression of inferior vena cava by gravid uterus</th>
</tr>
</thead>
<tbody>
<tr>
<td>↓</td>
</tr>
<tr>
<td>↑Venous pressure below the obstruction</td>
</tr>
<tr>
<td>↓</td>
</tr>
<tr>
<td>Diverts venous blood through vertebral plexus within the epidural space [Betsonic pressure]</td>
</tr>
<tr>
<td>↓</td>
</tr>
<tr>
<td>Distends the veins and reduces the spinal cerebrospinal fluid volume.</td>
</tr>
</tbody>
</table>

2.3.9 **Endocrine System**

i **Thyroid function**

- Thyroid gland enlarges → ↑ vascularity + follicular hyperplasia
- 50% increase in total T₃ and T₄ concentrations (Due to estrogen induced increase in thyroid binding globulin)
- Concentration of free T₃ and T₄ unchanged
- TSH ↓ in the first trimester but comes to normal at term
ii  Adrenal Cortical function

| Estrogen induced enhanced hepatic synthesis of corticosteroid binding globulin |
|↓|
|↓ Clearance | 100% increase of plasma cortisol at the end of first trimester and 200% increase at term |
|↑|
|Hypertrophy of zona fasciculata|

iii  Pancreas and glucose metabolism

Pregnancy is a diabetogenic state, as the placenta secretes placental lactogen leading to reduced tissue sensitivity to insulin.

- Altered fasting blood glucose due to high glucose use of feto-placental unit
- Pregnant women exhibit an EXAGGERATED STARVATION KETOSIS

2.3.11 Musculoskeletal System

| Uterus enlarges |
|↓|
|Lumbar lordosis enhanced |
|↓|
|Experience low back discomfort | Anterior flexion of neck and slumping of shoulders |
|↓|
|Aching/weakness/numbness of upper extremities due to traction on brachial plexus|
- Mobility of sacroiliac/sacroccocygeal/pubic joints ↑
- Widening of pubic symphysis
2.3.12 Immune System

- The blood leucocyte count rises from 6000/mm$^3$ to approximately 9000 – 11000/mm$^3$.
- Serum concentration of immunoglobulin A, G and M UNCHANGED although humoral antibody titres to certain viruses DECREASED
- Polymorphonuclear leukocyte function IMPAIRED during pregnancy
  \[ \downarrow \]
- Depressed neutrophil chemotaxis and adherence
  \[ \downarrow \]

*Increased incidence of infections with improvement of symptoms in pregnant women with autoimmune disease.*

2.3.13 Anaesthetic implications

i  Positioning the pregnant patient

- Accompanied by placing a cushion or wedge under the parturient’s right hip or placing her in the lateral decubitus position.

ii Blood replacement

- At delivery, maternal vascular capacitance is reduced by the volume of the intervillous space i.e. at least 500ml.

- Hemoconcentration occurs as maternal blood volume declines from 85 ml/kg to 65 – 70 ml/kg.

These facts should be considered when making a decision as to whether a parturient should receive crystalloid, colloid or blood for volume replacement.
iii General anaesthesia

<table>
<thead>
<tr>
<th>General anaesthesia: Anaesthetic implications of maternal physiologic changes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Endotracheal intubation</strong></td>
</tr>
<tr>
<td>• Smaller endotracheal tubes required</td>
</tr>
<tr>
<td>• Increased risk of trauma with nasotracheal intubation</td>
</tr>
<tr>
<td>• Increased risk of failed intubation</td>
</tr>
<tr>
<td><strong>Maternal oxygenation</strong></td>
</tr>
<tr>
<td>• Increased physiologic shunt when supine</td>
</tr>
<tr>
<td>• Increased rate of deoxygenation</td>
</tr>
<tr>
<td>• Increased rate of decline of $\text{PaO}_2$ during apnea</td>
</tr>
<tr>
<td><strong>Maternal ventilation</strong></td>
</tr>
<tr>
<td>• Increased minute ventilation required</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>General Anaesthesia: Pharmacology during pregnancy*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inhalation anaesthetics</strong></td>
</tr>
<tr>
<td>• Minimum alveolar concentration reduced by 20 – 40%</td>
</tr>
<tr>
<td>• Rate of induction increased</td>
</tr>
<tr>
<td><strong>Induction agents</strong></td>
</tr>
<tr>
<td>• $\text{ED}_{50}$ of thiopental reduced by 35%</td>
</tr>
<tr>
<td>• Elimination half life of thiopental prolonged</td>
</tr>
<tr>
<td>• Elimination half life of propofol unaltered</td>
</tr>
<tr>
<td><strong>Meperidine</strong></td>
</tr>
<tr>
<td>• Elimination half life unaltered</td>
</tr>
<tr>
<td><strong>Succinylcholine</strong></td>
</tr>
<tr>
<td>• Duration of blockade unaltered (or decreased)</td>
</tr>
<tr>
<td>• Sensitivity reduced</td>
</tr>
<tr>
<td><strong>Nondepolarising muscle relaxant</strong></td>
</tr>
<tr>
<td>• $\text{ED}_{50}$ of vecuronium reduced</td>
</tr>
<tr>
<td>• Elimination half life of vecuronium and pancuronium shortened</td>
</tr>
<tr>
<td>• Duration of blockade of atracurium unaltered</td>
</tr>
<tr>
<td><strong>Chronotropic agents</strong></td>
</tr>
<tr>
<td>• Response diminished</td>
</tr>
<tr>
<td><strong>Pressors</strong></td>
</tr>
<tr>
<td>• Response variable</td>
</tr>
</tbody>
</table>
iv Regional anaesthesia

<table>
<thead>
<tr>
<th>Regional Anaesthesia: Anaesthetic implications of maternal physiologic changes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technical consideration</strong></td>
</tr>
<tr>
<td>• Lumbar lordosis increased</td>
</tr>
<tr>
<td>• Head-down tilt when in lateral position</td>
</tr>
<tr>
<td>• CSF return unaltered</td>
</tr>
<tr>
<td>• Reduced sensitivity of “hanging drop technique”</td>
</tr>
<tr>
<td><strong>Hydration</strong></td>
</tr>
<tr>
<td>• Increased fluid requirements to prevent hypotension</td>
</tr>
<tr>
<td><strong>Local anaesthetic dose requirements</strong></td>
</tr>
<tr>
<td>• Subarachnoid dose reduced by 20 – 33%</td>
</tr>
<tr>
<td>• Epidural dose (large dose) unaltered</td>
</tr>
<tr>
<td>• Epidural dose (small dose) reduced</td>
</tr>
<tr>
<td>• Relative to that required by non-pregnant women</td>
</tr>
</tbody>
</table>

2.4 **Salient points to remember**

- Oxygen consumption is increased by 30-40% in pregnancy, hence the pregnant patient is susceptible to rapid desaturation.

- Due to aorto caval compression by the gravid uterus, the pregnant patient should never lie supine. A wedge should be placed under the right hip.

- Due to caval compression, there is engorgement of epidural veins, increasing the chances of intravascular injection while attempting an epidural injection and reduces the local anesthesia dose required to attain the same level of block.

- Gastric emptying is delayed in pregnancy. Hence the chances of acid aspiration are more. Adequate precaution should be taken before and during induction.
2.5 Check your progress

i. All of the following Cardio-vascular parameters change during pregnancy except:
   a). Cardiac Output
   b). Blood Volume
   c). Central Venous Pressure
   d). Systemic Vascular Resistance

ii. All are true about supine hypotension syndrome except:
   a). Hypotension associated with pallor
   b). Relieved by putting a wedge under parturient’s left hip
   c). Trendelenburg position may exacerbate the condition
   d). Occurs during latter half of the pregnancy

iii. All of the following drugs cross the placenta except:
   a). Thiopental
   b). Glycopyrrolate
   c). Diazepam
   d). Morphine

iv. All of the following are the complications of the Oxytocin except:
   a). Fetal distress
   b). Uterine activity
   c). Transient systemic hypertension
   d). Maternal water intoxication

v. All of the following are true regarding the changes in the respiratory physiology during pregnancy except:
   a). ↑ Oxygen consumption
   b). ↑ Tidal volume
Module-II

c). Decreased PaCO2
d). ↑ Functional residual capacity

vi. Following factors contribute to a decrease in the uterine blood flow during pregnancy except:
a). Systemic hypotension
b). Uterine vasoconstriction
c). Uterine contraction
d). Alpha-adrenergic antagonists

vii. Drug of choice for hypotension during pregnancy is:
a). Ephedrine
b). Mephenteramine
c). Methoxamine
d). Metaraminol

viii. Absolute contra-indication to regional anesthesia include all except:
a). Infection at injection site
b). Coagulopathy
c). Pre-existing neurological disease
d). True allergy to local anesthetics

ix. Decreased segmental dose requirement of local anesthetics can be due to all of the following except:
a). Reduction of spinal CSF volume
b). Enhanced neural susceptibility to local anesthetics
c). Injections made with the patients in the lateral position
d). Injections made with the patients in the sitting position
Following hematological changes occur during pregnancy except:

a). Factor II (Prothrombin) increases
b). Hypercoagulable state
c). Dilutional anemia
d). Nutritional anemia

Which of the following agents may be administered to suppress uterine activity in pre-term labor:

a). MgSO₄
b). Ethanol
c). Beta-sympathomimetics
d). Glucocorticoids

Hemodynamic measurements taken in pre-eclamptic patients prior to therapeutic intervention likely would reveal:

a). A high systemic vascular resistance
b). A decrease in Cardiac index
c). An increase in heart rate
d). An increased intra-vascular volume

State true or false

- Cell-mediated immunity is markedly depressed in pregnancy
- Increase in serum pseudo-cholinesterase activity occurs in pregnancy
- ‘Pyrosis’ is an uncommon feature in a pregnant woman
- Intra-gastric pressure is unchanged during pregnancy
- Serum Alkaline Phosphatase is secreted by placenta
- Minimal alveolar concentration increases during pregnancy
- Naso-tracheal intubations should be avoided in pregnant women
- Physiological dead space decreases towards term in pregnancy
Module-II

Answers

i. c
ii. b
iii. b
iv. c
v. d
vi. d
vii. a
viii. c
ix. d
x. a
xi. a
xii. a
xiii. T
xiv. F
xv. F
xvi. F
xvii. T
xviii. F
xix. T
xx. T

2.6 Further readings

- Obstetric anaesthesia – Chestnut
- Clinical anaesthesia – Barash
Module - III
Pharmacology
Module Structure

3.1 Introduction 49
3.2 Objectives 49
3.3 Contents 49

3.3.1 Inhalational anesthetic agents
Entonox
Halothane
Isoflurane
Sevoflurane 49

3.3.2 Intravenous anaesthetic agent
Thiopentone
Ketamine
Propofol 55

3.3.3 Local anaesthetics
Bupivacaine
Lignocaine
Adjuvant 59

3.3.4 Neuromuscular blocking agents
Suxamethonium
Pancuronium
Vecuronium
Rocuronium
Reversal agents 61

3.3.5 Narcotic analgesics
Pentazocine
Pethidine
Morphine
Fentanyl 66
Module-III

3.3.6 Non-narcotic analgesics  69
   Diclofenac
   Tramodol
   Ketorolac

3.3.7 Adjuvant drugs  70
   Antacids/antiemetics/prokinetics
   Benzodiazepenes, Sodium citrate
   H2 blockers, Ondansetron, Metoclopramide
   Cisapride

3.3.8 Oxytocics  73

3.3.9 Vasoactive agents  73
   Mephentermine
   Ephedrine

3.4 Salient points to remember  74

3.5 Check your progress  74

3.6 Further reading  76
3.1 Introduction

In this module you will know about the drugs used particularly in obstetric anesthetic practice. You will acquire knowledge on their uses, effects, dosages, complications and contraindications. This description will be practically oriented, so as to give you an adequate working knowledge of each drug. The time taken to read this module is 2 hrs. As pharmacology is a volatile subject, you will require repeated revisions.

3.2 Objectives

After reading the module and along with the hands-on training you should be able to

- Ascertain which drugs to be used in which situation
- Describe how to decide the dosage and route of administration of the drug
- Judge their effects and complications
- Describe how to manage their complication if and when they occur.

3.3 Contents

3.3.1 Inhalational anaesthetic agents

The ancient tradition of inhalation of fumes and vapors for intoxication forms the basis of administering anaesthetic agents by pulmonary route. Ether and chloroform were the initial agents. Now we will have brief review of pharmacokinetics of inhalational agents before going to respective agents.

Pharmacologic Principles

The safe administration of inhalational anaesthetic agents requires a good understanding of their pharmacokinetics.

These agents exert their anaesthetic effect in a way which is not fully understood, but the depth of anaesthesia is directly proportional to the tension (or partial pressure) of the agent in the brain or arterial blood.

Similarly speed of induction and recovery are related to rate of rise and fall of arterial/brain tensions.

*Dalton’s Law of partial pressures states that the pressure exerted by a mixture of ideal gases is the sum of the pressures exerted by the individual gases occupying the same volume alone.* In clinical practice we are using
gases at a pressure of 760 mm Hg. We will be referring to the partial pressure (tension) of anesthetic gases in the unit of percentage (%) i.e. 760 mm Hg of 100%.

The following factors affect the tension of anesthetic vapor in brain and in arterial blood:

Alveolar ventilation

- Concentration (or tension of the agent in the inspired gas mixture).
- Transfer of vapour from alveoli to blood in the lungs.
- Transfer of vapour from arterial blood to body tissues.

You as an anesthetist can change only the first two factors. But in the clinical practice you will manipulate only the second i.e. concentration and this will be guided by MAC.

**What is MAC?**

MAC is the minimum alveolar concentration of anesthetic agent (at one atmosphere ambient pressure) that produces immobility in 50% of those patients or animals exposed to a noxious stimulus so

- It is a measure of anesthetic potency.

There are limitations to its clinical use because

a. By definition 50% of patients move in response to incision.

b. The concept of MAC is applicable to only non-paralysed patient.

So a lower concentration than MAC may safely be used to prevent awareness, particularly when anesthesia is supplemented with nitrous oxide, opioids or other CNS depressants.

Other related terms

- $AD_{50}$
- $AD_{95}$
- MAC awake
- MAC BAR

Full term pregnancy is associated with reduced anesthetic requirement, i.e. by 25% for halothane and 40% for isoflurane.
Now we will have detailed account of nitrous oxide and halothane and a brief review of isoflurane and sevoflurane.

i  Nitrous oxide

Physical properties
- Colourless, slightly sweet smelling, non irritant
- Stable in the presence of sodalime
- Neither flammable nor explosive, but it will support combustion EVEN IN THE ABSENCE OF OXYGEN.
- As it is stored in a liquid form, pressure gauge is not an indicator of amount of content.

Entonox
Mixtures of equal volumes of $\text{N}_2\text{O}$ and $\text{O}_2$ remain gaseous under pressure and release a gas of constant composition. Below –8°C the contents separate into liquid $\text{N}_2\text{O}$ and gaseous $\text{O}_2$.

Danger
Initially that will give high $\text{O}_2$% and later high $\text{N}_2\text{O}$% (almost 100%) so may lead to hypoxia.

Impurities
During production, ammonia, nitric oxide, nitrogen, nitrogen dioxide and carbon monoxide are produced. Nitrogen dioxide in concentration greater than 50 ppm causes laryngospasm, reflex inhibition of breathing and pulmonary oedema.

Absorption and fate in the body
Nitrous oxide is readily absorbed in the body. 100 ml plasma will carry 45 ml $\text{N}_2\text{O}$. The gas being very soluble, the uptake and elimination are very fast. So there is risk of hypoxia at the time of recovery from anaesthesia – diffusion hypoxia (Fink 1955).

Systemic Effects of $\text{N}_2\text{O}$

a. CNS
- Weak anesthetic with a MAC of 104%
Module-III

- Powerful analgesic in sub anesthetic doses
- Acts primarily by directly depressing spinal transmission of impulses and activation of inhibitory supraspinal systems.

b. CVS
- Direct myocardial depressant.
- Due to action on the suprapontine areas of brain it has a sympathomimetic effect.
- Net result – No cardiovascular depression so safe in cardiac patients.

c. Respiratory System
- Decreases tidal volume and increases respiratory rate and minute volume
- During recovery – rapid outpouring – hypoxia.

d. GIT
- Causes nausea and vomiting
- Peripheral effect – causes distension of gut so avoid IPPV with face mask with N₂O.
- Central – interacts with endogenous opioid system.

e. Toxic effects
- More than 6 hours of anaesthetic exposure to N₂O causes almost total inactivation of methylcobalamin (Vit B12) → Bone marrow depression.
- During LSCS the duration of exposure to N₂O is rarely more than 2 hours so no cause for concern.

ii Halothane

Physical properties / Presentation
- Introduced into clinical practice in 1956.
- Colourless sweet smelling volatile liquid.
- Decomposed by light therefore stored in a brown bottle.
- A preservative, thymol is added - this is not volatile and stays in the vaporizer, causing it to stick. It can corrode metals.
- Blood/gas solubility is low (2.5)
Dosage and administration

The MAC value is 0.75. It takes 30 minutes for the partial pressure in the lungs to reach half of the partial pressure of the inspired gas. Therefore the gas is given at 2-3 times this level to achieve anaesthetic levels more rapidly (“overpressure”), before being turned to a lower level.

Anaesthesia is maintained with doses between 0.5 and 1.5%.

Advantages

Rapid, smooth induction, minimal stimulation of secretions so atropine is not required. It also produces bronchodilatation and some muscle relaxation. Relatively rapid recovery from anesthesia. It is non-flammable.

Disadvantages

Poor analgesia. Arrhythmias are common, especially with the use of adrenaline. Postoperative shivering and liver toxicity.

Pharmacokinetics

About 20% is metabolised in the liver. Some metabolites may cause liver toxicity due to either direct effect or hypersensitivity.

Pharmacodynamics

1. Cardiovascular System

Halothane depresses the heart in a dose related fashion resulting in a reduced cardiac output, the blood pressure and heart rate. The SVR is minimally reduced. This reduces the oxygen requirement of the heart.

Arrhythmias are common. These are made worse with hypercapnoea, hypoxia and adrenaline. Therefore only use LA solutions containing 1:160,000 or less adrenaline (corresponding to 6.25 mcg/ml)

2. Respiratory System

Halothane is non-irritant, nice to breathe. There is respiratory depression; increased rate and reduced tidal volume causing a rise in PaCO2 in a spontaneously breathing patient. Halothane also reduces secretions, the pharyngeal/laryngeal reflexes and bronchospasm.
3. **Uterus**

Halothane relaxes the uterus and may cause post-partum haemorrhage during GA for LSCS; this doesn’t occur at 0.5% - however you must keep the mother asleep.

4. **Contraindications**

Known hypersensitivity, malignant hyperthermia.

**Precautions**

Patients on beta-blockers, concurrent liver disease and arrhythmias.

Ideally patients should not have two halothane anaesthetics within 3-6 months, because of the risk of hepatotoxicity.

**Drug interactions**

β-blockers and other hypotensive agents. Adrenaline.

**Isoflurane**

- Introduced in clinical practice in 1983.
- Colourless, with slightly pungent smell.
- Blood/Gas partition coefficient = 1.4
- MAC-1.15.

**Pharmacodynamics**

- Less myocardial depressant as compared to halothane
- Decreases BP by decreasing SVR.
- Does not sensitise myocardium to catecholamines
- Powerful coronary vasodilatation
- Induction is rapid but not smooth because of irritant nature
- Relaxes pregnant uterus also
- Upto concentration of 0.75% suitable for LSCS
iv  **Sevoflurane**

Blood gas partition Coefficient = 0.69

MAC is 2%

- Very rapid induction and recovery - switch on and switch off anesthesia
- Does not sensitize myocardium.

3.3.2  **Intravenous induction agents**

Induction agents are drugs, which induce anaesthesia. Here we will look at only three agents; thiopentone (this causes a generalised depression of the CNS), ketamine (this causes a dissociative anaesthesia) and propofol.

i  **Thiopentone**

**Physical properties / Presentation**

Yellow powder, stored in nitrogen. Reconstituted with water to a 2.5% solution (5% solution was used but causes greater problems with extravasation). Available as multidose vials and 500 mg and 1 gram vials. Fresh solution may be kept for 24 hours (although in multidose vials it is safe for 6 weeks). The solution is strongly alkaline and irritant. Store in the freezer after making up the solution.

**Dosage and administration**

Dose of 3-5mg/kg. However the very young require 7mg/kg. This is based on the lean body mass. Dosage requirement are reduced in the elderly, hypovolemic, sick and premedicated patients.

Usually 4mg/kg is given by slow intravenous injection, titrating the dose against the effect. Further drug is given as required. Loss of the eyelash reflex shows anaesthesia. Anaesthesia occurs in less than 30 seconds after an adequate dose has been given -except in patients who have a prolonged circulation time (elderly, shocked), then give the drug VERY slowly.

**Advantages**

Smooth induction.
Disadvantages
• No analgesic action.
• Repeated doses cause prolonged effect.
• Cardiac depression; this is particularly marked in the elderly, sick and shocked patients.
• Respiratory depression usually causes a short period of apnoea.
• Tissue necrosis and intra-arterial injection.
• Occasionally laryngospasm and bronchospasm because the laryngeal reflexes are not fully depressed.
• Allergic reactions and thrombophlebitis are rare.

Pharmacokinetics
The initial blood concentration is high, causing high brain concentrations. The drug is then distributed around the body; the brain concentration decreases and the patient will wake up. Wake up is after approximately 3 to 6 minutes. It is metabolised and then excreted by the kidneys.

Pharmacodynamics
• Depression of the cardiovascular system - reduced contractility and vasodilatation
• Respiratory depression, which is increased with use of opiates.
• Minimal muscle relaxation
• Little effect on the uterine tone. Crosses the placental barrier and will sedate the foetus.

Clinical indications and uses
• Induction of anesthesia
• Combined with ketamine as IVA (Intravenous anesthesia)
• Maintenance of anaesthesia: 2-3ml boluses can be used, however dosages of 10mg/kg will cause markedly prolonged recovery time.

Contraindications
Airway obstruction, porphyria or previous hypersensitivity reaction
Precautions:
Cardiovascular disease. Severe liver and kidney disease.

Drug interactions
Other sedative agents will cause additive sedation. A thick “chalk” is produced if thiopentone is mixed with ketamine -this may also happen with suxamethonium.

ii Ketamine

Physical properties & Presentation
Presented as a clear solution. Ketamine 10mg/ml is preservative free. It also comes as 50 and 100 mg/ml with preservative. Store in the fridge once the vial has been opened.

Dosage and administration
- Intravenous induction with 1-2mg/kg by slow IV injection.
- Intramuscular induction with 8-10 mg/kg.
- Maintenance of anesthesia, by infusion 2-4 mg/kg/hour OR ½ mg boluses as required.
- Analgesia: 0.25 to 0.5 mg/kg

Advantages
- Prolonged action as a single agent with relative preservation of the airway reflexes.
- Maintenance of the blood pressure in shocked patients.
- Powerful analgesic.

Disadvantages
- Emergence reactions/delirium (though rare in children).
- There is no muscle relaxation and may in fact produce muscle rigidity.
- Prolonged recovery.
- Salivation (atropine required in children +/-adults also).
- Raised intracranial pressure -may cause medullary coning in head-injured patients.

Pharmacokinetics
Peak levels, after IM injection occurs at 20 minutes. Metabolised by the liver and excreted by the kidneys.
Pharmacodynamics

- Stimulation of the cardiovascular system.
- Respiration is well maintained, though apnoea will occur after rapid IV injection. The airway reflexes are relatively well maintained.
- Little effect on the uterine tone. Crosses the placental barrier and will sedate the foetus.

Indications/use

Induction of anaesthesia, maintenance of anaesthesia, analgesia

Contraindications

Airway obstruction and raised intracranial pressure

Precautions

Pre-existing hypertension

iii Propofol

- First use reported in 1977.
- Presented as 1% formulation in oil and water emulsion containing 10% soyabean oil, 1.2% egg phosphatide and 2.25% glycerol.
- Induction dose: 1-2.5 mg/kg – I.V.
- Resistance to the anaesthetic effects of propofol is occasionally encountered, those patients may require 50% increase in dosage.

Pharmacokinetics

Rapid distribution and elimination as glucuronide with mainly renal excretion.

Pharmacodynamics

- Dose related surgical anaesthesia
- Dose related respiratory depression
- Anti convulsant action
CVS

- Arterial hypotension
- Can be prevented by vascular volume loading or by head down tilt. To be used with caution in hypovolemic patients.
- Decrease in SVR

Disadvantage

- Pain on injections, more so in small peripheral veins can be reduced by
  - Mixing with local analgesics
  - Administration into a large vein
  - Cooling the drug.

3.3.3 Local anaesthetic agents

These are the agents, which block the conduction of nerve impulses at the site of injection so they are called as local anesthetic agents. The local injections produce only local effect but if the dose is exceeded, or the drug accidentally has intravenous access the following systemic actions can occur. You have to be very careful while using them and should be vigilant for any untoward effects.

Systemic actions

Central nervous system

The prodromal warnings of over-dosage include

- sleepiness
- sensation of cold
- tremor
- shivering
- numbness of lips and tongue
- tinnitus and speech difficulty

If unheeded these give way to convulsive seizure of a grand-mal type with tonic and clonic muscular movement. Unconsciousness and poetical amnesia follow, with complete recovery at about 1 hour later.
Cardiovascular effects

Massive doses produce cardiovascular collapse due to a reduction in cardiac output and peripheral vasodilatation.

Smaller amounts act:

• by direct action on cardiac and vascular smooth muscle;
• by direct action in the innervating autonomic nerves;
• by evoked reflexes;
• indirectly via the central nervous system.

Hence lignocaine is also used as an antiarrhythmic agent in the dose of 1.5mg/kg

Respiratory system

Applied directly to the mucosa of the respiratory tract impair the sensitivity of the laryngeal and cough reflexes. Their use introduces the risk of retention of secretions or pulmonary soiling from aspiration of pharyngeal contents.

Placental transfer

Local anaesthetics, because of their molecular size and high lipid-solubility, readily reach the fetus by passive diffusion.

i Lignocaine (Lidocaine)

Lignocaine can be used for any type of local anesthetic procedure and aqueous solution of the hydrochloride are non irritating and highly stable. Lignocaine is metabolised in the liver. Only 10% is excreted in the urine unchanged. The rate of metabolism is decreased in severe liver disease by impairment of hepatic blood supply and is increased by induction of liver enzyme activity by barbiturates. Lignocaine has duration of action of 60-90 min, which can be prolonged by the addition of adrenaline. For infiltration analgesia 0.5% solution is employed while nerve blocks and extra-dural anesthesia require concentrations of 1-2%.

In healthy patients, a dose of 300 mg can be administered. Lignocaine is an excellent surface analgesic, 2% solution being used in ophthalmic work and up to 4% for topical anesthesia of the mouth and the air passages. Other preparations include a 2% jelly lozenge containing 250 mg and a 5% ointment.
Lignocaine is used in the management of cardiac arrhythmias.

To obtain and maintain therapeutic blood levels it is therefore necessary to follow the loading bolus dose by a continuous infusion. The initial intravenous treatment should be 50-100 mg given slowly and this should be followed by a continuous infusion at a rate of 2-4 mg min\(^{-1}\) usually by way of a 0.2% solution.

ii Bupivacaine

Bupivacaine is about 4 times more potent and more toxic than lignocaine, with duration of nerve blocking effect some 3-4 times longer. For nerve blocks the maximum recommended dose in any 4 h period is 2 mg kg\(^{-1}\). Bupivacaine is highly cardiotoxic so the recommended dose should never be exceeded.

3.3.4 Neuromuscular blocking agents (muscle relaxants)

Depolarising muscle relaxants act as acetylcholine receptor agonists, while non-depolarising muscle relaxants function as competitive antagonists.

i Pancuronium

This is a long acting, non-depolarising neuromuscular agent.

It is available as a clear liquid in an ampoule containing 2 ml. Each ml contains 2 mg making up a total of 4 mg. It is stored in a refrigerator but not frozen.

When is it used

- It is usually used for maintaining muscle paralysis in an already intubated patient under an anaesthetic. It is administered only after the effects of suxamethonium have worn off and the patient has started breathing.

- Pancuronium can also be used for intubating the patient but only if one is reasonably sure that the intubation would not be difficult and certainly only if one is sure that one can ventilate the patient

Dosage and administration

- For maintaining an anaesthetic pancuronium is administered in a dose of 70-100 mcg/kg as an initial bolus dose. This will last for approximately 60–90 min. and subsequent doses
Module-III

would be about a fourth of the initial dose. This means that for the average patient weighing 50 kgs, the initial dose would be 4 mg and subsequent top-ups would be 1 mg each. The last top-up should be at least 40 min. before the end of surgery and reversal should not be given before the patient has started breathing.

• For intubating the patient the initial bolus dose is 100 mcg/kg—once again it is imperative that one can maintain the airway prior to giving this drug for intubation.

Systemic effects

It causes an increase in the heart rate due to its vagolytic properties. It also has a modest effect on the blood pressure causing it to marginally rise—both these effects are short lived and diminish with adequate analgesia.

What are the advantages and disadvantages of its use?

It can be used in shocked patients where both the blood pressure and heart rate have to be maintained. However this same effect is a problem when the patient is a hypertensive or with coronary artery disease where such effects can be deleterious.

When should it be used with caution?

• Due to its metabolism its effect is prolonged in renal failure and the dose should be reduced
• It should be avoided in hypertensives, ischaemic heart disease and valvular heart disease
• It should not be used for intubating in a difficult airway

ii Vecuronium

This is an intermediate acting non-depolarising neuromuscular agent. Each vial consists of a white crystalline powder, which contains 4 mg of vecuronium. When reconstituted with 4 ml of sterile water it makes each ml contain 1 mg of the drug. It should be stored in a refrigerator but not frozen.

Advantages over pancuronium

• Its onset of action is within 3-5 min and lasts only for 20-30 min. As a result it can be used in shorter procedures
• It does not cause an increase in the heart rate or blood pressure and thus is a safer drug in cardiac disease patients
• It should be used with caution in hepatic or renal disease
Dosage and administration

For intubation it is given at a dose of a 100 mcg/kg which would be about 5 mg in a 50 kg patient. For maintenance it is given as a bolus of 40-80 mcg/kg followed by top-ups by boluses of a fourth of the initial bolus.

iii Suxamethonium

This is a short acting depolarising neuromuscular blocking agent. This is available as a 2 ml ampoule or as a 10 ml multidose vial. It is a clear solution which has a strength of 50 mg/ml. It should be kept refrigerated.

Indication

Rapid sequence intubation or short intense neuromuscular paralysis as for endotracheal intubation as it acts within 30-60 sec. and lasts for only 3-5 min. It can also be used to break a laryngospasm.

Dosage and administration

It is given in a dose of 1-2 mg/kg. If there is no intravenous access it can be given intramuscularly in a dose of 4-5 mg/kg.

Advantages

It gives intense neuromuscular blockade creating excellent intubating conditions within 30–60 sec. and which last only for a short period of time. Thus if there is a problem in intubating, spontaneous breathing starts within a short time <5 min.

Problems

The administration of suxamethonium has certain complications-

- Hyperkalemia: rises of upto 0.5 mmol/l especially in neuromuscular problems or burns-should be avoided for the first 6 months to upto a year after burns

- Cardiovascular: can precipitate a bradycardia specially in children and usually after a second dose

- Muscle pains: usually in young male adults specifically after fasciculations
• Acetylcholinesterase deficiency: there are several types of this inherited condition which cause a prolonged action of the drug

• Raised intraocular and intracranial pressure: as a result should be used with caution in cases of raised intracranial pressure and open eye injuries

iv Rocuronium

This is a steroid analogue of vecuronium and is designed to provide rapid onset of action

Advantages over succinylcholine

Due to its rapid onset of action it can be used instead of succinylcholine in those patients where succinylcholine is to be avoided. This is particularly in patients with raised potassium or those with rhythm disturbances. To achieve ideal intubation conditions within 90 sec., it should be administered at a dose of 1 mg/kg.

Problems

It may be suitable for rapid sequence inductions but in contrast to succinylcholine, it has a much longer duration of action, which still makes it unsuitable if the intubation is anticipated to be difficult

It also has slightly greater vagolytic tendencies than vecuronium

Important considerations

What medical illnesses predispose a patient to delayed awakening or a prolonged neuromuscular block?

• Liver and renal disease both cause a delay in the metabolism and excretion of muscle relaxants and in such conditions the dose of such drugs should be reduced

• Uremia affects wakening

• Hypoglycaemia and ketoacidosis both cause a depressed level of consciousness and may thereby delay wakening

• Severe hypothyroidism has the same effects

Which drugs increase the effects of non-depolarising neuromuscular relaxants?

• Antibiotics especially aminoglycosides
• Antihypertensives – nitroglycerine
• Inhalation anaesthetics- halothane > enflurane > isoflurane
• Local anaesthetics
• Lithium
• Magnesium sulphate

**What other pharmacologic variables affect blockade?**

Neuromuscular blockade is prolonged by:

• Hypothermia
• Respiratory acidosis
• Hypokalemia and hypocalcemia
• Hypermagnesemia- as in eclamptic patients

v. **Cholinesterase Inhibitors**

These drugs also known as anticholinesterases are used to reverse the neuromuscular blockade of non-depolarising relaxants. Non-depolarising relaxants compete with acetylcholine to bind to nicotinic cholinergic receptors. The anticholinesterases indirectly increase the amount of acetylcholine available to compete with the non-depolarising agent thereby re-establishing neuromuscular transmission

**What are their effects on various organ systems?**

As a result the effects of these drugs on muscarinic receptors the effects on various systems are as follows

• Cardiovascular : bradycardias , dysrhythmias
• Pulmonary : bronchospasm, increased secretions
• Cerebral : excitation
• Gastrointestinal : intestinal spasm, increased salivation
• Genitourinary : increased bladder tone
• Ophthalmologic : pupillary constriction
Module-III

Neostigmine

It is available as vials of 1 ml containing 0.5 mg of the drug or 5 ml containing 2.5 mg of the drug.

How is it administered clinically?

To reverse muscular blockade it should be given at least 30 min after the last dose of non-depolarising relaxant and when the patient is making efforts to breathe. It is given in the dose of 0.04-0.07 mg/kg and takes about 3-4 min to take effect. Muscarinic side effects are minimised by concomitant administration of an anticholinergic agent either atropine 0.4 mg per 1 mg of neostigmine or glycopyrrolate 0.2 mg per 1 mg of neostigmine. Neostigmine crosses the placenta and causes fetal bradycardia.

3.3.5 Narcotic analgesics

These are the drugs, which cause drowsiness (narcosis)

i Morphine

Morphine is a controlled drug because it is addictive and can be abused. There is no problem of addiction in the acute phase when used for analgesia or anesthesia. It can also be used for premedication and intra-operatively as an adjunct to anesthesia to reduce the cardiovascular response to extra and excessive stimulation.

Morphine freely crosses the placenta and can affect the foetus more than the mother, so you should give it after the extraction of baby.

Dosage

For postoperative analgesia the adult dose is about 10 mg, although this may vary and up to 20 mg may be required. The paediatric dose is 100 mcg/kg. Traditionally, it is given every 4 hours “to be safe” but may give very poor analgesia, which is unsafe. If sedation and respiratory rate are monitored then it can be given every hour, if required intra-operatively use 50 mcg/kg boluses to achieve effect. It is better to do this earlier in the anaesthetic in order to give stable anaesthesia without excessive sedation at the end of surgery.

It is usually given either IV or IM in the peri-operative phase. The subcutaneous route may be used in the same dosage particularly for paediatrics using an indwelling subcutaneous catheter.
Side effects

- Morphine causes a reduced respiratory rate, some respiratory depression and even apnoea if given quickly in too large a dose. This means you must be careful with patients having respiratory disease. Postoperative monitoring must be thorough to be safe.
- Postoperative nausea and vomiting is also common and you must give an anti-emetic when you use morphine.
- Anorexia and constipation also occur.
- Anaphylaxis is rare though histamine release is not uncommon so it is best avoided in those patients with asthma.

The effect of morphine will be additive with other sedatives. Be careful. Slow, deep respiration, deep sedation and pinpoint pupils characterize overdosage. This can be fatal due to the respiratory depression or to cardiovascular collapse and arrest. You will need to support the respiration and ventilation and an opiate antagonist if available (naloxone is safer than nalorphine. Note that the effect of naloxone is shorter than morphine and so respiratory depression may recur. Monitor the patient in a high dependency area).

ii  Pethidine

Pethidine is a pure opiate agonist like morphine (though is synthetic) and therefore many of its effects are the same. The differences between the two drugs will be highlighted here.
- Pethidine’s action and side effects are of shorter duration than morphine.
- The analgesia is 10 times less intense although it is still very powerful.

It is given IM/IV/SC 50 to 100 mg for pre-medication. The same dose is used for postoperative analgesia (children, 1 mg/kg), given 3 hourly. Intra-operatively use 0.25 mg/kg boluses for effect. Oral dosage is 1 to 1.5 mg/kg every 3 hours.

It causes less smooth muscle spasm than morphine and so is often preferred in bowel anastomotic surgery.

iii  Pentazocine

Pentazocine is a partial opiate agonist. There is a ceiling on its effects. This has advantages and disadvantages. You cannot get the same intensity of analgesia with pentazocine that you get
with morphine and pethidine; BUT you also do not get the same amount of respiratory depression. There is very little PONV. It can be given oral or IM/IV/SC. Once again, do not use it orally postoperatively.

Orally: adult 50 mg (range 25 to 100 mg), children 0.5 to 1 mg/kg.

SC/IM/IV: For postoperative analgesia -adult 30 mg (up to 60 mg) and children 0.5 mg/kg 3 hourly. For intra-operative adjunct use 0.25 mg/kg boluses for effect.

iv  Fentanyl
   • A pethidine congener
   • 80-100 times more potent than morphine
   • Short duration of action 30-40 minutes
   • Exclusively used in anaesthesia in the dose of 0.5-2 µg/kg I.V.
   • But can be used by other routes like transdermal/transnasal/lollypops.

Side effects
   • Causes skeletal muscle rigidity if given fast I.V. → wooden chest syndrome.

v  Tramadol
   • Recently introduced centrally acting analgesic.
   • Relieves pain by opioid as well as additional mechanisms
   • 100 mg of Tramadol I.V. is equi-analgesic to 10 mg morphine
   • Good oral bioavailability
   • Duration of action 4-6 hours
   • Causes less respiratory depression, sedation, constipation and urinary retention.

Side effects
   • Dizziness, nausea, sleepiness, dry mouth
   • Sweating
   • Minimal haemodynamic effects
vi Naloxone

Competitive antagonist on all types of opioid receptors

Use: for reversal of opioid induced respiratory depression.

**Dose and administration**

Adults: 0.4-0.8 mg every 2-3 minutes up to a maximum dose of 10 mg

Infants: 0.02-0.04 mg every 2-3 minutes.

3.3.6 Non-narcotic analgesics

Because they do not cause dependence, respiratory depression, PONV, or impair the gut, NSAIDS can be useful post-operative analgesics. The main disadvantages are that they are not as potent as the pure agonists and that they may cause gastric erosions, bronchospasm and renal failure.

If there is history of peptic ulcer disease then do not use them. Use cautiously in patients who are dehydrated, the elderly and those with renal impairment.

They have several uses. Used alone they are effective in mild to moderate pain. They can be used if there is breakthrough to simple analgesia with paracetamol and/or codeine. They can also be used regularly postoperatively. They can be used after major surgery to reduce the amount of opiate required.

Occasionally there are allergic reactions to NSAIDS or there may be any of the large number of more minor side effects. If there are any new symptoms after starting the NSAID, it would be wise to stop the drug and observe the patient.

i Diclofenac

- Antipyretic anti-inflammatory drug
- Inhibits PG synthesis
- Has short lasting anti-platelet action

Dose: 50-75 mg deep I.M
Module-III

ii Ketorolac
- A novel NSAID with potent analgesic and modest anti-inflammatory activity
- Equals the efficacy of morphine
  But not the side effects of morphine i.e.
  - Respiratory depression
  - Hypotension
  - Dependence producing
  - Constipation
- Inhibits PG synthesis
- Dose: 15-30 mg I.M every 4-6 hours

3.3.7 Adjuvant drugs
i Benzodiazepines: Diazepam, Midazolam

Diazepam
- Long acting sedative – metabolites are also active
- Causes anterograde amnesia and hypnosis

Dose–given in the increments of 2-2.5 mg till the desired effect is achieved.

Side effects
- Painful on injection – give in a running drip
- May cause respiratory depression
- In hypovolemic patients can cause hypotension
- Effects remain for longer duration so there might be problems with breast feeding
- Is secreted in the breast milk
• Crosses placental barrier
  – Risk of neonatal respiratory depression
  – Decreases APGAR SCORE

Midazolam
• Three times more potent than diazepam
• Short acting
Dose: Given in the increments of 1 mg

Flumazenil
• Benzodiazepine antagonist
• For use in the reversal of neonatal/maternal respiratory depression
Dose: Incremental doses of 0.2 mg every minute till the desired effects are achieved.

ii Antacids/Antiemetics/Prokinetics
These are the drugs given for reducing the acidity of gastric contents and prevention or suppression of vomiting

Promethazine
• H₁ antihistaminic
• Useful in motion sickness, morning sickness, postoperative vomiting
• Duration of action 4-6 hrs

Side effects:
• Sedation and dryness of mouth
• By its central anticholinergic action it blocks the extrapyramidal side effects of metoclopramide while supplementing its antiemetic actions.

Metoclopramide
Introduced as a gastric hurrying agent
Module-III

Actions

- GIT– increases gastric peristalsis while releasing the pylorus and first part of duodenum– speeds gastric emptying
  
  Lower oesophageal spincter tone is increased and gastro- eosphageal reflux is prevented

Dose: 0.15-0.2 mg/kg IV/IM

Adverse effects

- Sedation, dizziness
- Extra pyramidal side effects

Ondansetron

- 5 HT₃ antagonist
- Very potent central antiemetic

Dose: 4-8 mg IV slowly

Side effects – headache, mild abdominal discomfort

Ranitidine

- Most commonly used H₂ blocker
- Reduces the gastric acid secretion

Dose: Oral–150 mg bd
  
  IV– 50 mg slowly

Sodium citrate

- Water soluble
- Acts instantaneously, but duration is short
- A potent acid neutralizer–1 gm neutralises 10 mEq HCl.
Adverse effect

- Increases sodium load—may worsen CHF

Dose: 30 ml, 30 minutes before surgery

3.3.8 Oxytocin

The important action of oxytocin is a stimulation of contraction of the pregnant uterus. Oxytocin is inactive orally, although it is absorbed through the buccal mucosa and can be administered by this route to avoid first-pass metabolism.

Clinical use

Oxytocin is used to stimulate uterine activity during labour. The dose used will depend on obstetric considerations, but will often start with 1-2 units Syntocinon in 500 ml, at a rate of 10 drops/min, doubling the rate of infusion or concentration of drug until labour is established, and with generally a maximum concentration of 32 units/500 ml. Oxytocin has a direct vasodilator effect, mentioned above, which may lead to hypertension if oxytocin or Syntocinon is used in large doses, especially in the anaesthetised patient. Also when used in high doses, the slight antidiuretic effect which it possesses has occasionally contributed to development of water intoxication.

3.3.9 Vasoactive drugs

i Ephedrine

It has both α and β agonist effects and acts both directly and indirectly. Its haemodynamic effects are similar to adrenaline but it has a longer duration of action and is active when administered orally. It causes an increase in cardiac contractility and heart rate. Cardiac output is thus increased. Peripheral vasoconstriction is balanced by vasodilatation with little overall change in SVR. Arterial blood pressure rises, systolic more than diastolic. It may increase cardiac irritability. Unlike adrenaline, ephedrine reduces uterine muscle activity in all situations.

Dose: bolus: 2.5-10 mg i.v.

ii Mephentermine

It is indirectly acting vasoactive agent. It acts on both α and β receptors with predominant action on α receptors. Therefore its primary effect is peripheral vasoconstriction with a concomitant
rise in systemic vascular resistance and arterial blood pressure. Its duration of action is about 10
minutes.
Dose: 3-10 mg i.v. (Bolus)

3.4 Salient points to remember

• Almost all intravenously administered drugs, with the notable exception of muscle relaxants
cross the placenta. Avoid drug which may have a depressant effect on fetus.
• Narcotics during caesarean section to be given only after the baby is delivered.
• Ketamine is the preferred induction agent in presence of hypovolaemia or hypotension.
• The rate of transfer of bupivacaine is lesser across the placenta as compared to lignocaine,
therefore bupivacaine is preferred for regional anesthesia in obstetrics.
• In hyperkalemia, avoid suxamethonium. Rocuronium may be good instead.

3.5 Check your progress

i Indicate whether the following statements are true or false. (T/F)
   a. Pregnancy is associated with reduced anaesthetic requirement (T/F)
   b. Halothane causes greater cardiac depressant effect than isoflurane (T/F)
   c. Bupivacaine hyperbaric is available as a 1% solution for spinal anaesthesia. (T/F)
   d. Lignocaine is more cardiotoxic as compared to bupivacaine. (T/F)

ii Fill in the blanks
   a. Entonox is a mixture of _____________ & _____________
   b. _____________ is an antagonist of midazolam
   c. The MAC of Halothane is _____ % and that of isoflurane is _____________ %.
   d. _____________ is the induction agent of choice in hypovolemia.

iii. MAC is the anesthetic concentration that produces immobility to surgical incision in-
   a. 25% of patients
   b. 50% of patients
c. 90% of patients
d. 100% of patients

iv. The concentration of adrenaline in the local anesthetic solution (1:2,00,000) is
   a. 2.5 micro gram per ml
   b. 5 micro gram per ml
   c. 12.5 micro gram per ml
   d. 20 micro gram per ml

v. Succinyl choline is the relaxant of choice in emergency surgery in all except:
   a. pregnancy
   b. diabetes
   c. fresh trauma
   d. raised intracranial pressure

vi. Thipentone is administered as ____________% solution.
   a. 2.5%
   b. 5%
   c. 10%
   d. 12.5%

Answers
ia true
ib true
ic false
id false
Module-III

ii a  oxygen and nitrous oxide
ii b  flumazenil
ii c  0.75%, 1.15%
ii d  ketamine
iii  b
iv  b
v  d
vi  a

3.6 Further readings

- Physiology and pharmacology for anesthesia (Stoelting)
- A practice of anesthesia (Wiley and Churchill Davidson)
- Intravenous anesthesia (Paul White)
Module - IV
Anaesthesia Machine
## 4.1 Introduction

## 4.2 Objectives

## 4.3 Contents

| 4.3.1 Components | 81 |
| 4.3.2 Cylinders | 82 |
| 4.3.3 Piped medical gases and vacuum systems | 83 |
| 4.3.4 Yoke assembly | 84 |
| 4.3.5 Pin index system | 84 |
| 4.3.6 Pressure gauge | 84 |
| 4.3.7 Pressure regulator | 85 |
| 4.3.8 Oxygen pressure failure warning devices | 85 |
| 4.3.9 Flow meters | 86 |
| 4.3.10 Oxygen ratio control devices | 87 |
| 4.3.11 Oxygen analyzer | 88 |
| 4.3.12 Continuous flow anesthesia machine | 89 |
| 4.3.13 Safety measures to prevent delivery of excessive anesthetic concentration | 90 |
| 4.3.14 Safety measures to prevent development of excessive pressure in the machine and breathing systems | 91 |
| 4.3.15 Check out procedure to be followed everyday before using the machine | 92 |
| 4.3.16 Anesthesia breathing circuit | 95 |

## 4.4 Salient points to remember

## 4.5 Check your progress

## 4.6 Further readings
4.1 Introduction

For a safe conduct of anesthesia it is important for you to know the working principles of the anaesthesia machine and be able to detect faults if and when they occur. You create an artificial atmosphere to which the patient is exposed and have, therefore, the responsibility to guarantee

- an oxygen concentration which will prevent hypoxia of the patient,
- satisfactory elimination of carbon-dioxide,
- avoidance of accidental administration of excessive anesthetic concentration.

4.2 Objectives

After going through this module you should be able to

- Describe the basic working principle of anesthesia machine
- Describe the various safety mechanisms incorporated in the machine for a safe delivery of anesthesia.
- Describe the ways to check the integrity and functions of the various component of the machine before using it.

4.3 Contents

4.3.1 Components

Understanding an anesthesia machine will be easier if the gas flow is traced from its source, through the machine, to the patient. The following components are likely to be encountered in sequence:

- Source of gas supply
- Yoke assembly
- Pressure gauge
- Pressure regulators
- Oxygen pressure failure safety/warning devices
- Flow meters
- Oxygen ratio control devices
- Vaporizers
• Common gas outlet
• Breathing systems.

We will discuss individual components briefly in the following pages to give a comprehensive view of the whole machine.

4.3.2 Cylinders

The anesthetic gases are supplied in cylinders made of molybdenum steel, an alloy, which allows the cylinders to be made thinner and lighter. Oxygen, nitrogen and air are stored as compressed gases. These gases do not liquefy at the pressures to which they are filled at 20°C since their critical temperature is low. The quantity of gas inside the cylinder can easily be estimated using a pressure gauge, as the quantity is directly proportional to the gauge pressure. In clinical practice changes in ambient temperature do not affect the pressure significantly.

Nitrous oxide (N$_2$O) and carbon dioxide (CO$_2$) liquefy at pressures to which the cylinders are filled at 20°C and are therefore stored as liquids.

The cylinders are not filled completely but only up to a filling ratio. Filling ratio = Weight of liquid with which it is filled/weight of the water it can hold.

The filling ratio for N$_2$O and CO$_2$ is 0.67 in the tropics. The contents of these cylinders can be accurately measured by weighing these cylinders rather than by using a pressure gauge. The pressure gauge will only measure the pressure of the gas (vapour) above the liquid level, which will remain constant till all the liquid is converted into (vapour) gas. Thus the gauge cannot reflect the quantity of gas in the cylinder. If the environmental temperature is above the critical temperature of the gas, then the cylinder contents will be fully in gaseous state and the pressure gauge will reflect the quantity of the contents. While using a cylinder of N$_2$O with a continuous flow, the cylinder pressure tends to fall mainly due to cooling of the liquid as it vaporizes and the consequent fall in vapor pressure. If the flow is interrupted for a brief period, the gauge will again read full.

Table 4.1

<table>
<thead>
<tr>
<th>Gases</th>
<th>Critical Temperature °C</th>
<th>Color coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>-118.38</td>
<td>Black body with white shoulder</td>
</tr>
<tr>
<td>Air</td>
<td>-125</td>
<td>White and black</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>-140</td>
<td>Black</td>
</tr>
</tbody>
</table>
Medical gas cylinders are colour coded and the name of the gas is also written on the neck of the cylinder. The cylinders are hydraulically tested every 5 years and the year and quarter of testing is recorded by a mark on the neck of the cylinder and valve block. The other markings on the valve block and cylinder include the number, the name of the owner, the manufacturer, and the pressure upto which it can be safely filled. They also show the tare weight (weight of an empty cylinder in kilograms) for gases that are stored as liquids.

The medical gas cylinders that can be fixed to the anaesthesia machine are provided with a flush type valve. The valve has got a tapered screw thread to fit the cylinder, pin index holes, spindle, and gland with a gland nut and an outlet. When the valve is screwed to the cylinder, a fusible material is used to seal the leak between the valve and the cylinder. This material will melt and prevent the risk of an explosion in the event of fire. Occasionally, there is a leak around the spindle of the valve. This can be prevented by gently screwing down the gland nut.

When a cylinder is fitted to the machine, care should be taken to see that the sealing washer (Bodok seal) is present and is in good order to prevent leak between the cylinder and yoke. It is dangerous to use more than one washer because it can override the pin index system and allow fixation of a wrong cylinder. Also, before fixing the cylinder, the outlet of the valve should be cleared of oil and dust by slowly opening the cylinder and letting out some gas. This is known as ‘cracking the cylinder’. After fitting, the cylinder should always be opened slowly to release the pressure gradually. Sudden opening can produce a shock wave in the pressure gauge and regulator and damage the parts.

4.3.3 Piped medical gases and vacuum systems

Piped medical gases and vacuum systems are used in bigger institutions in India. These systems allow bulk storage of gases in one place and deliver at a constant working pressure through fixed pipelines to the place of utility, using terminal outlets.

The terminal outlets are of the Shrader quick coupler type. Each quick coupler consists of a pair of non-threading gas specific male and female components. A releasable spring mechanism locks the components together. The probes (male component) fixed to one end of the flexible pipeline carry an index collar and the outlets (female component) a groove to accept the collar. Fixation into an incorrect outlet is thus prevented by the use of index collars. The wall outlet and the connectors for the flexible pipeline should be from the same manufacturer.

The other end of the flexible pipeline is attached to a yoke block with a pin index. Several accidents have been caused by the connection of the probe for one gas at one end and the yoke
block for another gas at the other end of the flexible pipeline. Nearly all these accidents have been caused by the alterations or faulty repairs carried out by incompetent or unauthorized people. To prevent these accidents, the flexible pipelines are also colour coded now and should be serviced by authorized people. The present standard is to fix the flexible pipeline directly to the machine at the special inlet points meant for them using diameter indexed safety system (DISS) screws.

4.3.4 Yoke assembly

The hanger yoke assembly supports the cylinder and connects it to the machine. It has 1) a body, which is the frame work and the supporting structure, 2) the retaining screw, that tightens the cylinder in the yoke, 3) the index pins, that prevent connection of a wrong cylinder, 4) a gas seal (Bodok seal) to prevent a leak between the cylinder and the yoke, 5) a filter, that removes dirt from the gas and 6) the check valve assembly that ensures unidirectional flow.

4.3.5 Pin index system

The pin index system is used in small cylinders, which fit directly on to the anesthesia machine. The cylinder has a flush type valve and the machine has a yoke to accept the valve. The pin index consists of two pins projecting from the inner surface of the yoke and two corresponding holes in the cylinder valve. There are seven hole positions on the circumference of a circle of 9/16 inch radius centered in the port. The pins are 4 mm in diameter and 6 mm long. Two pins are assigned for each gas, one on either side of the mid-line (table 4.2). This prevents fixing a wrong gas cylinder into the yoke assembly.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Index pins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>2-5</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>3-5</td>
</tr>
<tr>
<td>Air</td>
<td>1-5</td>
</tr>
</tbody>
</table>

4.3.6 Pressure gauge

All machines have a pressure gauge on the cylinder side of the regulator to measure the cylinder pressure. These gauges are usually of Bourdon type. They consist of a hollow metal tube, bent into part of a circle, connected to the pressure line. The application of pressure to the inside of
the tube causes the tube to straighten and this movement is transmitted through a clockwork mechanism to the indicator needle.

4.3.7 Pressure regulator

Pressure regulators convert the high, variable pressure in the cylinder into a constant working pressure suitable for use in anesthesia machines. Because of the use of pressure regulators frequent adjustments are not necessary to maintain a constant flow, fine adjustment of low flow is possible, and there is less chance of bursting of the tubing and blowing up of connections.

This device is designed to prevent delivery of anesthetic gas without oxygen, when the oxygen supply fails. This is incorporated at the level of the pressure regulators. The oxygen pressure regulator works as the primary regulator. The output from this regulator controls the secondary regulators of the slave regulators that are located in the N₂O line. In such systems, if the pressure from the oxygen regulator falls, the slave regulator of nitrous oxide will automatically close and will not allow flow of N₂O.

These are two types: one, in which the N₂O regulator will be totally cut off, when the oxygen pressure falls below a critical level, and the other, where the N₂O outlet pressure will also fall proportionate to the fall in O₂ pressure and so the proportional flow will be maintained, though the total flow will fall and finally stop.

4.3.8 Oxygen pressure failure warning devices

It is mandatory that in addition to cutting off N₂O flow, there should be an alarm that alerts the anesthesiologist to a failing O₂ supply. Devices have been developed which activate an alarm when the oxygen pressure falls to a certain critical level. The alarm may be visual, audible or both. With the activation of alarm, the device either cuts off the N₂O flow or directs the N₂O flow to the atmosphere. The present Boyle’s machine made by Indian oxygen limited (namely the ‘Boyle Basic’ ‘Boyle Tec’ and ‘Boyle Ultima’) incorporate a device with a small oxygen tank. This tank is pressurized during normal use. When the oxygen pressure at the source falls, the oxygen from this small cylinder flows through a whistle, incorporated on line, giving rise to an audible alarm for a period of seven to ten seconds. Cessation of the alarm does not mean that the alarm condition has been rectified and measures must be taken to correct it.

The oxygen pressure failsafe systems and warning devices control the gas in its associated gas line in response to the pressure in oxygen line. Its safety potential is limited. It will permit administration of hypoxic gas mixtures when the gas flow is erroneously composed with low
oxygen flow, the oxygen flow control valve is accidentally adjusted downward, or the oxygen piping system contains a gas other than oxygen.

4.3.9 Flow meters

All the flow meters have a flow control valve, a graduated stem to measure the flow, and an outlet. The flow control valve is a needle valve or pit valve used to adjust the amount of gas entering the flow meter. It consists of a body, a stem that screws into the body and ends in a pin, and a seat. The control knob attached to the stem will control the relative position of the pin to seating and hence the orifice for the gas flows. The gland of the flow control valve is filled with packing material to maintain a grip on the stem. If the packing is not tight, the flow control knob may become very loose and flow alterations may occur accidentally even with slight touch.

A flow meter measures the flow-rate of the gas passing through it. The one used in modern anesthetic machines is of the variable orifice type. It consists of a transparent tapered tube known as Thorpe tube. It has a smaller bore at the bottom than the top. It contains a float, which has oblique notches cut in the rim, and rotates freely in the middle of the gas stream without touching the walls of the tube and hence called a rota meter. The taper of the bore of the rota meter tube varies in order to elongate a part of the scale at the bottom. Low flows can be more accurately measured because of this construction. The gas flow pathway between the float and the tube varies from top to bottom. At the bottom of the rota meter, it is tubular and the flow rate is more dependent on the viscosity of the gas. As the tube widens above, it becomes an orifical flow and flow rate is dependent on the density of the gas.

The flow meters are individually calibrated with their floats for a particular gas at a specific temperature and pressure. The flow meter calibrated for one gas cannot be used for another with the same calibration as the viscosity and density of the gases differ.

The flow meter will read an inaccurate flow if the float sticks to the tube. Sticking may be because of the mounting of the tube is not vertical, static electricity or dirt on the tube or float.

i Arrangement of Flow meters

Conventionally, the oxygen flow meter is at the extreme left followed by CO$_2$, C$_3$H$_6$ and N$_2$O. In the present day machines the CO$_2$ and C$_3$H$_6$ flow meters are removed and replaced with air flow meter. Some machines have only oxygen and nitrous oxide flow meters. Flow meter sequence can be a cause for delivery of hypoxic mixture. Normal gas flow in the flow meter assembly is from bottom to top and from left to right at the top. If oxygen is upstream and a leak occurs
through the flow meter not in use, a substantial portion of oxygen can pass through the leak whereas nitrous oxide is directed towards the common gas outlet leading to delivery of hypoxic mixture. One safety measure taken at this level, by the American Society of Testing and Material (ASTM), is to keep the oxygen flow meter downstream of all the flow meters in the flow meter manifold. At this position, the oxygen will be directed towards the common gas outlet and the leak will be that of N\textsubscript{2}O. The Indian manufacturer, Indian Oxygen Limited, follows these guidelines and places the oxygen flow meter down stream. But other manufacturers do not follow these guide-lines and keep the oxygen flow meter upstream. This is dangerous, because users unfamiliar with a particular anesthesia machine might reach for the site where they were used to finding the control knobs. Because the position of the control knobs is reversed, they might turn off oxygen instead of nitrous oxide. A uniform standard is very much needed in this regard in our country. A leak in the oxygen flow meter tube between the float and the manifold can cause selective loss of oxygen.

4.3.10 Oxygen ratio control devices

Most modern machines used in all developed countries utilize proportioning systems in an attempt to prevent delivery of a hypoxic mixture. Oxygen and nitrous oxide are interfaced either mechanically or pneumatically so that the minimum oxygen concentration at the common outlet is 25 percent.

i Oxygen Ratio Monitor

Recognising the limitations of the oxygen pressure fail-safe system, the manufacturers of the ‘Drager’ machine developed a device called Oxygen Ratio Monitor (ORM). It is incorporated at the level of the flow meter. The ORM consists of a set of linear resistors inserted between the oxygen and nitrous oxide flow control valves and the respective flow meter. The pressure drop across the resistors is monitored and transmitted via pilot lines to an arrangement of opposing diaphragms. These opposing diaphragms are linked together with the capacity of closing a leaf spring contact and activating an alarm in the event of oxygen percentage in the mixture of oxygen and nitrous oxide dropping below a certain predetermined value. The ORM generates an alarm but does not actively control the gas flow. It will not sound an alarm if a hypoxic mixture is administered when the oxygen piping system contains a gas other than oxygen.

ii Oxygen Ratio Monitor Controller (ORMC)

This not only monitors the ratio of oxygen flow and gives an alarm when it falls below 30% but also reduces the flow of N\textsubscript{2}O correspondingly to maintain the ratio. The basic design principles
Module-IV

are similar to ORM with the exception that a slave regulator is additionally controlled by the mechanism of opposing diaphragms, which controls the nitrous oxide delivery pressure to the nitrous oxide control valve, and thus, the nitrous oxide flow. The advantage of ORM is its capability to automatically respond to reduction in oxygen pressure or operator error. The disadvantage is that the operator can not over ride the function of the device when desired.

Ohmeda anesthesia machines as well as the ‘Boyle ultima’ machine introduced in India use this Link-25 proportion limiting control device. The heart of the system is the mechanical integration of the nitrous oxide and oxygen flow control valves. It allows independent adjustment of either valve, yet automatically intercedes to maintain a minimum oxygen concentration of 25%. In this system, the nitrous oxide has a gear with 14 teeth, which is fixed to the spindle. The oxygen has a gear with 29 teeth, which is mounted on the oxygen spindle with threads so that it can float over the spindle. For every 2.07 rotations of the nitrous oxide spindle, the oxygen gear will rotate once. The thread mounting of the oxygen gear allows independent rotation of the oxygen flow control valve. The link arrangement is so set, that opening of nitrous oxide will always rotate the oxygen gear, but the gear itself will engage the oxygen control valve spindle only when the proportion of nitrous oxide in the mixture exceeds 75%. The flows in the flow meters are precisely linked to the rotation by regulating the supply pressure of these gases with secondary regulators situated just before the flow meter. The N\textsubscript{2}O is supplied at 26 psig and oxygen at 14 psig. This combination of pneumatic and mechanical control maintains the minimum oxygen percentage at 25% whenever a mixture of oxygen and nitrous oxide are used. The oxygen percentage can be independently varied between 25 and 100.

The disadvantage of this system is in the mechanical linkage. If the spindle and the gear are not properly aligned or if the threads in the spindle undergo wear and tear, the link system is likely to malfunction. Secondly, the proportioning devices can link only oxygen and nitrous oxide. If a third gas like air is included in the flow meter assembly then it no longer assures a 25% oxygen delivery in the mixture. Most of the modern machines allow an air flow meter in the flow meter block.

4.3.11 Oxygen analyser

The use of an oxygen analyser with an anaesthesia system is the single most foolproof measure to prevent delivery of hypoxic mixture to the patients. This is because it is not dependent on pneumatic or mechanical links, but actually measures the oxygen percentage in the gas mixture either by polarographic method or by using a fuel cell. One still has to make sure that the
analyzer is working properly and the alarms are set accordingly. These analysers should be calibrated at regular intervals, preferably with room air to read 21%, as we are interested in detecting hypoxia rather than hyperoxia.

4.3.12 Continuous flow anesthesia machine

The components of the anesthesia machine are usually mounted on a table with wheels. It has a provision for two cylinders each of oxygen and nitrous oxide. Each gas cylinder is connected via its yoke to the pressure regulator. There is a pressure gauge before the regulator to read the cylinder pressure. Connections between the yoke, the inlet of the pressure regulator and pressure gauge are made of high-pressure metal tubing. The outputs of the two oxygen pressure regulators are connected together and to the flow control valve of the oxygen flow meter, with metal tubing. This intermediate pressure oxygen line has branches (i) the nitrous oxide slave regulator, (ii) to the oxygen flush and (iii) to two outlets for powering ventilators, suction etc. Blind ends are also left for fixing oxygen pressure fail-safe alarms. The connections in these intermediate pressure metal tubing are made of compression couplings.

The pressure regulators in all modern anesthetic machines are preset to 45-55 psig so that the outlet pressure does not exceed 60 psig. When both cylinder and piped supply are fixed to the machine, the piped supply is preferentially used even if the cylinder is open because the piped pressure is slightly higher than that of the cylinder regulator output.

The nitrous oxide regulators, which are slave regulators to oxygen, work only when the oxygen pressure is adequate. The outputs of the two nitrous oxide regulators are connected together and to the N\textsubscript{2}O flow control valve.

The O\textsubscript{2} and N\textsubscript{2}O flow control valves control the flow of gases through the flow meters. The flow meters of O\textsubscript{2} and N\textsubscript{2}O are mounted together as flow meter manifold. For reasons already discussed the oxygen is now at the right extreme. The anesthesiologist must always note the position of flow meters before using the machine. The flow meter manifold is secured to the back bar of the machine by one or more bolts. That part of the frame of an anesthesia machine which supports the flow meters, vaporizers and various other components is known as the back bar. Flow meters and vaporizers are connected to each other by tapered fittings and are bolted on to the back bar.

At the end of the back bar is common gas outlet to which is attached the breathing system. Before the common gas outlet there usually is:
Module-IV

i. A back-flow check valve. It prevents back pressure from being transmitted to the vaporizers.

ii. A relief valve which opens at 5 psig to protect the flow meters and vaporizers from over pressure when the outlet is obstructed.

iii. A valve to direct the flow towards a semi-closed system or a closed system.

iv. An oxygen flush, the patient will receive pure oxygen uncontaminated with N\textsubscript{2}O or volatile agent, when it is mounted at this position.

4.3.13 Safety measures to prevent delivery of excessive anesthetic concentration

There are few situations in which excessive anesthetic concentration can be delivered to the patient. The first is delivery of a fully saturated gas mixture, which is most often the result of liquid anesthetic spilling into the fresh gas delivery system. Non-precision vaporizers such as the Goldman vaporizer are often used by mounting it in the common gas outlet. They are likely to get accidentally disconnected from the machine, spilling the liquid anesthetic into the breathing system. This is a very dangerous situation and very high concentration of the anesthetic can be inhaled if the vaporiser is connected back to the machine and used. Vaporisers designed in the last ten years are precision vaporizers, which do not allow this to happen as they are mounted on the machine. Laying the vaporiser on its side or turning it over will cause the liquid anesthetic to spill into the bypass chamber with the same end result.

Another dangerous situation is when the vaporiser is filled with a wrong anesthetic agent. For example, methoxyflurane vaporiser filled with halothane or isoflurane will deliver a very high concentration endangering the life of the patient. Another situation when excessive anesthetic concentration can be delivered is, when the carried gas used is changed from N\textsubscript{2}O to air-oxygen or oxygen alone. This is because of the ability of N\textsubscript{2}O to dissolve in the liquid anesthetic and get liberated when it is cut off. It is estimated that 100 ml of halothane can dissolve 450 ml of N\textsubscript{2}O. This will be released from the liquid when N\textsubscript{2}O is cut off, increasing the amount of carrier gas exiting the vaporizing chamber and thereby increasing the vapour concentration.

The following safety measures have been incorporated in modern machines to prevent some of the above mentioned causes:

- Use of back flow check valve at the common gas outlet, so that the fluctuations in pressure during controlled ventilation are not transmitted to the vaporisers.
The construction of the vaporisers has been modified to make them back pressure compensated vaporisers so that both pumping effect and pressuring effects are negated.

The size of the common gas outlet has been changed from 23 mm female to 22 mm male/15 mm female connector to prevent connection of vaporiser to common gas outlet.

Vaporisers with liquid anesthetic inside should be handled carefully without tilting or turning. If the vaporiser is accidentally tipped or lid on its side, it should be emptied and then flushed with a high flow of oxygen with concentration dial turned set to the maximum for at least 10 minutes before using the equipment on patients.

Only one precision vaporiser should be used at any time, so that condensation of liquid-anesthetic does not take place into another vaporiser. To prevent simultaneous use of two vaporisers, the contemporary machines are fitted with vaporisers, which have a locking mechanism, which prevents a second vaporiser to be opened without closing the first one.

Keyed filling devices are available for most newer inhalation agents to prevent the use of a wrong volatile anesthetic in a given vaporiser.

4.3.14 Safety measures to prevent development of excessive pressure on the machine and breathing systems

To prevent development of excessive pressures in the machine, pressure relief valves are incorporated into the intermediate pressure system and low pressure system of the machine, and also in the breathing systems connected to the patient. There is one pressure relief valve after the pressure regulator. If there is a defect in the pressure regulator the intermediate pressure system is protected from the high pressures by this relief valve, which will release the pressure to the atmosphere.

The flow meter and the vaporisers are protected by a pressure relief valve situated before the common gas outlet. If there is obstruction to flow at or after the common gas outlet, the pressure in the low pressure system rises and the relief valve will open when the pressure exceeds 200 cm H₂O (in Boyle’s machine). This is mainly to protect the flow meter and the vaporisers.

All breathing systems have an adjustable pressure-limiting (APL) valve, which opens the system to the atmosphere. The opening pressure of this valve is adjusted normally according to the breathing system used and its applications. Occasionally, this valve may get stuck and allow development of high pressure. If such an event occurs, the system should be immediately
disconnected from the patient to avoid barotrauma. If the fault cannot be rectified, alternative methods should be used to ventilate the patient and the breathing system should be changed. Some of the APL valves manufactured nowadays vent gases to the atmosphere when the pressure exceeds 60 cm H₂O even when they are fully closed. Another safety feature in the breathing system is the reservoir bag. Most of these bags give way when the pressure builds up above 50 cm H₂O.

4.3.15 Check out procedure to be followed everyday before using the machine

i  High pressure system

Check high-pressure system to prevent connection of wrong gas.

- Check the gas cylinders by color-coding and by label to confirm they are connected to the correct yoke.
- Open O₂ cylinder and verify atleast half the cylinder is full (1000 psig) for emergency use.
- Open the oxygen flow control valve and register a flow of 4-5 lit/min.
- Open the nitrous oxide flow control valve and note that the flow meter does not register a flow.
- Close the cylinder and note the flow meter bobbin falls to zero.
- Listen for oxygen pressure fail alarm is present.

Check oxygen pressure fail-safe mechanism.

- Open N₂O cylinder and note the pressure in the pressure gauge (750 psig).
- Open the N₂O flow meter. It should not register any flow, as the oxygen line is not pressurized.
- Open the oxygen cylinder. Now, flow should be registered in both oxygen and nitrous oxide flow meters.
- Close the oxygen cylinder and note the flow meter bobbins in both fall to zero and oxygen pressure fail alarm is activated.
- Close the N₂O cylinder, and both the flow control valves.
Check the pipeline supply.

Hose test

- Connect the oxygen pipeline to the oxygen wall outlet. Open the oxygen flow control valve to note that it registers a flow. This confirms that oxygen is flowing into the oxygen flow meter and there is no cross over of the flexible pipeline.

- Open the N\textsubscript{2}O flow meter and note that the flow meter bobbin falls to zero after registering initial flow. (The flow is from the N\textsubscript{2}O pressure regulator, which has not been released after closing the N\textsubscript{2}O cylinder).

- Connect the N\textsubscript{2}O pipeline to the wall outlet and note that the N\textsubscript{2}O flow meter registers a flow.

- Disconnect O\textsubscript{2} pipeline and note both flow meter bobbins fall to zero. Reconnect O\textsubscript{2} pipeline.

- Check the pipeline pressure to be between 55-60 psig (4-4.2 Kg/cm\textsuperscript{2}) if the machine is provided with a pipeline pressure gauge.

ii Low Pressure System

Check initial status of low-pressure system. (From flow control knob to the common gas outlet)

- Close the flow control valves and turn vaporizers off.

- Check fill level and tighten vaporizer’s filler caps.

Perform leak check of machine low-pressure system.

- Verify that flow control valves are closed.

- Attach suction bulb to common gas outlet.

- Squeeze bulb repeatedly until fully collapsed.

- Verify the bulb stays fully collapsed for at least 10 sec.

- Open the vaporizer one at a time and repeat above steps.

- Remove suction bulb and reconnect fresh gas hose.
Module-IV

iii Test flow meter
- Adjust flow of the gases through their full range, checking for smooth operation of the floats.
- If the machine has a proportioning device, attempt to create a hypoxic gas mixture and verify the correct changes in flow.

iv Turn on the main switch of the machine (if it has one) and all the electrical monitoring equipment. Connect the breathing system and the oxygen analyzer (if available) to the common gas outlet.

v Calibrate oxygen analyzer if available.
- Calibrate to read 21% in room air.
- Connect to common gas outlet and flush with 100% oxygen
- Verify if it reads above 95%.

vi Breathing System
Check initial status of breathing system
- Check the breathing system is complete undamaged and unobstructed
- Verify the CO₂ absorbent is OK.
- Connect the breathing system accessories to be used during the case.

Perform leak test of the breathing system.
- Set all gas flows to Zero.
- Close APL valve and occlude patient end.
- Pressurize system to 30 cm H₂O using O₂ flush
- Squeeze bag and check for leak.

Checking the integrity of inner tubing -Bain Circuit
- Register a flow of 500 ml oxygen.
- Occlude the inner tube and note the flow meter bobbin falls slightly.
- Release occlusion and note the bobbin coming back to original level.
Check the ventilation system if a ventilator is attached to the anaesthesia machine (check procedure as per the manufacturers instructions.)

vii Check Laryngoscope and intubating accessories

- Check laryngoscope light is adequate.
- Stylet
- Keep appropriate endotracheal tubes, masks and airways

viii Check, calibrate and set alarms for all monitors as required

- ECG.
- Capnography.
- Pulse oximeter.
- Blood pressure monitor.
- Airway pressure monitor.
- Anaesthetic gas monitor.

ix Check Final status of Machine

- Vaporizers ‘off’.
- All flow meters to Zero.
- APL valve open.
- Reservoir bag in place.
- Patient suction level adequate.
- Breathing system ready to use.

4.3.16 Anaesthesia breathing circuit

Breathing systems provide the final conduit for the delivery of anesthetic gases to the patient. Many modifications in circuit design have been developed. One of the commonest of which is Mapleson system. The two most commonly used Mapleson breathing circuits are the Bain circuit (Mapleson-D) and Jackson-Rees modifications of Ayre’s T-piece (Mapleson-F), which will be described.
Module-IV

i  Bain Circuit

Bain circuit is a co-axial modification of Mapleson-D system, in which the fresh gas tube runs within the expiratory tube. The diameter of the outer tube is about 22 mm and is made of corrugated plastic, and the diameter of the inner tubing is about 7 mm. The length of the commonly used Bain circuit is about 1.8 meters. The fresh flow required to prevent re-breathing during spontaneous ventilation is 2-3 times the minute ventilation (200-350 ml/kg) and during controlled ventilation is 1-2 times the minute ventilation (100-200 ml/kg).

Advantages

• It is the most efficacious circuit for controlled ventilation
• Conservation of heat and humidity
• Universal nature

ii  Jackson-Rees modification of Ayre’s T-piece

It is the circuit most commonly used in the pediatric age group (<20-25 kg). It is basically a T-piece with an open-ended reservoir bag attached at the end of the exhalation tubing. The volume of the exhalation tubing and reservoir bag should exceed the tidal volume of the patient. The fresh flow required is 2-3 times the minute ventilation.

Advantages

• It can be used for both spontaneous and controlled ventilation
• It is valve less, minimizing the resistance to breathing.

Disadvantages

• It needs higher flow rate in controlled ventilation as compared to Bain circuit
• Less efficacious in preserving heat and humidity

4.4 Salient points to remember

• Check all your equipment, including the anesthesia machine and breathing circuit before you start.
• The oxygen cylinder must be at least half full and other cylinders must be available immediately at hand before administration of anaesthesia.
• Ensure that the bobbins are freely moving and rotating during the flow of gases.
• Most modern anaesthesia machines have a number of safety features to prevent the delivery of a hypoxic mixture and development of excessive pressures.

4.5 Check your progress
i. Oxygen cylinder is usually made of:
   a. Iron
   b. Copper
   c. Silver
   d. Molybdenum steel

ii. The following gases are stored as compressed gas except:
   a. Oxygen
   b. Nitrogen
   c. Air
   d. Nitrous oxide

iii. Carbon-dioxide and ———— are stored as liquid

iv. The filling ratio of nitrous oxide in tropics is:
   a. 0.47
   b. 0.77
   c. 0.67
   d. 0.87

v. The color-coding of nitrous oxide is———

vi. The pin index number for oxygen is:
   a. 3-5
   b. 2-5
vii. The flow rate of gases at the bottom of the flow meter is dependent on:
   a. Viscosity of the gas
   b. Density of the gas
   c. Total flow of the gas
   d. All of the above

viii. Which of the following arrangement of flow meter do you think is safe for the patient:
   a. Oxygen on the extreme left
   b. Oxygen on the extreme right
   c. Safety is not effected by the position of the flow meter
   d. None of the above

ix. In the oxygen ratio control devices the minimum oxygen concentration at the common gas outlet is:
   a. 20%
   b. 25%
   c. 30%
   d. 35%

x. The pressure regulators in all modern anesthesia machines are preset to:
   a. 45-55 psig
   b. 55-65 psig
   c. 65-70 psig
   d. 70-80 psig
xi. The pressure relief valve at the common gas outlet opens at
   a. 10 psig
   b. 5 psig
   c. 15 psig
   d. 20 psig

4.6 Further readings
   • Understanding anesthesia equipment (Dorsch & Dorsch)
   • Anaesthesia equipment (Wards)
Module - V
Patient Preparation Pre-Medication and Theatre Preparation
Module Structure

5.1 Introduction 105
5.2 Objectives 105
5.3 Contents

5.3.1 Patient preparation 105
5.3.2 Quick assessment of patient 106
5.3.3 Psychological preparation 108
5.3.4 Administrative consideration 108
5.3.5 Theatre preparation 109
5.3.6 Monitoring 110

5.4 Salient points to remember 110
5.5 Check your progress 111
5.6 Further readings 111
5.1 Introduction

In obstetric emergency, anesthetist can be called for:

- An emergency cesarean section
  - Fetal distress
  - Obstetric hemorrhage
- Removal of retained placenta
- Management of
  - Uterine rupture
  - Post partum hemorrhage

In such cases you have to respond promptly and take hold of the situation. Every woman admitted to the labour and delivery unit is a potential candidate for emergency administration of anesthesia. Therefore evaluate every patient after admission.

This module will help you in patient preparation, pre-medication and theatre preparation.

5.2 Objectives

After going through this module you should be able to

- Describe how to prepare the patient, take a history and perform an examination.
- Describe theater preparation.

5.3 Contents

5.3.1 Patient preparation

- Administer a clear antacid (30 ml of 0.3 M sodium citrate) about 30 minutes before surgery
- Administer ranitidine 50 mg and metoclopramide 10 mg i.v as soon as surgery is decided.
- Optimise maternal position

A left uterine displacement has to be maintained to avoid aortocaval compression.
Module-V

Left uterine displacement

- Ensures adequate venous return
- Minimizes compression of aorta
- Prevents decrease in uterine artery perfusion

Change position to relieve umbilical cord compression.

- Administer oxygen by facemask.
- Maintain maternal circulation
  - A good i/v line has to be established.
  - Start resuscitation with i/v fluid crystalloid/colloid (non-dextrose solution should be used).
  - Maternal hypotension should be promptly treated with ephedrine.
  - If there is no improvement use phenylephrine.

5.3.2 Quick assessment of patient

i Focused History

- History of any significant illness
  - Diabetes
  - Hypertensive disorder
  - Asthma
  - Sickle cell disease
  - Valvular heart disease
- History of previous operation and anesthesia
  - Any problem with airway management.
  - Outcome of anesthesia
• History of any complication during previous anesthesia exposure
  - Malignant hyperthermia
  - Nausea/vomiting
  - Delayed recovery
• History of oral intake
  - Liquid
  - Solid

ii Examination

General physical examination
• Hydration
• Anaemia
• Nutritional status
• Pulse rate
• Blood pressure
• Jugular venous pressure (JVP)

Airway assessment
• Profile examination of head, neck and face (Patient with short neck, receding chin causes difficulty in intubation)
• Mouth opening (Mouth opening less than three finger breadths causes difficulty in oral intubation)

Modified Mallampati score
Ask the patient to open mouth as wide as possible and protrude the tongue to the maximum, oral cavity is visualized.

Class I  -  Able to visualize tonsillar pillars, uvula, soft palate.
Class II -  Uvula and soft palate
Class III - Soft palate
Class IV - Only hard palate

[Class IV is almost always associated with difficult intubation]

Teeth
- Loose teeth
- Cap/ crown
- Denture
- Protruding maxillary teeth

Systemic Examination
- **Cardiovascular system**: Auscultation of heart sounds. Any murmur (All diastolic murmurs are organic, palpable thrill is indicative of organic disease)
- **Respiratory system**: Auscultation of breathing sounds. Any added sounds like, crepitation and rhonchi
- **Abdominal examination**: Any hepatosplenomegaly (Splenomegaly is found in thalassemia)

5.3.3 Psychological preparation
- Reassure the patient
- Tell the patient you are here for her.
- Tell her you will look after her during the whole procedure
- Do not forget to tell a lady suffering from labour pain that you will relive her pain.

By this psychological assurance patient usually calms down

5.3.4 Administrative considerations
- Ask the name of patient
- Check the consent form- whether it is signed or not
- Confirm she is the same patient to be operated
5.3.5 Theatre preparation

i Anesthesia equipment checklist

- Back up ventilation
- High pressure system
- $O_2$ fail safe mechanism
- Low pressure system
- Breathing system

ii Resources for airway management

- Laryngoscope and assorted blades.
- ET tubes with stylet.
- Suction source with tubing and catheter.
- Medication for hypnosis, relaxation and blood pressure support.

iii Resources for difficult airway management

- Rigid laryngoscope blade.
- ET tubes of different size.
- LMA
- Jet ventilation/cricothyrotomy unit with TTJV
- Combitube
- Semirigid stylet
- Equipment for emergent surgical airway
- Topical anesthesia and vasoconstrictor
- Fibreoptic bronchoscope
iv Resources For Obstetric Hemorrhagic Emergency

- Large bore i/v catheter.
- Fluid warmer
- Forced air body warmer
- Blood bank resource
- Pressure bags and automatic infusion device

5.3.6 Monitoring equipment

i Maternal monitoring

- ECG
- Blood pressure (non-invasive)
- Pulse oximetry
- Temperature

ii Fetal Monitoring

- Fetal heart rate

5.4 Salient points to remember

- A brief but thorough pre-anesthesia checkup of the patient is essential even in emergency circumstances.
- Administration of non-particulate antacid (30 ml 0.3 m sodium citrate) 30 minutes before surgery increases the gastric pH.
- Once the patient is shifted to the operation theatre, administer oxygen by face mask to the mother.
- Always maintain left uterine displacement.
- Start a large bore intravenous line before commencement of any procedure.
- A functioning suction and airway equipment should always be at hand.
5.5 Check your progress

i. Indicate whether true or false (T/F)
   a. Sodium citrate is available as a 0.6 molar solution (T/F)
   b. Mouth opening less than 4 cm is associated with difficulty in intubation. (T/F)

ii. Fill in the blanks
   a. A non-particulate antacid e.g. sodium citrate should be given _______ minutes before surgery.
   b. A left uterine displacement is provided to avoid ________ compression.
   c. In modified Mallampati class iv, only _____ is visible.

iii. Which of the following represent modified Mallampati class iii.
   a. Hard palate & soft plate
   b. Hard palate
   c. Hard palate, soft palate & uvula
   d. Hard palate & fauces

Answers
   ia  false
   ib  true
   iia 30-45 minutes
   iib aortocaval
   iic hard palate
   iii a.

5.6 Further readings
   • Miller – Anaesthesia
   • Clinical anaesthesia (Barash)
Module - VI
General and Regional Anaesthesia for Emergency Obstetric Procedures
Module Structure

6.1 Introduction 117
6.2 Objectives 117
6.3 Contents
   6.3.1 Pre-Anaesthesia Check Up 117
   6.3.2 Regional Anaesthesia 117
      Choice of the drugs for the regional anaesthesia
      Individual techniques
      Contraindications to regional techniques
      Management of complications of regional anaesthesia
   6.3.3 General anesthesia 123
      Things to remember before starting general anaesthesia
      Techniques
   6.3.4 Anaesthesia for labour and vaginal delivery 129
      Drugs that can be used for vaginal delivery
      Inhalation anesthetic for vaginal delivery
      Regional anaesthesia techniques for vaginal delivery
      Drugs that can be used in spinal and epidural block
6.4 Salient points to remember 132
6.5 Check your progress 133
6.6 Further readings 138
6.1 Introduction

Obstetric anesthesia is a demanding and gratifying subspecialty of anesthesiology. Most patients are young and healthy. The obstetric patients differ from their non-pregnant counterparts by the physiological changes of pregnancy and the presence of a fetus, both being affected by anesthesia. The process is risky and the death of a young and healthy individual would lead to disastrous consequences not only for the family but also for the society. Medico legal consequences of this type of patients are in a rising trend. Therefore a complete knowledge and adequate skill is required to handle this type of special situation.

6.2 Objectives

After going through this module you should be able to

- Describe the guidelines regarding administration of general or regional anesthesia for emergency obstetric procedure.
- Describe important considerations to be kept in mind while anaesthetizing a patient for emergency caesarean section

6.3 Contents

6.3.1 Pre anaesthesia check up

- History in these patients is very important.
- Any events during pregnancy should be noted.
- Any co-existing disease
- Coordination with obstetrician is vital for the management of cases.

6.3.2 Regional anaesthesia

Regional anaesthesia provides the laboring mother to have the most effective and reliable method of pain relief. The mother remains awake and able to participate in the birth.

i Choice of the drugs for the regional anaesthesia

Local Anaesthetics - Bupivacaine, Lignocaine, Prilocaine

Opioids – Morphine, Fentanyl, Sufentanil
ii Individual techniques

For Regional Anaesthesia

Epidural

Indication:

• Pain of labour
• Significant heart disease in the mother
• Hypertensive patient
• Prolonged dysfunctional labour

It can be extended for the caesarean section at any point of time.

For all practical purposes, bupivacaine is the most commonly used drug for epidural analgesia.

Method

• Ensure intravenous access with large bore cannula, start infusion of lactated Ringers solution up to 1000 ml to 1500 ml.
• Monitor fetal heart rate.
• Place the patient in lateral decubitus position or sitting position as preferred.
• Disinfect the skin and infiltrate local anesthetics.
• Locate the space with loss of resistance technique during gradual advancement of needle attached with airtight syringe.
• Thread the catheter leaving no more than 4 cms in epidural space.
• After negative aspiration, give test dose of 3 ml 1.5% lignocaine with 1:200000 adrenaline. Look for the heart rate and motor blockade in the limb.
• Monitor maternal heart rate, blood pressure after 2 minutes, continue monitoring every 5 minutes for 20 minutes.

• If test dose is negative after 5 minutes, give 10 ml of 0.25% bupivacaine with or without 50 microgram of fentanyl in two divided doses.

• Maintain sensory block unto T10 to L1 for labour analgesia, this can be extended whenever there is need of caesarean section.

• Continue monitoring of vitals, ECG, pulse oximetry, blood pressure.

• Always maintain a left lateral tilt to prevent aortocaval compression

**Spinal anaesthesia technique**

• Ensure intravenous access with large bore cannula, start infusion of lactated Ringers solution up to 1000 ml to 1500 ml.

• Monitor fetal heart rate.

• Place the patient in lateral decubitus position or sitting position as preferred.

• Disinfect the skin using savlon, betadine and spirit and infiltrate local anaesthetic.

• Locate the space.

• Insert the spinal needle in desired space, gradually penetrate millimeter wise till dura is punctured and CSF is detected at the needle hub.

• Administer 1.5 ml to 2 ml of 0.5% heavy bupivacaine.

• Make the patient supine from lateral decubitus position without losing much time, maintaining left lateral tilt.

• Monitor heart rate continuously, blood pressure every 2 minutes to start with then every 5 minutes till 20 minutes.
Module-VI

The line passing through the highest point of Iliac Crest also passes through the L4 spine or L₄L₄ space (Tuffier’s line)

Sitting position useful in obese / pregnant patient

Drug being injected into sub arachnoid space after confirming aspiration of clear fluid

Note The hand should not move during injection
Paracervical block

It is performed injecting local anaesthetics to the sub-mucosa of lateral fornices on either side of the vaginal vault. Continuous monitoring of fetal heart rate has shown that paracervical block is associated with a high incidence of fetal bradycardia as well as depressed neonates. Even intrauterine deaths have been reported. This is why this block is not so popular.

Pudendal nerve block

Lower sacral roots are blocked (S2-4). 10 ml of local anaesthetic is given around each nerve at the sacrospinous ligament using a 10 cm needle passed either through transvaginal or transperineal route. It has disadvantages like incomplete analgesia, thus less used in high forceps delivery.

Combined spinal epidural technique

It is highly recommended for labour analgesia as well as cesarean section. The same steps should be followed as epidural block method till the epidural space is identified, then spinal needle (27 gauze) is introduced through the epidural needle and CSF is detected at the needle hub. Spinal anesthetic drug (0.5%) heavy bupivacaine administered through the spinal needle. Then the spinal needle is taken out and epidural catheter is inserted through the epidural needle without losing much time. Then, the patient is turned supine, maintaining left lateral tilt.

Contraindications to regional techniques:

**Absolute contraindications:**

- Infection at local site
- Coagulopathy
- Marked hypovolemia
- Allergy to local anaesthetic
- Patient refusal and inability to cooperate for regional block

**Relative Contraindications:**

- Pre-existing neurological disorders
- Spine problems like backache
Module-VI

- Severe heart disease
- Heparinised patients

Prior to regional technique, appropriate equipment should be available and all the resuscitation equipment should be available. The most important is that the anesthesiologist should be ready for failure of block with prior preparation for general anesthesia.

**Equipment which should be ready:**
- Oxygen supply
- Positive pressure delivery device
- Functioning laryngoscope with different size blades
- Suction machine with suction catheter
- Oral and nasal airways
- Intravenous fluids/ephrine/mephentermine
- Thiopentone
- Succinylcholine

Cesarean section needs a T₄ sensory level. This is a high sympathetic block, which can cause hypotension. Preloading of patient with 1000 ml to 1500 ml bolus of Ringer lactate prior to epidural or spinal anesthesia avoids a major hypotensive response.

Blood pressure, ECG, pulse oximetry should be monitored. Ephedrine can be given when the systolic blood pressure is less than 100 mmHg or blood pressure falls by more than 20% of baseline.

### iv Management of complications of regional anaesthesia

- **Hypotension**

  Generally it is defined as 20 to 30% reduction in blood pressure or systolic pressure less than 100mgHg. It is the most common side effect of regional anesthesia. Treatment should be abrupt, intravenous fluid, left lateral displacement of uterus so that aorto caval compression is avoided. Boluses of ephedrine 5 to 15 mg or mephteramine 3 to 6 mg boluses can counteract hypotension.
• **Unintentional intravascular injection of epidural blocks**

It may cause seizures or cardiovascular collapse: Seizures occurs with lignocaine or chlorprocaine. Thiopentone 50 to 100 mg may abort seizures. During the treatment of this type of complication oxygenation by ventimask or simple facemask should not be forgotten. Immediate intubation with succinylcholine should be considered if seizures are uncontrolled with the above measures. Bretylium is the drug of choice in bupivacaine induced ventricular arrhythmias.

• **Dural puncture**

Patient should be put in left lateral position, head down, intravenous fluids; patient should be intubated and ventilated with 100% if the anesthetic drug has already been administered.

• **Post-dural puncture headache**

Absolute bed rest, plenty of oral fluids, epidural saline 50 to 100ml, caffeine tablets, and lastly epidural blood patch. If Caffeine tablets are not available then patient should be encouraged to take coffee.

6.3.3 **General anaesthesia**

General anaesthesia technique for emergency obstetric cesarean section. Common indications for emergency surgery in obstetrics are:

- Fetal distress
- Umbilical cord prolapse
- Maternal hemorrhage
- Amnionitis
- Genital herpes with rupture of membranes
- Dystocia
- Abnormal fetopelvic relation
- Transverse lie
- Breech presentation
- Labour unsafe to mother and fetus
Module-VI

- Previous classic cesarean section
- Previous large uterine surgery or large myomectomy surgery
- Central or partial placenta previa
- Abruptio placentae
- Vaginal reconstruction

What to choose?

General

Regional

Epidural

Spinal

It depends on multiple factors:

- Urgency of operation
- Patient preferences
- Skill of the anaesthesiologist
- Associated disease affecting pregnancy
- Anticipated difficulty in airway management
- Presence of contraindications to regional anaesthesia.

Cesarean section rates have been steadily increasing in recent years (25%) of all deliveries.

**Advantages of regional anaesthesia**

- Less neonatal exposure to potential depressant drug
- Less chance of maternal pulmonary aspiration
- Awake mother and child after delivery
• Early ambulation
• Avoidance of difficult airway and airway trauma related complications.

Epidural anaesthesia is preferred over spinal in more cardiac compromised patient because it affects hemodynamics slowly, allowing more reaction time.

**Advantages of general anaesthesia**
• A very rapid and reliable onset
• Control over airway and ventilation
• Potentially less hypotension than regional
• No danger of neuro deficits
• No PDPH

As it is well known by now, parturients are high risk cases in comparison to other general anaesthesia procedures. All the equipment, anaesthesia machine and drugs should be ready and checked prior to starting of general anaesthesia.

**i Things to remember before starting general anaesthesia:**

**Pre-oxygenation:**

Why is it needed? We know from physiological changes, pregnant mothers have less oxygen reserve because, they have low functional residual capacity. They have high metabolic rate needing more oxygen per minute. Pre-oxygenation prevents rapid desaturation of pregnant mother. Therefore the anaesthesiologist not only gets some more time for difficult intubation but it also avoids hypoxia related complications, if due to some reason the endotracheal intubation is delayed or difficult.

**Method**

How is preoxygenation performed?

Patient should be supine with left lateral tilt and comfortable on the operation theatre table. 100% oxygen at a flow rate of 6 to 8 lts/min is administered using a tight-fitting facemask connected to a circuit with fully open expiratory valve. The parturient is allowed to breathe spontaneously. This procedure is done for at least 4 to 5 minutes, which has been found to be the time required to completely refill the lungs with oxygen. After completion of 5 minutes, induction by intravenous method is started.
Module-VI

ii Induction and rapid sequence intubation

Intravenous route is the method of choice for induction in the pregnant woman.

Drugs used

Thiopentone Sodium.
Propofol.
Ketamine.

Thiopentone Sodium is the most commonly used drug. Dose: 4 to 5 mg/kg. The drug is used as 2.5% solution with precalculated doses, which is kept ready in a syringe prior to starting of induction.

Propofol dose: 2 mg/kg
Ketamine dose: 1-2mg/kg

Muscle relaxant

The drug of choice is succinylcholine.

Recently, a newer drug has been introduced for rapid sequence intubation (Rocuronium)

Doses: Succinylcholine 1.5 mg/kg to 2 mg/kg
Rocuronium 0.6 mg/kg to 1 mg/kg

Onset of action for both these drugs is around 60 seconds. After initiation of intravenous line and connecting the patient to monitor. ECG, pulse oximetry, blood pressure, and capnograph should be monitored prior to induction of anaesthesia.

Steps of induction

After adequate preoxygenation, a precalculated dose of Thiopentone sodium is administered intravenously. Apply cricoid pressure as consciousness is being lost.

- Administration of succinylcholine intravenously.
- Do not ventilate during this period.
- Wait for 60 seconds after giving the relaxant.
- Laryngoscopy and intubation are performed.
• Inflation of endotracheal tube cuff.
• Allow the surgeon to start the surgery after the circuit is connected and endotrachel tube cuff is inflated.

**Maintenance**

General anaesthesia is maintained with oxygen and nitrous oxide in a mixture of 50\%:50\%. Along with this mixture inhalation anaesthetic, halothane 0.5\% or Isoflurane 0.75\% can be given. Continue monitoring of ECG, blood pressure, pulse oxymetry and capnography. Administer opioids and oxytocin after delivery of the baby.

**General anaesthesia for emergency caesarean section**

Incidence of complication

<table>
<thead>
<tr>
<th>Condition</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspiration</td>
<td>1:400</td>
</tr>
<tr>
<td>Failed intubation</td>
<td>1:300</td>
</tr>
</tbody>
</table>

An anaesthesiologist should remember this value always because in comparison to other surgery the incidence of aspiration and failed intubation is very high. It is 1:2000 in the non-pregnant. In view of high incidence of aspiration and failed intubation it is always preferable to administer non particulate antacid like 30 ml of 0.3 M sodium citrate 30 to 45 min prior to induction of general anaesthesia, especially to those who have taken food recently. Ranitidine and Metoclopramide are the drugs, which are commonly used prior to induction of general anaesthesia because ranitidine, being an H-2 blocker serves to reduce the gastric acid production, and metoclopramide hastens gastric emptying.

Examination of the airway should be done very carefully as described in the module for difficult airway management.

**Failed intubation drill**

If intubation failed for 2 times by the same anaesthesiologist

Call for help

Ventilate with 100\% oxygen

Use
1. Face mask
2. Laryngeal mask airway (LMA) with cricoid pressure
3. Combitube

Assess ventilation and oxygenation

<table>
<thead>
<tr>
<th>Inadequate (EMERGENCY PATHWAY)</th>
<th>Adequate (NON-EMERGENCY PATHWAY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combitube or</td>
<td></td>
</tr>
<tr>
<td>LMA with Cricoid pressure</td>
<td></td>
</tr>
<tr>
<td>Failed</td>
<td>Fetal distress</td>
</tr>
<tr>
<td>Cricothyroidotomy</td>
<td>No fetal distress</td>
</tr>
<tr>
<td>Tracheotomy</td>
<td></td>
</tr>
<tr>
<td>Delivery of baby</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

One must remember that the mother’s life takes priority over life of the fetus.

Technique of GA for cesarean section:

- The patient is placed in supine position with a wedge under right hip for left uterine displacement.
- Pre-oxygenation with 100% O₂ for 3 to 5 min
- The patient is draped and prepared for surgery
• When surgeon is ready, rapid sequence induction and intubation with cricoid pressure is performed. Thiopentone sodium 4-5 mg/kg and succinylcholine 2 mg/kg is given in a pre-calculated dosing method.

• Surgery begins only after intubation is complete

• Anaesthesia is maintained with 50% O₂; 50% N₂O and Volatile agent 0.5% halothane, 0.75% isoflurane

Non-depolarizing agent for muscle relaxation, Vecuronium, 0.05 mg/kg, Rocuronium 0.3 mg/kg, Atracurium 0.25 mg/kg

• After delivery of the fetus 10-20 units of oxytocin is given intravenously in each litre of balance salt solution.

• Opioids should be given ideally after delivery of baby.

• After completion of surgery residual neuromuscular blockade is reversed with neostigmine + glycopyrolate or atropine.

• Patient’s trachea should be extubated when she is fully awake and vitals are stable.

6.3.4 Anaesthesia for labour and vaginal delivery

Pain during the first stage of labor results from uterine contractions and cervical dilatation. It is usually confined to T11-12 dermatomes during the initial phase, but eventually involved the T10-L4 dermatomes as the labor enters the active phase. Similarly pain in the second stage is conveyed by pudendal nerve (S2-4).

i Drugs that can be used for vaginal delivery

All opioids cross placenta so it has a depressive effect on the fetus as well. If fetus is premature these effects are aggravated.

Pethidine: It is only given when the delivery is expected 4-5 hours after or within one hour of giving the drugs. The duration of action of pethidine is 1-3 hrs.

Morphine: is never used because with equianalgesic dose it causes more respiratory depression than pethidine and fentanyl in patient delivering vaginally.
Module-VI

**Fentanyl:** Fentanyl 50-100µg has also been used with good effect. Administration of opioids should always be carried out after having a discussion with obstetricians knowing the duration left for delivery.

**Diazepam:** Diazepam is no longer used during labor unless indicated because it has a prolonged depressant effect on fetus.

**ii Inhalation anaesthetic for vaginal delivery**

This was once a popular technique. In due course of time it has been replaced by regional technique.

It involves giving sub anesthetic dose of inhalational anesthetic agents during 2nd stage of labour only, along with oxygen. Nitrous oxide is used with oxygen. Any of the available anesthetic agents like isoflurane, halothane, methoxyflurane can be used and during this period. Anesthesiologist should be present throughout the procedure and he should be having repeated communications with the patient. The most important thing is that the patient should be arousable at any point of time. Confusion, excitement or drowsiness is indicative of over dose and the need to reduce concentration of the anesthetic agent used. This technique is hardly used now a days.

**iii Regional anaesthesia techniques for vaginal delivery**

Regional techniques are widely accepted now a days. It is easy to perform, low cost, devoid of complications associated with general anesthesia (specially the airway complications).

Among the regional techniques: We have two most popular techniques- epidural method and intrathecal method (spinal). Others are paracervical and Pudendal nerve block.

One more technique that is coming up with lots of advantages is combined spinal epidural anesthesia (CSE technique).

**iv Drugs that can be used in spinal and epidural block**

**Opioids**

Preservative free opioids may be given intra-spinally as a single injection or intermittently via an intra-thecal catheter (although not popular in India). This is useful for patients who have co-
existing disease that is going to affect adversely by sympatholysis produced by epidural or spinal block e.g. (Severe CVS disease, hypovolemia, aortic stenosis, tetralogy of Fallot, pulmonary hypertension).

Advantages: Intra-spinal opioids, when used alone do not produce motor blockade that is, do not interfere with pushing the baby out; do not cause maternal hypotension.

Disadvantages: Complete anaesthesia may not be there, lack of perineal relaxation, pruritus, nausea, vomiting, sedation, respiratory depression.

Intra-spinal doses of opioids (Epidural/Intra-thecal)

<table>
<thead>
<tr>
<th>Agents</th>
<th>Intra-thecal</th>
<th>Epidural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphine</td>
<td>0.5-1 mg</td>
<td>7.5-10 mg</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>5-25 µg</td>
<td>50-200 µg</td>
</tr>
<tr>
<td>Sufentanil</td>
<td>3-10 µg</td>
<td>10-50 µg</td>
</tr>
</tbody>
</table>

Epidural blockade

A relatively high dose of morphine is needed to produce analgesia for labour. It acts after 30 min and the duration of action may last upto 24 hours. So it may not be a good choice because it is associated with side effects like neonatal respiratory depression and it has to be given at first stage because of delayed onset. The alternative would be giving fentanyl along with morphine, in this combination both the doses of morphine (2.5 mg) as well as fentanyl is reduced (25-50 µg), so also the side effects.

Advantages: Rapid onset duration 4-5 hrs with less side effects.

Local anaesthetic alone by lumbar epidural analgesia

It is the most commonly used technique using bupivacaine which causes previously mentioned differential block. It is has the advantage that it can be used from first stage of labour to the 3rd stage; another added advantage is that it can be used for cesarean section, if required.
Lumbar epidural analgesia for vaginal delivery

First of all it should be remembered that lumbar epidural is administered only when labour is well established.

Criteria for inserting a lumbar epidural catheter

- No fetal distress
- Good regular contraction
- Adequate cervical dilatation 5 to 6 cm
- Engagement of the fetal head

Space

L₃/₄ or L₄/₅ interspace is generally chosen. If dural puncture occurs the anesthesiologist has two choices. Either insert the epidural catheter in the intra-thecal space or re-try inserting the catheter in the next space.

Choice of local anaesthetic:

Bupivacaine: 0.25 to 0.125% for labour analgesia.

  0.5% bupivacaine for cesarean section

  2% lignocaine for caesarean section

6.4 Salient points to remember

- Regional anaesthesia/analgesia is the most reliable and effective method to provide pain relief to the patient.

- An intravenous line is the life line

- Every epidural doze of local anaesthetic should be considered a test dose, and should be given in small parts.

- Remember that equipment for general anaesthesia should always be checked and ready, even while administering regional anesthesia.

- Preloading of patient with 1 to 1.5 liter of ringer’s lactate prior to epidural or spinal anaesthesia avoids a major hypotensive response.
- The patient should be pre-oxygenated prior to induction of anaesthesia using 100% oxygen at a flow rate of 6-8 liter/minute for at least 4-5 minutes.
- Rapid sequence induction using succinylcholine is the technique of choice in pregnancy.
- One must be thorough with the failed intubation drill.
- Regional anaesthesia is always the technique of choice for an emergency caesarean section at the FRU.
- Reconfirm drug name, basicity and expiry date of the drug before injecting in to the subarachnoid space.

6.5 **Check your progress**

i. Commonest size endotracheal tube used for obstetric anaesthesia?
   a. 6.5
   b. 7.5
   c. 8.0
   d. 8.5

ii. Amount of Halothane that can be used safely in a normotensive parturient after induction?
   a. 1.0%
   b. 0.5%
   c. 1.5%
   d. 2%

iii. Intubation is difficult in obstetric patient in comparison to other patient because?
   a. Air way is edematous
   b. Edematous tongue
   c. Enlarge breast
   d. All of the above
   e. None of the above
Module-VI

iv. Preoxygenation is very important step in parturient because?
   a. Low FRC
   b. High O2 consumption
   c. Difficult intubation
   d. All the above
   e. None of the above

v. Size of the LMA which can be mostly used for Indian mothers?
   a. 2-3
   b. 3-4
   c. 4-5
   d. None of the above

vi. Intravenous opioid analgesia is obtained in pregnant mother before delivery of baby undergoing general anaesthesia?
   a. It causes maternal respiratory depression
   b. It causes fetal respiratory depression
   c. It dose not act at all
   d. Very high dose is required

vii. In a failed intubation situation the first thing which is needed most is?
   a. Try the intubation again and again
   b. Call for help
   c. Try surgical airway
   d. Differ the operation
viii. Why are pregnant mothers more prone to aspiration?
   a. High intragastric pressure
   b. High acidity because of placental secretion
   c. Low gastric motility
   d. All of the above
   e. None of the above

ix. In a pre-eclamptic parturient the method of anaesthesia intervention for elective LSCS is?
   a. Spinal anaesthesia
   b. General anaesthesia
   c. Epidural anaesthesia
   d. Combined spinal epidural anaesthesia

x. Most common complication of spinal and epidural anesthesia is?
   a. Aspiration
   b. Hypotension
   c. Vomiting
   d. Fetal distress

xi. In present day obstetric practice which drug does not have any role?
   a. Bupivacaine
   b. Thiopentone sodium
   c. Pethidine
   d. Diazepam
xi. What is the confirmatory signs of intubation?
   a. Undervision putting of ET tube
   b. ET CO$_2$
   c. Chest expansion
   d. Confirmation of air entry by stethoscope

xiii. What is the most important step in getting spinal/epidural block?
   a. Proper position of patient
   b. Proper needle quality
   c. Proper preloading
   d. Availability of proper staff

xiv. In a fetal distress with severe bradycardia method of anaesthesia should be:
   a. General anaesthesia
   b. Spinal anaesthesia
   c. Epidural anaesthesia
   d. Combined spinal epidural anaesthesia

xv. Definitive treatment of PDPH is
   a. Plenty of oral fluids
   b. Caffeine tablet
   c. Epidural blood patch
   d. Supine position

xvi. The most cost effective way of giving anaesthesia to a parturient is
   a. spinal
   b. Epidural
   c. GA
   d. CSEA
xvii Arrhythmia just after intubation is best treated with
   a. Lidnocaine
   b. Amiodarone
   c. Sotalol
   d. Propranolol

xviii Intubation is best performed in
   a. Head down position
   b. Sniffing position
   c. Lateral position
   d. Supine position

xix Intravenous opioids are best given
   a. Just before delivery of baby
   b. Immediately after delivery of baby
   c. At the time of intubation
   d. At the time of extubation

xx Oxytosic is given
   a. Just before delivery of baby
   b. Immediately after delivery of baby
   c. At the time of intubation
   d. At the time of extubation
Module-VI

Answers

i. b xi. d
ii. b xii. b
iii. d xiii. a
iv. d xiv. a
v. b xv. c
vi. b xvi. a
vii. b xvii. a
viii. d xviii. b
ix. c xix. b
x. b xx. b

6.6 Further readings

- Anaesthesia – Miller
- Clinical anaesthesia – Barash
- Obstetric anaesthesia – Chestnut
Module - VII
The Parturient with Systemic Disease
Module Structure

7.1 Introduction

7.2 Objectives

7.3 Contents

- 7.3.1 Hypertensive disorders of pregnancy 143
- 7.3.2 Pregnancy and diabetes mellitus with medical and anaesthetic management 146
- 7.3.3 Anaesthetic management of pulmonary disease in pregnant patient 148
- 7.3.4 Antepartum and post partum haemorrhage 150
- 7.3.5 Common haematologic and coagulation disorders in pregnancy 154
- 7.3.6 Anaesthetic management of patients with liver disease 155
- 7.3.7 Amniotic fluid embolism 157
- 7.3.8 Pregnancy and renal disease 158
- 7.3.9 Anaesthetic management of pregnant patient with preterm labour 159
- 7.3.10 Pregnancy and heart disease. 160

7.4 Salient points to remember 165

7.5 Check your progress 165

7.6 Further readings 167
7.1 **Introduction**

Pregnancy may be associated with many other systemic illnesses like diabetes mellitus, hypertension, bronchial asthma, bleeding abnormalities and heart disease. The parturient may have developed these diseases for the first time or they may be detected on routine antenatal check-up. It is important for the anesthesiologist to have a thorough knowledge of such a disease and its management for the safety of both the mother and fetus. It is beyond the scope of this module to write a detailed description of all of them but the more common diseases and their management relevant to anesthesia are described below.

7.2 **Objectives:**

After going through this module you should be able to

- Describe various systemic diseases that may be associated with pregnancy.
- Describe their clinical presentation, diagnosis and emergency management.
- Describe how to make a decision regarding shifting of the patient to a referral center.

7.3 **Contents**

7.3.1 **Hypertensive disorders of pregnancy**

The hypertensive disorders of pregnancy can be classified as follows

<table>
<thead>
<tr>
<th>Table 7.1</th>
</tr>
</thead>
</table>

**Classification of hypertensive disorders in pregnancy**

- Pregnancy-induced hypertension
  - Pre-eclampsia
    1. Mild
    2. Severe
  - Eclampsia
    Chronic hypertension preceding pregnancy (any etiology).
    Chronic hypertension preceding pregnancy (any etiology) with superimposed pregnancy-induced hypertension.
  - Superimposed pre-eclampsia
  - Superimposed eclampsia
Module-VII

i. **Chronic hypertension** - It is defined as any BP of more than 140 mm Hg systolic or 90 mmHg diastolic of any etiology diagnosed before pregnancy.

**Anesthetic management** - Continue the antihypertensive drug the patient is already on. No special anaesthetic technique is recommended if BP is well controlled. To obtund (suppress) the cardiovascular response to intubations, xylocard (lignocaine) 1-1.5 mg/kg i.v may be given. Pain relief of labour pain may be provided with epidural analgesia with no additional risk to the mother or fetus.

ii) **Pre-eclampsia** - It is a syndrome of hypertension (developed during pregnancy), proteinurea, and oedema that occur during pregnancy. Though pre-eclampsia by itself is not life threatening, it can progress to a more life-threatening condition like eclampsia and HELLP syndrome (Haemolysis, Elevated Liver Enzymes, and Low Platelet count, characterized by serum bilirubin of more than 1.2 mg/dl, abnormal peripheral smear, SGOT >70 IU, LDH >600 IU/L and platelet count of less than 100,000/dl). The anaesthetic management of this condition is similar to eclampsia and discussed later.

**Medical management** – No clear benefits of drug therapy have been reported in mild pre-eclampsia (BP <160/90 mmHg). Methyldopa is the drug of choice for long-term therapy to control BP. Severe pre-eclampsia should be referred to tertiary hospital for further management, as they required intensive monitoring and investigation. The monitoring should include four-hourly BP record; fluid balance chart; daily urine analysis; twice weekly full blood count especially platelet count; uric acid, urea, creatinine and electrolytes; liver function test; 24-hour urinary protein estimation if more than a trace of protein in urine; and weekly weighing. If platelet count is less than 100×10^3, a prothrombin time and APTT should be measured.

<table>
<thead>
<tr>
<th>Table 7.2</th>
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</table>

**Definition of severe pre-eclampsia**

Hypertension (BP ≥140/90 mmHg) with proteinuria (≥0.5 g/24 h or ≥ 2+ on urine-analysis) and one of the following:

- Epigastric pain, headache, visual disturbance
- Clonus
- Platelet count <100 × 10^3, ALT >70 IU, LDH > 600 U

Severe hypertension (systolic BP ≥170 mmHg or diastolic BP ≥ 110 mmHg) with proteinuria (≥ 0.5 g/24 h or ≥ 2+ on urine-analysis)
Drug therapy to control BP is recommended if BP is more than 160/110 mmHg. The drugs that may be safely used are -

a) Hydralazine: 5 mg intravenously, can be repeated every 15 minutes until the BP is < 160/110, or heart rate > 120/minutes. It may be associated with headache, tremulousness and vomiting.

b) Sublingual Depin (nifedipine): 10-20 mg sublingual may be given which can be repeated after 6-8 hours.

c) Labetalol: intravenous therapy with 20 mg Labetalol can be repeated after 10 minutes upto 220 mg.

Women with severe pre-eclampsia do not require routine anti-convulsion therapy.

iii) Eclampsia - Pre-eclampsia when associated with fits is called eclampsia. It is an emergency situation and the patient should be treated with intravenous diazepam 5-10 mg or midazolam 1-2 mg for the first fit, then immediately assess the ABC of basic resuscitation: airway, breathing and circulation. Magnesium-sulphate infusion should be started. The loading dose of magnesium-sulphate is 4 gm i.v slowly over 15-20 minutes followed by infusion of 1-2 gm/hr. Note for signs of toxicity (e.g. depressed patellar reflexes, decreased respiratory rate) as given in the table and urine output. If oliguria or suspicion of magnesium toxicity develops the serum magnesium dose should be adjusted accordingly. Continue magnesium therapy upto 24-48 hrs after delivery. Contraindications to magnesium therapy include renal failure, cardiac disease, and neuromuscular disorder. If magnesium therapy is contraindicated diazepam infusion of 2-2.5 mg/hr may be started.

<table>
<thead>
<tr>
<th>Serum Mg²⁺ level</th>
<th>Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-7 mEq/L</td>
<td>Therapeutic range</td>
</tr>
<tr>
<td>10 mEq/L</td>
<td>Loss of patellar reflexes</td>
</tr>
<tr>
<td>10-15 mEq/L</td>
<td>Respiratory arrest</td>
</tr>
<tr>
<td>&gt; 25 mEq/L</td>
<td>Asystole</td>
</tr>
</tbody>
</table>

Anesthetic management

- Labour Pain: Regional nerve block is the preferred method of analgesia as it improves placental perfusion and helps to control BP. A prothrombin time and platelet count is required. Bupivacaine is the drug of choice for regional nerve block.
• Caesarean Section- If no contraindication, regional nerve block is preferred over general anaesthesia for operative intervention. The two major problems faced by anaesthetist for general anaesthesia are: oedema of the upper airway which can cause difficulty with endotracheal intubations hence a smaller size endotracheal tube should be available and secondly, there may be an exaggerated rise in BP during intubations, so it should be controlled pharmacologically. The interaction between magnesium and suxamethonium may extend the duration of action of suxamethonium. Non-depolarising drugs should be used in a reduced dosage.

7.3.2 Pregnancy and diabetes mellitus

Maintaining normal maternal blood glucose is very important throughout gestation and anesthesiologist is often involved with these tasks in the peri-operative period. Patient in labour can be managed with slow infusion of insulin and glucose as given in the table.

Table 7.4 Suggested insulin and glucose infusion rate based on finger-stick glucose measurement

<table>
<thead>
<tr>
<th>Blood Sugar (mg/100 ml)</th>
<th>Insulin Dose (Units/hr)</th>
<th>Intravenous Fluid (125 ml/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 100</td>
<td>0</td>
<td>D₅LR</td>
</tr>
<tr>
<td>100-140</td>
<td>1.0</td>
<td>D₅LR</td>
</tr>
<tr>
<td>141-180</td>
<td>1.5</td>
<td>NS</td>
</tr>
<tr>
<td>181-220</td>
<td>2.0</td>
<td>NS</td>
</tr>
<tr>
<td>&gt; 220</td>
<td>&gt; 2.5</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS: Normal saline, LR: Ringer lactate, D₅: 5% Dextrose

Monitor blood glucose regularly every 1-2 hr. Do not use glucose solution for intravenous hydration or preloading before regional anesthesia.

i. Analgesia for labour and delivery: - Adequate pain relief is very essential in a pregnant lady with DM as it provides two benefits. First, it decreases the level of circulating catecholamines which itself cause a reduction in blood sugar. Secondly, a decrease in circulating catecholamines improves placental perfusion.
ii. Anaesthetic management

Patient preparation:
- Do not use glucose-containing fluid for pre-hydration or volume replacement.
- Keep nil per orally overnight.
- Give H2 blocker at night and morning on the day of surgery as patient with DM are known to have a higher gastric volume.
- Gastric prokinetic (e.g. Metoclopramide) may be given at night and morning as DM patient have a slower gastric emptying time.
- Measure maternal glucose by finger dextro-stick.
- Start an intravenous infusion of insulin and glucose at rate mentioned in the table.
- **Remember**, after delivery maternal insulin requirement decreases due to loss of insulin resistance conferred by the placenta. Hence, patient-receiving insulin before delivery may develop hypoglycemia.

Anesthetic technique - The fetal and maternal outcome is equally good both by regional and general anaesthesia technique, provided the blood sugar is properly controlled before surgery. Clinical studies of acid-base status of neonates born of normal or diabetic parturient who received general anaesthesia for caesarean delivery have shown no major differences between the two patient groups. However, neonatal depression (defined as APGAR score of less than 7 at 1 minute) occur more commonly in the newborn of diabetic mother due to high incidence of prematurity and not due to the anaesthetic technique per se.

Regional anesthesia is probably the most appropriate technique for caesarean section. However, hypotension and hyperglycaemia should be avoided, as both the conditions are known to cause fetal acidosis leading to poor neonatal outcome. Hypotension can be avoided by pre-loading with intravenous fluid and putting the patient in the left lateral position, while hyperglycaemia can be avoided by avoiding glucose-containing fluid for pre-loading.

In the post-operative period decrease the dose of insulin and watch for signs of neonatal hypoglycemia (defined as BS < 35mg/dl). These signs include poor muscle tone, apnea, respiratory distress, lethargy, hypothermia and seizure.
Module-VII

7.3.3 Anesthetic management of pulmonary disease in pregnant patient

Maternal hypoxia and hypocapnea will impair fetal oxygenation. Good control of asthma is important to minimize adverse effect of the disease on pregnancy.

i. Preoperative evaluation

It includes assessment of:

• Severity of Asthma
• Symptom (shortness of breath, cough, wheezing)
• Medication she is on (inhaler $\beta_2$ agonist, steroid, cromolyn sodium)
• Any events that can precipitate asthma (exercise, infection, allergen, stress, and exposure to cold)

ii. Treatment of acute asthma during labor and delivery

• Give supplemental oxygen by face mask
• Make sure the patient is well hydrated.
• Look any inciting cause that can precipitate bronchospasm (e.g. upper respiratory tract infection, exposure to allergen)
• Treat initially with inhaled $\beta_2$ agonist like salbutamol or salmeterol. Subcutaneous terbutaline 0.25 mg may be given as an alternative drug. If no relief with this therapy, intravenous hydrocortisone 100-200 mg every 6 hours may be given. Intravenous aminophylline may be used if symptoms are not relieved with the above therapy (dose: loading 5 mg/kg over 30 minutes followed by 0.5 mg/kg/hr).

iii. Analgesia for labor and delivery

Adequate pain relief is very essential both during labor and delivery as pain of active labor can precipitate bronchospasm. Systemic medication can provide analgesia in the early phase of labor. However in a more active and painful part of (i.e. later phase) labor this may not be sufficient and epidural analgesia may be necessary.

iv. Anaesthesia for caesarean section

• If possible optimize the patient’s pulmonary status before surgery.
• Continue medication for asthma upto the time of surgery
• Monitor pulmonary status during surgery.
Regional anaesthesia - It is the technique of choice for caesarean section and it offers significant advantage in asthmatic patient. First avoiding general anaesthesia and endotracheal intubations, it decreases the incidences of bronchospasm. Secondly, in awake patient, continuous verbal contact will elicit sign of respiratory difficulty.

General anaesthesia - It carries a significant risk in parturient with asthma. The rapid induction and intubation sequence used for caesarean delivery can precipitate bronchospasm. Provide deep plane of anaesthesia throughout surgery. Ketamine is a good induction agent in asthmatic patient as it causes bronchodilatation (dose 0.5-1.5 mg/kg i.v). Brochodilatation begins within 1.5 minutes and lasts for 6-8 minutes. But it causes sympathetic stimulation, which can cause an increase in maternal BP and heart rate. This effect makes ketamine a less favourable induction agent in hypertensive patient.

Propofol is another alternative agent. Propofol in the dose of 2-2.5 mg/kg reduces the incidence of bronchospasm due to intubations in comparison to thiopentone.

Other techniques, which can reduce the incidence of bronchospasm after intubations are

- Intravenous xylocard 2% (lignocaine) (1-1.5 mg/kg i.v. about 90 seconds before intubations) decreases the incidence of bronchospasm.
- Avoid manipulation of the airway until full skeletal muscle relaxation has been achieved.
- Give adequate dose of intravenous induction agent.

Per-operative Treatment of Bronchospasm

- Look for kinking of tube if intubated
- Find out and remove any possible triggering agent.
- Deepen the plane of anaesthesia.
- Use high concentration of oxygen till bronchospasm is controlled.
- Inhaled bronchodilator can be given via the endotracheal tube (8-10 puffs).
- If no relief with the above therapy aminophylline infusion may be started at the dose given above.

Extubation - An awake extubation will minimize the chance of pulmonary aspiration of gastric content but extubation of the endotracheal tube may prompt bronchospasm. Inhaled
bronchodilator and small dose of intravenous fentanyl or intravenous xylocard (lignocaine) before extubation can help minimize airway reactivity during extubation.

7.3.4 Antepartum and postpartum haemorrhage

Peripartum haemorrhage is a major cause of maternal mortality. It may be defined as follows:

i. **Antepartum haemorrhage** - Bleeding from the genital tract between 28 completed weeks and the onset of labour. Common causes are placenta praevia and placental abruption and they are discussed in details below.

ii. **Postpartum haemorrhage**-(primary) - Greater than 500 ml of blood loss from the genital tract after vaginal delivery of the fetus until 24 hours after birth. The most common cause is retained placenta.

iii. **Postpartum haemorrhage**- (secondary)
Abnormal bleeding between 24 h and 6 weeks postpartum.

<table>
<thead>
<tr>
<th>Causes of peripartum haemorrhage</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Antepartum and intrapartum</em></td>
</tr>
<tr>
<td>Placenta praevia</td>
</tr>
<tr>
<td>Abruptio placenta</td>
</tr>
<tr>
<td>Uterine rupture</td>
</tr>
<tr>
<td>Trauma</td>
</tr>
<tr>
<td>Advanced ectopic pregnancy</td>
</tr>
<tr>
<td>Other genital tract bleeding</td>
</tr>
</tbody>
</table>

| *Postpartum*                     |
| Uterine atony                    |
| Retained placenta cervical and vaginal laceration |
| Placenta accreta                 |
| Uterine inversion                |
| Coagulopathy                     |
Table 7.6

Aetiology of coagulopathy in obstetrics

♦ DIC secondary to
  Abruptio placentae
  Pre-eclampsia
  Chorioamnionitis
  Amniotic fluid embolism
  Prolonged intrauterine death
  Massive transfusion
♦ HELLP syndrome
♦ Pre-existing disease
♦ Iatrogenic (heparin)

iv. Assessment
♦ Obstetric history to establish diagnosis
♦ Clinical signs
  - Maternal: level of consciousness; pulse; BP
  - Fetal: heart rate; CTG
♦ loss- measured or concealed.
♦ Obstetric examination- speculum examination; ultrasound
♦ General medical history and examination- to assess fitness for anaesthesia
♦ Send blood for cross match and arrange blood

v. Resuscitation
♦ Summon extra staff
♦ Position patient head down
  Raise leg
  Left tilt (Ante or intrapartum)
Module-VII

♦ Give oxygen
♦ Intravenous access – two large bore cannulae
♦ Fluid resuscitation:
  - Crystalloid (1-2 l)
  - Colloid (haemaccel; hetastarch)
  - Blood if available (start with O Rh negative in case of emergency and cross matched blood is unavailable)
  - Warm fluid and blood
♦ Maternal monitoring:
  - Essential
    a) BP
    b) Pulse
    c) Urine output
    d) Pulse oximetry (if available).
  - Optional:
    a) Temperature
♦ Fetal monitoring: heart rate

**Indication for medical treatment**
• Atonic uterus—give oxytocin, ergot alkaloid or prostaglandin.
• Coagulopathy—give fresh frozen plasma, cryoprecipitate, platelet.

**Indication for surgical treatment**
• Delivery of fetus
• Delivery of placenta or retained products
• To repair local trauma or ruptured uterus
• To ligate vessel or perform hysterectomy in case of failed medical treatment.
vi. **Anesthetic Management**

**Placenta previa** - A placenta previa is present when the placenta implants in advance of the fetal presenting part. The incidence is about 1 in 200 pregnancies. The classic sign of placenta previa is painless vaginal bleeding in the second and third trimester. The preoperative assessment and pre-op preparation is the same as given above. If epidural is in-situ and cardiovascular stability can be maintained and the patient is conscious, then surgical intervention can proceed under regional block. Except in the above circumstances, a general anaesthesia is the technique of choice. Ketamine can be used for induction but it increases uterine tone. If cardiovascular status is stable thiopentone can be safely used. All inhalation agents relax the uterus with progressive depression of uterine contractility above 1 MAC. Above 2 MAC inhalational agents block the uterine response to oxytocics. Isoflurane 0.5 MAC or les does not cause uterine relaxation, and therefore is the agent of choice. If the uterus is tetanically contracted (common with abruptio) the relaxation induced by an inhalation agent may improve placental perfusion.

**Placental Abruption** - Placental abruption is defined as separation of the placenta from the decidua basalis before delivery of the fetus. Acute blood loss can cause fetal distress as the surface area of gas exchange between the fetus and mother is decreased. The classic presentation includes sudden vaginal bleeding, uterine tenderness, and increased uterine activity. The major problem includes hemorrhagic shock, acute renal failure, coagulopathy and fetal distress. The preoperative assessment and resuscitation are done as mentioned above. Often the patient requires immediate surgery because of fetal distress. General anaesthesia is the technique of choice in a hypovolemic patient. Thiopentone and propofol for induction may cause a severe hypotension in a hypovolemic patient so it is better to avoid it. Ketamine and etomidate (not available in India) are a good choice but ketamine can cause an increase in uterine tone, which may cause a decrease in fetal perfusion in already distressed fetus. But a single induction dose of ketamine (upto 1 mg/kg) is found to be a safe induction agent. Severe hypotension associated with thiopentone is more harmful than an increase in uterine tone caused by ketamine. Adequate restoration of intravenous volume (colloid or crystalloid) is very important in the anaesthetic management. Since these patients are at risk of uterine atony, oxytocin (20 units in 1000 ml of Ringer Lactate through i.v. drip but not as bolus) should be immediately infused after the delivery of the baby. Persistent uterine atony may require other uterine ecbolic like methergine.

**Retained placenta** - Retained placenta is the main cause of both early and delayed postpartum bleeding. The treatment includes manual removal and inspection of the uterus for which the services of anaesthetist is often needed. The choice of anaesthetic technique depends upon the
severity of blood loss. Regional technique is a good choice for patient in whom blood loss is minimal. Sometimes administration of 50% nitrous oxide is sufficient. In some cases a complete uterine relaxation may be required to facilitate the removal of placenta hence a general anaesthesia may be required with administration of halogenated agents. Whichever technique is used for anaesthesia protection against aspiration is important.

7.3.5 Common haematologic and coagulation disorders in pregnancy

i. **Thalassemia** - They are a group of hemolytic disorders of RBC due to a reduced synthesis of the polypeptide globin chain. In α-thalassemia, alpha chain production is defective and similarly beta chain production is defective in β-thalassemia. β-thalassemia is the common one in India hence we will discuss this in detail which is relevant to anaesthesia.

β-Thalassemia major patient are usually unable to conceive. Due to repeated haemolysis and transfusion of blood to maintain life there is usually a resultant increase in iron load in the blood secondary to haemolysis. Deposition of such iron into endocrine tissues may lead to DM, adrenal insufficiency and infertility. Accumulation of iron in the myocardial tissue can lead to conduction abnormality, and intractable heart failure. There is no special anaesthetic technique in the management of such a patient. The preoperative evaluation should be based on the pathophysiological changes that may be present as mentioned above and the anaesthetic technique should be individualized based on the preoperative assessment.

β-thalassemia minor is usually benign and the anaemia is usually mild and transfusion is seldom required even during pregnancy. Most patients with β-thalassemia minor tolerate pregnancy well. Transfusions are reserved only for patients with haemoglobin of below 8 gm/dl. Again no special anaesthetic is required for such a patient.

ii. **Sickle Cell Disease** - It refers to a group of disorders where RBC undergoes sickling when they are in deoxygenated states resulting in clinical signs and symptoms. Sickle cell is elongated and crescent shaped unlike the normal biconcave shape of normal RBC.

**Pathophysiology** - In sickle cell disease valine of beta chains (at 6th position) is replaced by glutamic acid resulting in a tendency of haemoglobin to aggregate when the haemoglobin is deoxygenated. Such a sickle cell stacks on one another and can block the blood vessel. Though the sickle cell can return to the normal shape after oxygenation, repeated sickling can cause alteration in the membrane resulting in decreases in life span of RBC to approximately 12 days.

The other factors that affect sickling are

♦ Increase in haemoglobin S (sickling occurs when haemoglobin S is more than 50%).
♦ Vascular stasis (increased sickling with slow circulation).
♦ Temperature (Hypothermia increases sickling).
♦ Acidosis (increase sickling with acidosis).

**Interaction of sickle disease and pregnancy**

♦ Pregnancy usually exacerbates the complications of sickle cell anaemia
♦ Patients with sickle cell anaemia have a high incidence of preterm labor, abruptio placentae, PIH and placenta previa.
♦ Maternal mortality is about 1% usually due to infection (commonly pyelonephritis and pneumonia).
♦ Fetal mortality is usually about 20%.

**Management**

- **Medical** - the goal of medical therapy is to maintain HbA > 40% and haematocrit of 35%-40%. Transfusion is indicated only when Hb is below 8 gm/dl. Maintaining a haemoglobin concentration of more than 10 gm/dl during pregnancy decreases the incidences of painful crisis but does not appear to alter fetal or maternal mortality.

iii **Anaesthetic management**

♦ The choice of anaesthesia depends on patient’s preferences, physical status of the patient and anaesthesiologist’s choice.
♦ Adequate pain control during labor is essential.

**Principles of anesthetic management** -

♦ Maintain adequate intravascular volume to reduce viscosity
♦ Transfusion of RBC to maintain oxygen carrying capacity.
♦ Administration of supplemental oxygen
♦ Maintenance of normothermia.
♦ Prevention of peripheral venous stasis.

7.3.6 **Anaesthetic management of patients with liver disease**

i. **Guidelines**

♦ Evaluate the extent of hepatic involvement by history and investigations.
Module-VII

♦ Recognize and evaluate underlying systemic abnormalities.
♦ Exclude or correct coagulopathy before administration of regional anaesthesia.
♦ Prevent hepatic injury by optimizing hepatic blood flow and oxygenation.
♦ Recognize altered pharmacokinetics and pharmacodynamics.

ii. Systemic abnormalities associated with liver disease

♦ **Coagulation factors**- Impaired synthesis of clotting factors I, II, V, VII and X the plasma half-life of factor VII is 5 hours hence coagulopathy develops very rapidly. Vitamin-K administration corrects the abnormalities if due to malabsorption but cannot be corrected if it is due to liver failure. Coagulopathy has to be corrected by transfusion of FFP, cryoprecipitate if clinical bleeding develops.

♦ **Cardiovascular system**- there is an increase in cardiac output due to low systemic vascular resistance secondary to extensive arterio-venous shunting. Hepatic failure results in an increase in blood volume that is greater than that occurs in normal pregnancy hence may develop cardiomyopathy. Tense ascites often seen in liver failure may impair venous return.

♦ **Pulmonary system**- impaired hypoxic pulmonary vasoconstriction along with ascites and splinting of diaphragm by the gravid uterus may lead to significant hypoxia. Patients with liver disease have an increase in 2, 3-DPG levels, hence a shift of oxygen dissociation curve to the right.

♦ **Nervous system**- Inadequate clearance of ammonia and mercaptans may lead to hepatic encephalopathy. Impairment may range from mild confusion to coma. These patients are at increased risk of pulmonary aspiration of gastric contents. The integrity of blood brain barrier is altered hence a careful titration of anaesthetic agent is required.

♦ **Metabolic abnormalities**- they include tendency to develop hypoglycemia, hyponatremia, hypokalemia and acid-base disturbances. Blood sugar should be measured frequently.

♦ **Renal system**- abnormal sodium retention is usually present. Sudden oliguria may occur which heralds the onset of hepatorenal syndrome. Maintenance of adequate circulatory volume and monitoring of urine output is very important.

iii. Anaesthetic management:

♦ **Regional anaesthesia**- If no coagulation abnormalities, regional anesthesia can be safely
administered in patients with hepatic failure. Local anaesthetic of amide type undergoes hepatic biotransformation and the half-life of xylocaine (lignocaine) is found to be increased by more than three fold in hepatic failure and the volume of distribution is increased. Ascitis and portal hypertension lead to engorgement of epidural veins, hence an increased incidence of bloody tap and the use of test dose to rule out intravascular injection is essential.

- **General Anaesthesia** - General anaesthesia is indicated when there are coagulation abnormalities, severe hemorrhage, fetal distress and altered sensorium. Evaluate intravascular volume before induction of anaesthesia. Patient with variceal bleeding should be intubated awake. Induction may be done with thiopentone, or ketamine depending on the haemodynamic status of the patient. Pseudocholinesterase level may be reduced in liver failure, which causes a delay in the metabolism of succinylcholine but it is usually of minimal significance. Give non-depolariser (long acting) preferably atracurium only after the recovery of the effect of succinylcholine. Isoflurane is the preferred inhalation agent of choice. Reversal of neuromuscular blockade must be documented before extubation.

7.3.7 **Amniotic fluid embolism**

Amniotic fluid embolism is a syndrome characterized by sudden onset of peripartum shock and pulmonary edema. The incidence is about 1 per 100,000 live pregnancies but it accounts for 12% of maternal mortality.

i. **Clinical presentation:** There are no specific signs and symptoms attributable to amniotic fluid embolism; hence the diagnosis is one of exclusion. They often present with history of dyspnea, hypoxemia, and severe hypotension. In some cases they may present with excessive bleeding and seizures.

ii. **Management:**

- Initiate cardiopulmonary resuscitation
- Support maternal circulation.
- Established intravenous access with many large gauge catheters
- Begin inotrope support if necessary
- Monitor fetal well being
- Treat coagulopathy—decide between component therapy versus fresh whole blood
- Intubate the patient if necessary.
7.3.8 Pregnancy and renal disease

Most authors agree that pregnancy does not alter the natural history of pre-existing renal disease. Fetal outcome depends on the extent of maternal renal insufficiency. Women with renal impairment during conception have an increase incidence of spontaneous abortion, perinatal loss, preterm delivery and small for gestational age baby.

i. Pathophysiology – Acute renal failure is suggested by a sharp elevation of BUN greater than 13 mg/dl and creatinine greater than 1 mg/dl. In complete renal failure serum creatinine rises at the rate of 0.5-1.0 mg/dl/day. Urine output typically falls to less than 400 ml/day. The pre-renal causes are the most common. The urinary indices show urinary osmolality greater than 500 mOsm/kg water, urine sodium less than 20 meq/l, fractional sodium excretion of less than 1% and urinary/plasma creatinine ratio of greater than 40.

Table 7.7

<table>
<thead>
<tr>
<th>Causes of acute renal failure during pregnancy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prerenal</strong></td>
</tr>
<tr>
<td>Hyperemesis gravidarum</td>
</tr>
<tr>
<td>Uterine haemorrhage</td>
</tr>
<tr>
<td>Heart failure</td>
</tr>
<tr>
<td><strong>Post renal</strong></td>
</tr>
<tr>
<td>Ureteral obstruction by the gravid uterus</td>
</tr>
<tr>
<td><strong>Intrarenal</strong></td>
</tr>
<tr>
<td>Septic abortion</td>
</tr>
<tr>
<td>Amniotic fluid embolism</td>
</tr>
<tr>
<td>Pre-eclampsia/eclampsia</td>
</tr>
<tr>
<td>HELLP syndrome</td>
</tr>
<tr>
<td>Acute fatty liver of pregnancy</td>
</tr>
<tr>
<td>Idiopathic postpartum liver failure</td>
</tr>
</tbody>
</table>

ii. Anaesthetic Management There is no a standard technique for the anaesthetic management of a pregnant patient with renal failure. It should be individualized and will depend upon the severity of the renal function impairment, the urgency for surgery and the patient’s choice. Whichever technique is chosen the following points should be remembered -
- Proper evaluation of maternal intravascular volume is essential
- The level of azotemia, electrolytes, and hematologic status should be assessed
- If BUN is greater than 80 mg/dl or the serum potassium is greater than 5.5 meq/l, Dialysis should be done before elective procedure.
- Regional anaesthesia may be administered in the absence of coagulopathy, thrombocytopenia or hypovolemia.
- Epidural anaesthesia is preferred over spinal anaesthesia when the volume status is not clear as the level of sympathetic block can be achieved more slowly.
- Avoid potassium-containing fluid.
- General anaesthesia is indicated for urgent caesarean delivery, coagulation abnormalities or hemorrhage.
- Try avoiding drugs that are excreted by kidney.

7.3.9 Preterm infant

A term fetus tolerates the stress of labor and delivery very well but the pre-term infant may not tolerate such a stress. A preterm fetus is more vulnerable to the depressant effects of analgesic and anesthetic drugs because of the following

- Decreased protein available for binding and decreased affinity by the protein for the drug hence more free drugs are available in the circulation.
- Higher level of bilirubin, which may compete with the drug for protein binding.
- Greater entry of drug to the CNS due to incomplete blood brain barrier more depressant action to the nervous system for an equipotent dose.
- Decreased ability to metabolize and excrete drug.
- Higher incidences of acidosis during labor and delivery.

Anaesthetic management for caesarean section

- Administration of general anaesthesia is similar to that for patient with term pregnancy.
Module-VII

- Most of the anaesthetic agents can depress the preterm infant more than the term infant hence a more careful titration of all drugs used for the mother.
- If no contraindication, regional anaesthesia is the technique of choice.

7.3.10 Pregnancy and heart disease

A wide range of problems, affecting approximately 1 in 350 pregnancies. It is beyond the scope of this book to discuss all the heart diseases in detail. We will have a brief review of heart disease and a detailed discussion of the most common heart diseases in pregnancy.

i. Major Problems
- Valvular diseases-Mitral stenosis and mitral regurgitation are the common ones.
- Congenital heart diseases
- Dysrhythmias
- Ischaemic heart disease-incidence is increasing
- Cardiomyopathies

ii. Antenatal Assessment
- Cardiac reserve
- ECG/echocardiography
- Medication she is taking
- Consider delivering in center with cardiac facility

iii. Intrapartum Monitoring
- Continuous ECG
- BP
- Consider CVP monitoring if facilities are available.

iv. Choice of Analgesia/Anaesthesia
- Sedation reduces cardiovascular responses to stress.
- Continuous conduction anaesthesia reduces stress response.
- Low dose local anaesthesia and opioid epidural infusions provide optimal analgesia and minimize cardiovascular instability.
- Continuous spinal/epidural is not contraindicated in fixed cardiac output state (except in severe MS/AS) if appropriate invasive monitoring is used.
- The technique of anaesthesia should be based on the type and severity of the heart disease.

v. Anaesthetic Management Of Patient With Mitral Stenosis In Pregnancy

Evaluation:

- Define the NYHA classification (table 7.8) as it gives a rough idea of the severity of the disease.
- Review the medications the patient is on.
- Get ECG and look for atrial fibrillation, evidence of RVH (Right ventricular hypertrophy).
- Get chest X-ray and look for the left border of heart and lung field.
- Echocardiography in special circumstances to rule out the nature of the valvular disease, severity, and define the pressure gradient across the valve.

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Dyspnea only on severe exertion (with unaccustomed work)</td>
</tr>
<tr>
<td>II</td>
<td>Dyspnea on mild exertion (with accustomed work)</td>
</tr>
<tr>
<td>III</td>
<td>Dyspnea with daily routine activities.</td>
</tr>
<tr>
<td>IV</td>
<td>Dyspnoea at rest</td>
</tr>
</tbody>
</table>

Table 7.8 NYHA classification of heart disease

Antibiotic prophylaxis

Antibiotic prophylaxis against bacterial endocarditis is necessary for both vaginal and operative deliveries in all patients with valvular or congenital heart disease. The only two conditions where such a prophylaxis is not necessary: 1) repaired ASD, 2) PDA repaired more than 6-months
before. The recommended drugs and the doses are given in the table below.

**Table 7.9  Antibiotic prophylaxis against endocarditis**

I. Dental, oral, pharyngeal, upper airway and esophageal procedures.

A. Standard
   **Adults**
   Amoxycillin, 3 g orally, 1 hour before and 1.5 g, 6 hours after the procedure
   Or
   Ampicillin, 2 g IV or IM, 30 minutes before
   **Children**
   Amoxycillin, 50 mg/kg orally, 1 hour before and 25 mg/kg, 6 hours after the procedure
   Or
   Ampicillin, 50 mg/kg IV, 30 minutes before

B. Penicillin allergy
   **Adults**
   Erythromycin, 1 gm orally, 2 hours before and 500 mg, 6 hours afterward
   Or
   Azithromycin or clarithromycin, 500 mg before
   Or
   Clindamycin 600 mg orally, 2 hours before and 300 mg 6 hours afterward
   Or
   Clindamycin 600 mg IV 30 minutes before
   Or
   Cefazolin 1 g IV or IM 30 minutes before
   Or
   **Children**
   Erythromycin 20 mg/kg orally 2 hours before and 10 mg/kg 6 hours afterward
   Or
   Clindamycin 10 mg/kg orally 2 hours before and 10 mg/kg 6 hours afterward
   Or
   Clindamycin 20 mg/kg IV 30 minutes before and 5 mg/kg 6 hours afterward
Or
Cefazolin 25 mg/kg IV or IM 30 minutes before and 25 mg/kg 6 hours after the procedure

C. High risk (prosthetic valve or prior endocardities)
   Adults
   Ampicillin 2 g IV or IM and gentamicin 1.5 mg/kg (upto 80 mg) IV or IM 30 minutes before; and amoxycillin 1.5 g orally 6 hours afterward or repeat IV regimen 8 hours later
   Children
   Ampicillin 50 mg/kg IV or IM and gentamicin 2 mg/kg IV or IM 30 minutes before and amoxycillin 50 mg/kg orally 6 hours afterward or repeat IV regimen 8 hours later.

D. High risk with penicillin allergy
   Adults
   Vancomycin 1 g 1 hour before (infuse over 1 hour)
   Children
   Vancomycin 20 mg/kg IV 1 hour before (infuse over 1 hour)

II. Genitourinary and gastrointestinal procedure
   A. Standard
      Adults
      Ampicillin 2 g IV or IM and gentamicin 1.5 mg/kg (upto 80 mg) IV or IM 30 minutes before and amoxycillin 1.5 g orally 6 hours afterward or repeat IV regimen 8 hours later
      Children
      Ampicillin 50 mg/kg IV or IM and gentamicin 2 mg/kg IV or IM 30 minutes before and amoxycillin 50 mg/kg orally 6 hours afterward or repeat IV regimen 8 hours later.

   B. Penicillin allergy
      Adults
      Vancomycin 1 g 1 hour before (infuse over 1 hour) and gentamicin 1.5 mg/kg (upto 80 mg) IV
      Children
      Vancomycin 20 mg/kg IV 1 hour before (infuse over 1 hour) and gentamicin 2mg/kg IV
Anaesthetic management

- Avoid maternal tachycardia. A small increase in heart rate will decrease diastolic filling time which will therefore cause a marked increase in left atrial pressure: β-blocker can control heart rate.

- Epidural analgesia will control increase in heart rate associated with pain. It also helps to accommodate the increase in blood volume with contracting uterus.

- If epidural analgesia is contraindicated NYHA class I & II can be safely managed with intermittent parenteral analgesia. Pethidine is not a drug of choice as it can cause tachycardia. For NYHA III & IV intermittent analgesia will be insufficient, infusion will be required.

Regional anaesthesia

It is a safe technique in patients, especially NYHA I & II. But even in patients with NYHA III & IV it is a safe option as a sudden increase in heart rate or afterload after intubation may precipitate pulmonary edema. The venodilatation produced by supplemental epidural anaesthesia is of benefit.

General anaesthesia

Etomidate is the most suitable agent for induction if available. Thiopentone should be given slowly as sudden decrease in after-load can cause an increase in heart rate to compensate for a fall in BP. Maintain anaesthesia with oxygen in nitrous oxide with halothane.

Postpartum

They are at risk of developing pulmonary edema immediately postpartum as blood volumes expand due to contraction of uterus and weaning of the venodilatation effect of regional block, so fluids should be given with caution. Because of this high incidence of pulmonary edema one may give furesemide (lasix) 20-40 mg i.v with delivery of placenta.

vi. Anaesthetic management of patient with mitral regurgitation (MR)

- Mitral regurgitation usually improves with pregnancy due to a decrease in systemic vascular resistance (SVR) and increase in blood volume.

- The key to anaesthetic management in patient with MR is to encourage forward flow of blood by reducing SVR, avoiding bradycardia and maintain an adequate blood volume. Epidural anaesthesia and pre-loading provides this condition.
7.4 Salient points to remember

- No special anaesthetic technique is recommended in a hypertensive patient if the BP is well controlled.
- The anti-hypertensive drugs that may safely be used in pregnancy are methyl 1 dopa, hydralazine, nifedipine and labetol.
- In presence of severe pre-eclampsia/eclampsia, a prothrombin time and patient count should be performed and they should be documented to be normal before a regional block is attempted.
- Maternal insulin requirement decreases after delivery, necessitating a reduction in the dosage of insulin.
- Regional anaesthesia is the technique of choice in an asthmatic.
- General anaesthesia is the technique of choice in a hypovolemic patient.
- In a patient suffering from thalassemia, the following should be considered, anaemia, deformed facial skeleton and airway problems, and iron deposition in various tissues due to multiple transfusions, leading to dysfunction of heart, liver, pancreas.
- In a patient suffering from sickle cell anaemia, avoid factors that can increase sickling e.g. dehydration, hypoxemia, acidosis.
- In absence of coagulation abnormalities, regional anaesthesia may safely be administered in a patient with hepatic disease.
- Atracurium is the muscle relaxant to be used in presence of severe hepatic or renal disease.
- Antibiotic prophylaxis against bacterial endocarditis is necessary in all patients with valvular or congenital heart disease.

7.5 Check your progress

i. a. Epidural analgesia can be given safely to the mother without risk to the fetus. (T/F)
   ib To obtund the intubation response, intramuscular lignocaine is given. (T/F)
   ic Following delivery, the insulin requirement increases. (T/F)
   id There is no disturbance with cardiac function in thalassemia. (T/F)
Module-VII

ii. Fill in the blanks
   iia. In HELLP syndrome, the following are seen: Haemolysis, _____ and _______
   iib Neonatal depression is defined as an APGAR score of less than ______ at 1 minute.
   iic. The half life of coagulation factor vii is about ______ hrs.
  iid. If cross-matched blood is unavailable _______ group blood may be used in an extreme emergency.

iii. The dose of xylocaine to suppress the intubation response
   a. 0.5 – 1 mg/kg
   b. 1 – 1.5 mg/kg
   c. 2 – 3 mg/hr
   d. 3 – 5 mg/hr

vi The therapeutic levels of Mg are
   a. 1 – 2 me/l
   b. 4 – 7 me/l
   c. 10 – 12 me/l
   d. 15 – 25 me/l

v. Neonatal hypoglycemia is defined as a blood sugar below
   a. 35 mg/dl
   b. 45 mg/dl
   c. 55 mg/dl
   d. 75 mg/dl
Answers

i.  ia  T
    ib  F
    ic  F
    id  F

ii. iia  Elevated liver enzymes, Low platelets
     iib  7
     iic  6
     iid  O Neg

iii.  b

iv.  b

v.  a

7.6 Further readings

- Obstetric anaesthesia – Chestnut
- Anaesthesia - Miller
- Clinical anaesthesia - Barash
Module - VIII
Trauma and Pregnancy
### 8.3 Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.3.1 Anatomic changes in pregnancy</td>
<td>173</td>
</tr>
<tr>
<td>8.3.2 Physiologic changes in pregnancy</td>
<td>173</td>
</tr>
<tr>
<td>8.3.3 Initial assessment</td>
<td>174</td>
</tr>
<tr>
<td>8.3.4 Secondary assessment</td>
<td>175</td>
</tr>
<tr>
<td>8.3.5 Maternal assessment</td>
<td>175</td>
</tr>
<tr>
<td>8.3.6 Fetal assessment</td>
<td>175</td>
</tr>
<tr>
<td>8.3.7 Types of trauma during pregnancy and their management</td>
<td>175</td>
</tr>
<tr>
<td>8.3.8 Algorithm for trauma management in pregnancy</td>
<td>179</td>
</tr>
<tr>
<td>8.3.9 Unique problems of CPR in pregnancy</td>
<td>180</td>
</tr>
<tr>
<td>8.4 Salient points to remember</td>
<td>180</td>
</tr>
<tr>
<td>8.5 Check your progress</td>
<td>181</td>
</tr>
<tr>
<td>8.6 Further readings</td>
<td>182</td>
</tr>
</tbody>
</table>
8.1 Introduction

Trauma during pregnancy accounts for 6-7% mortality in women. It is one of the most common causes of maternal death other than medical complications of pregnancy. Both mother and fetus may face the consequences of trauma during pregnancy. Management of pregnant women is different in certain aspects from non-pregnant women because of major physiologic changes that occur during pregnancy. One should be aware of maternal physiologic adaptation to pregnancy. Apart from obvious trauma to pregnant women, transfusion of fetal blood into maternal circulation, abnormal separation of placenta, premature labor, fetal injury and fetal death can occur. As with any other patient with trauma, early recognition and intervention is key to good outcome.

8.2 Objectives

After going through the module you should able to

- Describe the various types of trauma that a pregnant lady may commonly sustain.
- Describe how the management of such a patient may differ from that of a non-pregnant patient.
- How to resuscitate a pregnant trauma victim.

8.3 Contents

8.3.1 Anatomical changes

Increase in uterus size, so more chances of blunt or penetrating injury – or :
First trimester -well protected by amniotic fluid and thick walled uterus
Third trimester-less amniotic fluid and thin walled so more chances of trauma to the baby.

8.3.2 Physiological changes

i. Respiratory

- Physiologic hyperventilation
- Increase in tidal volume
- Increase in respiratory rate
• Mild respiratory alkalosis
• Increased oxygen consumption and decreased functional residual capacity (FRC) causes more rapid de-saturation.

ii. Circulatory changes
• Heart rate increases by 15%
• Blood pressure decreases in initial stage
• Cardiac output increases by 30-40%
• Aortocaval compression
• Systemic vascular resistance decreases

Loss of circulating volume and hemorrhage are major physiologic challenges associated with trauma. The actual amount of blood loss that results in clinical manifestation of response is greater in pregnant patient than non-pregnant patient. Fetal tolerance of maternal hemorrhage depends on the degree of maternal sympathetic response, maternal blood pressure and oxygen carrying capacity

8.3.3 Initial Assessment

“Best way to treat the fetus is to treat the mother. Pregnancy should not restrict any diagnostic, therapeutic or resuscitative measures deemed to be necessary in a trauma patient. Management is similar to non-pregnant trauma patients”

The principles of management of a trauma victim are-
• Secure airway
• Administer Oxygen
• Fluid administration- first goal is to restore circulating blood volume
• Blood Administration – if blood loss exceeds 30% of blood volume.
• Vasopressors only after optimizing intra vascular volume.
• Assess Neurological status and for the presence of any other major injury
• Always use wedge under right hip
• Nurse and examine in left lateral position to avoid supine hypotension

8.3.4 Secondary assessment
Use necessary investigative modalities to reach a definitive diagnosis for both the mother and fetus.

8.3.5 Maternal assessment
• Physical examination from head to toe
• Get relevant and essential x-rays done if facility available
• Continually monitor vital signs
• Continue primary management
• Look for premature labor
• Vaginal examination
• If laparotomy is indicated, don’t postpone because of pregnancy

8.3.6 Fetal assessment
• Auscultate for fetal heart sounds
• Bradycardia is a sign of fetal distress
• Assess gestational age by ultrasonography.

8.3.7 Types of trauma during pregnancy
Three types of trauma can occur during pregnancy
• Penetrating trauma
• Non-penetrating trauma (Blunt trauma)
• Heat related trauma (Thermal trauma)
i. **Penetrating trauma**

Penetrating violence against women could be:

- Gunshot injury
- Sharp instrument injury (Knife, broken bottle)

In early pregnancy, the abdominal organs commonly injured are intestine, spleen and liver. In late pregnancy due to an increase in the size of the uterus there are more chances of uterine injury, direct fetal, placental membrane and umbilical cord injury.

**Evaluation and management**

- Thoracic/abdominal wound may need exploration
- Radiological evaluation for any cavity penetration
- Dye evaluation of wound can be done if no X-rays are available
- If mother’s condition is stable, evaluate fetal well being
- If bloody amniotic fluid suspect fetal injury
- Examine uterus for any penetrating injury during exploratory laparotomy
- If injury present and fetus > 25 weeks and there is evidence of fetal compromise, deliver the baby by cesarean section
- If fetus < 25 weeks conservative management should be attempted. The role of tocolytics is controversial

ii. **Non-penetrating (Blunt trauma)**

The types of blunt trauma in pregnancy are similar to those in the non-pregnant state viz. retroperitoneal hemorrhage, fracture pelvis, placental separation and head injury. But the most common cause of maternal mortality is head injury while commonest causes of fetal mortality are maternal shock or death and placental separation.

**Assessment**

“Unless otherwise proven, assume a trauma patient to be hypovolemic, full stomach and having an injured cervical spine.”
• Take a brief history to assess the type of injury and its severity
• Monitor vital signs
• While examining or intubating always keep possibility of cervical spine injury in mind
• Chest examination to rule out haemothorax, rib fracture, pneumothorax etc.
• Examine all the four limbs individually
• Examine abdomen for bruising/pain/tenderness/rigidity which may suggest intra-abdominal organ injury or haemoperitonium.
• Vaginal examination should be performed gently to look for blood, meconium and amniotic fluid.

Management
• Maintain airway and administer oxygen
• Intravenous cannulation (large bore cannula) for i.v. fluids and blood
• Monitor vital signs
• Obtain blood for laboratory investigations and cross-matching
• Administer tetanus toxoid
• Endotracheal intubation and mechanical ventilation if indicated
• Urinary bladder catheterization to monitor urine output and to rule out bladder trauma
• Nasogastric tube insertion for suction and to assess GI tract integrity
• If fetus > 24 weeks fetal monitoring is to be instituted. Fetal heart rate acceleration (increase of >15 bpm lasting for at least 15 seconds) is a good sign. Bradycardia and late deceleration are bad signs.
• During placement of i.v. cannula and establishment of monitoring take detailed history and do complete examination of mother and fetus
• Radiological examination is not contra-indicated because the risk of undiagnosed trauma to mother is more dangerous than risk of irradiation to fetus
• If the gestational age of the fetus is more than 24 weeks and is in distress but the general condition of the mother is stable, perform cesarean section

• In case of suspected intra-abdominal trauma do a diagnostic peritoneal lavage.

• Exploratory laparotomy is to be performed if positive lavage, free air under diaphragm or abdominal distension is present.

iii. Thermal injury

A pregnant woman may sustain flame burns, chemical burn or electrical burns. Burn injuries are described according to the percentage of body surface area involved and the depth of the skin destroyed. The rule of nines is used to estimate the surface area burnt. Electrical burns are typically more serious than indicated by a superficial inspection due to underlying tissue damage.

Management

The management of a pregnant woman with burns does not significantly differ from that of a non-pregnant woman. But the fetus is an additional consideration, which should be kept in mind.

• The patient with a thermal injury to the respiratory tract may rapidly develop airway obstruction—give humidified high concentration oxygen.

• Consider the need for early intubation if there is altered sensorium, direct burns to face, hoarseness or stridor, soot in nostrils or sputum or dysphagia, all of which suggest smoke inhalation.

• Establish i.v access and start fluid resuscitation. The estimated fluid replacement using crystalloid is about 4ml/kg/percent in the first 24-hours. Half of this is given in the first 8-hours and half over the next 16-hours.

• Patients with burns will require potent analgesia—give titrated intravenous opioid.

• Continued monitoring of vital signs, CVP and urine output are important.

• Blood sample is obtained for Hb%, Electrolytes, glucose, renal function tests
8.3.8 Algorithm for management of trauma in pregnancy

Trained Obstetrician and Paediatrician should be available

Stabilization
- Secure airway
- Oxygenation
- IV fluids to maintain fluid status
- If cervical/Neck injury > stabilize head and neck
- Monitor vital signs

Further examination/intervention
- Control any external hemorrhage
- Stabilize serious injuries
- Uterine examination for size
- Vaginal examination bleeding, dilatation, meconium
- Blood investigation if facility available
- Fetal blood injection in maternal circulation

FETAL EVALUATION

- Less than 24 weeks
  - FHT Document it
  - Uterine contractions (> 4/hr)
  - Rupture of membranes
  - Vaginal bleeding
  - If serious maternal trauma
  - Fetal HR, tachycardia
    - Late decelerations

- More than 24 Weeks
  - Intensive fetal monitoring should be started
  - Manage accordingly
  - Further surgical/medical Rx
  - Tetanus toxoid
  - Anti-D globulin

YES
Hospitalize, if facilities available
Transfer to nearest Maternity center

- 24 weeks

Maternal shock

YES

NO

Fetal monitoring

Emergency cesarean section

CPR

Fetal distress

Perimortem cesarean section

CARDIAC ARREST IN PREGNANCY

8.3.9 Unique problems of CPR in pregnancy

Alteration in maternal cardiovascular and respiratory physiology

Two lives are involved

Standard CPR techniques are ineffective due to aortocaval compression

Changes from routine CPR-

- Site of chest compression- midsternum
- Ensure left uterine displacement to avoid aortocaval compression, promote venous return & improve cardiac output.
- If there is no return of spontaneous circulation after 4-5 minutes of CPR deliver fetus immediately by cesarean section.

8.4 Salient points to remember

- The best way to treat the fetus is to treat the mother
- Administration of blood is indicated if blood loss exceeds 30% of blood volume, in absence of pre-existing anaemia.
• Unless otherwise proved, assume a trauma patient to be hypovolemic, full stomach and having an injured cervical spine.

• The estimated fluid replacement in a burns patient using crystalloid is about 4 ml/ks/\%24 hr.

8.5 Check your progress

i. ia. In a pregnant lady with trauma, with fetal distress, caesarean section is indicated if the gestational age is greater than 24 weeks (T/F)
   ib. FHR acceleration is a bad sign (T/F)

ii. Fill in the blanks
   iia. The best way to treat the fetus is to treat the __________
   iib. The extent of burn is estimated by rule O/S _________’s

iii. Half of the estimated 24 hrs fluid requirement in the burns patient is to be given over
   iiiia. 4 hrs
   iiiib. 8 hrs
   iiiic. 12 hrs
   iiiid. 16 hrs

iv. Bad signs are
   iva. Late deceleration in FHR
   ivb. Late acceleration in FHR
   ivc. Bradycardia (fetal)
   ivd. Early acceleration in FHR

Answers

i. ia. T
   ib. F
Module-VIII


ii.  iiia mother
     iiib nine

iii.  b

iv.  c

8.6 Further readings

•  A practice of anesthesia – Wiley, Churchill Dundon
•  Oxford handbook of anaesthesia - Wilson
Module - IX
Difficult Airway in Obstetrics
9.1 Introduction 187
9.2 Objective 187
9.3 Contents
  9.3.1 Certain basic considerations 187
    • Definition of difficult intubation
    • Basic technique of laryngoscopy
  9.3.2 Preoperative assessment of airway 189
    • Global
    • Regional
    • Radiologic
  9.3.3 Grading of glottic exposure 191
  9.3.4 Airway assessment- Deductions derived 192
  9.3.5 Contents of the difficult airway cart 192
  9.3.6 Certain useful airway equipment 193
    • Face masks
    • Mechanical airway
    • LMA
    • Combitube
    • Laryngoscopes
  9.3.7 Needle Cricothyrotomy 200
  9.3.8 Difficult Intubation Drill (Flow Chart) 201
9.4 Salient points to remember 202
9.5 Check your progress 202
9.6 Further readings 203
9.1 Introduction

A quarter of preventable deaths related to anaesthetics are due to airway mismanagement, hence assessment of airway preoperatively goes a long way in preventing such mishaps. Inclusion of this module in this curriculum has been done in order to train you people to identify a difficult airway pre-operatively and to be ready for an unanticipated difficult intubation. A delay in intubation in a pregnant patient may lead to poor outcome of the infant. Pregnancy being an additive factor for the difficulty in intubations you have to be very careful in determining the grade of difficulty pre-operatively.

9.2 Objectives

After going through this module you should be able to

- Describe the method of evaluation of the airway
- Describe how to diagnose a difficult airway and to weigh the advantages of proceeding for anaesthesia at the FRU
- Describe the airway adjuncts available and their usage
- Describe the technique of intubation and difficult intubation drill.

9.3 Contents

9.3.1 Certain basic considerations

i. Definition of difficult intubation

The intubation is called difficult if a conventionally trained anaesthesiologist is unable to intubate the trachea within three attempts or ten minutes. The best method to avoid a fatal outcome is preoperative evaluation and to be ready for the difficulties anticipated.

ii. Basic technique of laryngoscopy

Successful and proper exposure of the glottic opening using direct laryngoscopy requires an alignment of the oral, pharyngeal and laryngeal axes, which is accomplished by elevation of the patient’s head by 8-10 cm using a ring or a pillow under the occiput and extension of the head at the atlantooccipital joint. This is described as the “sniffing position”
Retraction of tongue to left side with laryngoscope blade

Introduction of laryngoscope blade into oral cavity

Optimising position of head traction on laryngoscope Handle (Not levering on the upper incisors) To obtain view of larynx

Tip of laryngoscope blade fits into the Vallecula
9.3.2 Preoperative assessment of airway

Preoperative assessment of airway is compulsory for all patients coming for anaesthesia. This helps to formulate and prepare a plan of action. A difficulty, which has not been anticipated and evaluated, can lead to a delay in placing the ETT and may also be fatal. Airway assessment - can be done globally, regionally and radiologically.

i. Global

General examination of the body, head and neck to look for the following (as all these factors may interfere with ventilation/intubation or both):

- Facial profile
- Symmetry
- Proportions of face and neck
- Presence of beard
- Double chin
- Flat bridge of nose
- Oedema
- Swelling or scarring

ii. Regional examination

The regional examination of the airway includes Oral cavity, relative tongue/pharyngeal size, atlanto-occipital joint extension and mandibular space. Some details of these are given below.

Oral cavity

Look for

- Mouth opening-Adequacy (an inter incisor gap of at least 4 cm).
- Lip and palate- Growth/deformity
- Teeth- Number, loose or missing teeth.
Relative tongue size with respect to pharynx

Mallampati and subsequently Samsoon and Young described a test, which assesses the size of the tongue and its effect on Laryngoscopy. If the base of the tongue is disproportionately large, viewing of the larynx with direct laryngoscopy is likely to be difficult.

Similarly, a large tongue may obscure viewing of the faucial pillars uvula and soft palate. With the patient sitting upright, head in neutral position, mouth fully opened and tongue maximally protruded, the observer sitting opposite the patient with eyes at the level of the pharynx to assess the pharyngeal structures. Laryngoscopy is likely to be difficult when the base of the tongue obscures viewing of the faucial pillars; uvula and soft palate.

Depending on the structures visualized, the patient may be assigned to one of the following classes. Samsoon and Young’s modification of Mallampati classification

- **Class I**: Soft palate, uvula, tonsillar pillars seen
- **Class II**: Soft palate and faucial seen
- **Class III**: Soft palate seen
- **Class IV**: Hard palate only seen
- **Class I&II**: Intubation likely to be easier.
- **Class III&IV**: Intubation likely to be more difficult.

Atlanto-occipital joint extension

Extension of the head with the neck flexed brings the axis of the mouth into alignment with the axes of the larynx and pharynx. Measure range of head and neck movement – by asking the patient to extend the head and neck and keeping a pencil on the forehead with its orientation parallel to a window frame and then sighting it against the horizontal of the window frame to see if it has moved through 90°. When the movement at this joint is less than 30°, difficulty in intubation is to be anticipated.

Mandibular space

The Thyromental distance reflects the mandibular space, which is the space into which the tongue gets displaced during laryngoscopy in order to align the oral, pharyngeal and laryngeal axes.
• Is the distance from the thyroid notch to the mental prominence when the neck is extended fully
• The normal distance is 6.5cm or greater
• 6.0-6.5 cm- without other anatomical problems laryngoscopy and intubation are difficult but usually possible
• Less than 6.0 cm-Laryngoscopy may be impossible

A rapid assessment of the airway by the rule of 1-2-3:

Three factors determine the ease of visualization of the glottis.
• Movement of temporomandibular joint
• Extent of Mouth opening
• Size of Mandibular space

This consists of 3 basic steps

Step 1 Ability to insinuate 1 finger in from the tragus while the patient opens his mouth (establishes movement at temporomandibular joint).

Step 2 Determining the adequacy of mouth opening by quantifying the interincisor gap, which would be at least 2 fingerbreadths.

Step 3 Measurement of thyromental distance, which should be at least 3 fingerbreadths.

Radiological Assessment

• Posterior depth of the mandible
• Gap between occiput and C1 vertebra

Note— no one factor can predict difficulty in intubation accurately as the adverse effect of one factor may be offset by favorable features among others. When more than one adverse factors are identified, it is important to plan for a difficult intubation.

9.3.3 Grade of glottic exposure

Described by Cormack and Lehane

Grade-1 Glottis (including the anterior and posterior commissures) could be fully exposed.
Module-IX

Grade-2  Glottis could be partly exposed (anterior commissure could not be visualized)
Grade-3  Glottis could not be exposed (corniculate cartilages only could be visualized)
Grade-4  Glottis including corniculate cartilages could not be visualized.

9.3.4 Airway assessment-deductions derived
- Whether the airway can be maintained with a mask
- Whether mask ventilation is sufficient or intubation would be needed.
- If intubation is needed, can it be performed safely with the patient anaesthetized or an awake intubation would be necessary.
- Whether the patient can be safely paralyzed or spontaneous respiration needs to be maintained.
- If nasal intubation is needed, if whether a direct view is possible or must it be blind.

9.3.5 Difficult airway cart- contents
- Face masks –All sizes
- Endotracheal tubes – all sizes with intact cuffs
- Tongue depressor
- Rigid mouldable stylets
- At least 2 working laryngoscopes with all sizes of blades both curved and straight types
- Airways of all sizes both oropharyngeal and nasopharyngeal
- Magill’s forceps
- Suction apparatus with suction catheters
- Oxygen source
- A ventilating apparatus with suitable adaptors to the mask and tube
- A head rest or a pillow with a minimum height of 10 cms
- LMA-All sizes
- Flexible fibreoptic laryngoscope/Bronchoscope
- Tracheostomy kit
- Light wand
- Equipment for retrograde intubation and needle cricothyrotomy
- Combitube.

9.3.6 Certain useful airway equipment

i. Face mask

Anaesthesia facemasks are made of either rubber or plastic and are employed to administer oxygen and anaesthetic gases and to ventilate the non-intubated patient.

Note Mask being held by thumb and index finger and upward pull on the jaw by other three fingers to obtain air tight seal

Ventilation with mask requires a tight fit that involves

- Downward displacement of the mask with the thumb and index finger
- Upward displacement of the mandible with the other three fingers
• Mandibular displacement along with upper cervical extension and chin lift all tend to pull the tongue and soft tissues up off the posterior pharyngeal wall, and relieve the upper airway obstruction that occurs in the anaesthetized or unconscious patient.

• This may require holding the mask with two hands and vigorously pulling the mandible forwards.

ii. Mechanical airways

When airway integrity cannot be maintained with manipulation of mask, mandible or neck a mechanical airway may help restore airway patency. Both oral and nasal airways serve to separate the tongue from the posterior pharyngeal wall.

Oral Airways

It is inserted upside down and then rotated 180 degrees into the position of function. Avoid trauma to the teeth as well as a misplacement in which the airway pushes the tongue back into the pharynx and actually increases airway obstruction. For this, selection of an appropriately sized oral airway is vital. This can be done by selecting an airway whose length from flange to tip equals the distance between the angle of the mouth to angle of the mandible. After intubation an airway may be inserted to prevent the patient from biting down on the tube. It is generally made of plastic.

Insertion of oro-pharyngeal air way to maintain air way patency

Sizes

Adult – 80, 90 and 100 mm (nos. 3, 4 & 5 respectively)
Children – 50, 60, 70 mm (nos. 0, 1 & 2)
Special small airways (00,000) for premature and newborn babies
Nasal airway

Nasal airways are softer and are useful in patients who are not deeply anaesthetized since they tend to provoke less of a gag reflex.

Vasoconstriction with phenylephrine nasal drops (and topical anaesthesia with lidocaine if the patient is awake) should precede insertion. However in the acute situation the lubricating quality of lidocaine ointment is sufficient. Tip of airway is inserted perpendicular to the face and not upwards towards the cribiform plate. Length of airway should correspond to the distance from tip of nose to meatus of the ear. It is better to avoid nasal airway insertion in presence of coagulopathy, basilar skull fractures, nasal infections or deformities.

Insertion of naso-pharyngeal airway to maintain airway patency
iii. The Laryngeal Mask Airway (LMA)

LMA allows administration of inhaled anaesthetics through a minimally stimulated airway. Its relative ease of insertion suggested its potential usefulness in fields of airway management of difficult or failed intubation.

**Design** - It Consists of a tube, cuff, and pilot tube

<table>
<thead>
<tr>
<th>LMA Sizes</th>
<th>Patient Weight (kg)</th>
<th>Maximum Cuff Volume(ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Upto 5</td>
<td>4</td>
</tr>
<tr>
<td>1.5</td>
<td>5-10</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>10-20</td>
<td>10</td>
</tr>
<tr>
<td>2.5</td>
<td>20-30</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>Small adult</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>Average sized adult</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>Large sized adult</td>
<td>40</td>
</tr>
</tbody>
</table>

**Technique of insertion**

- Head position (recommended by Brain) for insertion is “SNIFFING THE MORNING AIR” (i.e. neck flexion and head extension).
• Lubrication - only the posterior aspect of cuff is lubricated (because any gel on the anterior aspect of the cuff may cause airway obstruction or laryngospasm at light levels of anaesthesia).
• The Index finger of the operator’s hand may be used to guide the LMA over the back of the tongue.
• The tip of the cuff is pressed posteriorly against the hard palate.
• The black longitudinal line on the shaft of the LMA should face the midline of the upper lip.
• IPPV is usually accompanied by an audible leak around the LMA.
• Removal - done when patient is awake and obeying commands.
• Physiologic responses to insertion are of a lesser magnitude compared to that of a tracheal tube insertion.

iv. The combitube (oesophago-tracheal combitube)

It is a double lumen tube that is inserted blind orally. The oesophageal lumen tube has a closed distal end, it has a flexibility in that it may be used regardless of which orifice the tube enters e.g. the trachea or the oesophagus. If the tube enters the oesophagus which is the most likely pathway, following blind insertion, the oesophageal cuff is inflated to prevent regurgitation around the tube. The proximal cuff occupies the pharynx above the airway and prevents leakage externally through the mouth and nose. Perforations in the oesophageal lumen allow ventilation of the lungs. If the oesophageal tracheal tube enters the trachea, ventilation may take place via the tracheal lumen. The combitube is an excellent alternative to endotracheal tube for cardiopulmonary resuscitation or failed endotracheal intubation, which could be used by paramedical staff in the ICU or at the site of accident.

### Esophageal tracheal combitube

- **Distal cuff**
- **Pharyngeal cuff**
- **Pilot balloon**
**Laryngoscopes**

Standard rigid laryngoscope consists of a detachable blade with removable bulb that connects to a battery-containing handle. Curved blade introduced by MacIntosh is probably most popular for adult use. A variant of the MacIntosh blade is the McCoy blade, which has a flexible tip controllable through a lever attached to the handle. The commonly used straight blade is the Miller blade.

Straight blade - only advantageous when the mouth opening is limited or larynx is anterior. Curved blade - advantageous when more room is desired to perform instrumentation (e.g. use of Magill’s forceps; changing tubes; intubation with esophageal obturator in place).
Endotracheal intubation accomplished with the help of rigid stylet
Note- cricoid pressure being applied by the assistant
9.3.7 Needle cricothyrotomy (TTJV)

In the event of inability to intubate the trachea or ventilate the lungs needle cricothyrotomy or tracheostomy are the final recourse.

**Advantage of Cricothyrotomy over Tracheostomy**
- Can be performed in lateral position.
- Easier to perform.
- Less instruments needed.
- Takes shorter time.

**Procedure**

It is performed by placing a 12-14 gauge needle or catheter through the cricothyroid membrane into the trachea. An alternative site - is the subcricoid region between the cricoid cartilage and 1st tracheal ring. The correct placement of needle is confirmed by aspiration of air from the trachea. A needle is preferred to a plastic intravenous cannula as the latter may kink and occlude. An artery forceps is clipped onto the needle where it penetrates the skin to hold it in position. Intermittent pressurized oxygen provides the most suitable method for ventilation through these small diameter needles and the simplest method is to use the emergency O₂ flush button. The pressurized O₂ is delivered from the common gas outlet via a length of tubing with a luer lock connector for attachment to the needle. A three-way tap interposed between the tubing & needle will provide the initial facility to aspirate air from the trachea thus confirming correct placement. In order to avoid barotraumas it is important to allow deflation of the lungs to occur between inflation. This takes place passively through the mouth and it is usually possible since most airway obstructions are inspiratory.
9.3.8 Failed intubation drill

If intubation failed for 2 times by the same anaesthesiologist
Call for help
Ventilate with 100% oxygen
Use:
- Face mask
- Laryngeal mask airway (LMA) with cricoid pressure
- Combitube
Assess ventilation and oxygenation

Inadequate (EMERGENCY PATHWAY)

Fetal distress
- Halothane + 100% O₂
- Spontaneous ventilation
- Delivery of the baby

No fetal distress
- Awaken the patient
- Awake intubation or regional block
- Delivery of the baby

Adequate (NON-EMERGENCY PATHWAY)

Combitube or LMA with Cricoid pressure

Failed
- Cricothyroidotomy
- Tracheotomy
- Delivery of baby

One must remember that the mother’s life takes priority over life of the fetus.
9.4 Salient points to remember

- Pre-operative airway assessment is compulsory for all patients coming for anaesthesia.
- Airway assessment includes the ftesing methods about, regional and radiologic.
- A difficult airway cart should be equipped and ready for use in case of an anticipated difficult intubation or an anticipated difficult airway.
- The answer to almost every difficult airway is ‘Awake Intubation’.
- In case of an anticipated difficult intubation, it is preferable to use a subarachnoid block.

9.5 Check your progress

i. ia. The Mallampati test measures the tongue size with respect to that of the larynx (T/F)
ib. The thyromental distance reflects the mandibular space. (T/F)
ic. The recommended position for LMA insertion is ‘sniffing the morning air’. (T/F)
id. Radiology cannot guide regarding the estimation of ease of intubation (T/F)
ie. Oesophago-tracheal available is in paediatric sizes (T/F)

ii. Fill in the blanks

iia. Intubation is called difficult when an anaesthesiologist is unable to intubate in ______ attempts or ______ minutes.

iib. Laryngoscopy may be difficult if the thyromental distance is less than _____ cms.

iic. Sniff position is obtained by extension of ______ and flexion of ______.

iii. In the average size adult, the LMA used is

a. 2.5
b. 3
c. 4
d. 5
iv. In carmak and lehane grade 3,
   a. Gloths is fully exposed
   b. Postenior commissine only visualized
   c. Epiglottis visualized
   d. Not even epiglottis visualized
v. Emergency cricothyrotomy is usually done with _______ size needle
   a. 12-16 G
   b. 18-20 G
   c. 20-24 G

Answers
i. ia F
   ib T
   ic T
   id F
   ie F
ii. iia 3, 10
    iib 6
    iic Head, cervical spine
iii. C
iv. C
v. A

9.6 Further findings
   • Obstetric anaesthesia – Chestnut
   • Airway Management - Benunof