# Textbook of Physiotherapy for Cardio-respiratory Cardiac Surgery and Thoracic Surgery Conditions

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***Textbook of Physiotherapy for Cardio-respiratory Cardiac Surgery and Thoracic Surgery Conditions***



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*To*
*My Father*
*G Ananda Rao*
*Mother*
*GA Laxmi*
*and*
*Brother*
*GB Sudhakar*

# PREFACE

The book titled *Textbook of Physiotherapy for Cardio-respiratory Cardiac Surgery and Thoracic Surgery Conditions* has been design to cater to the needs of the bachelor students of physiotherapy especially in their third and final years. This book is also useful to the professionals of physiotherapy, rehabilitation and other paramedics.

The book has been prepared as per the curriculum and requirement of degree course in India and also abroad. Books on this subject are yet not abundantly available. Very few textbooks are existing in the market which are written by foreign authors.

Physiotherapy is an essential and basic subject for the undergraduate as well as postgraduate courses. The book has been written in a systemic manner and opts a very simple approach in presenting the text. Recently, lots of advances have taken place in cardio-thoracic field. Utmost efforts have been made to cover all the necessary aspects of this subject. All the chapters have been written in a very simple and clearly expressed style.

Physiotherapy is an ever advancing field. The recent advances have made this subject very interesting and it is playing an important role in health care world. I have tried my best to make this book updated starting from introduction to recent advances. To make more informative, Glossary and Bibliography are given at the end of the book.

Any suggestions from the teachers and students will be highly appreciated for the further improvement which can be made in next edition.

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# Cardio-respiratory System

CHAPTER 1

## ANATOMY

### ANATOMY OF RESPIRATORY SYSTEM

#### PLEURAE

The cavity of the thorax contains the right and left pleural cavity that are completely invaginate and occupied by the lungs. The right and left pleural cavities are separate by a thick median partition called the mediastinum. The heart lies in the mediastinum.

There are two pleural sacs on either side of the mediastinum.

#### Layers of Pleura

Outer layer is called Parietal pleura

Inner layer is called Visceral or pulmonary pleura.

*Space*: The space in between is called pleural cavity.

*Nerve supply:* Intercostal and Phrenic nerves

*Blood supply*: Intercostal artery, internal thoracic artery and musculo Phrenic artery.

*Venous drainage*: Azygos vein, internal thoracic vein.

*Lymphatic drainage*: Bronchopulmonary lymph nodes.

## APPLIED ANATOMY

1. *Parencentesis thoracis*: Aspiration of any fluid from the pleural cavity is called parencentesis thoracis. It is done at 6th Intercostal space.
2. *Pleurisy*: Inflammation of the pleura
3. *Pleural effusion*: Collection of fluid in the pleural cavity
4. *Pneumothorax*: Presence of air in the pleural cavity
5. *Haemothorax*: Presence of blood in the pleural cavity
6. *Hydropneumothorax*: Presence of both fluid and air in the pleural cavity
7. *Empyema:* Presence of pus in the pleural cavity.

### The Lung

The lungs are the pair of respiratory organs situated in the thoracic cavity. The right and left lungs are separated by the mediastinum. Lungs are spongy in texture and mottled black in colour. The right lung weighs about 625 grams and the left lung weighs 575 grams. The right lung is 50 grams heavier than the left lung.

### Features

Each lung is conical in shape and has an upper end called apex. Lower end called base rests on the diaphragm. There are three borders. They are anterior, posterior and inferior, has two surfaces costal and medial. The medial surface inturn divided into vertebral and mediastinum surfaces.

### Fissures and Lobes

The right lung has three lobes and two fissures. The lobes of the lung are superior, middle and inferior. The fissures are oblique and horizontal. The left lung has two lobes. They are upper and lower lobe and one fissure called oblique fissure.

### Bronchial Tree

The trachea divides at the level of lower border of the fourth thoracic vertebra into two primary or principal bronchi. Each principal bronchi is divided into right bronchus and left bronchus, the right bronchus is divided into three secondary bronchi or lobar bronchi for the three lobes of the right lung. Each secondary bronchi is divided into tertiary or segmental bronchi. One for each broncho-pulmonary segment. These are ten in the right lung and eight in the left lung. The tertiary bronchioles inturn divided into terminal bronchiole which inturn divided into respiratory bronchiole or pulmonary unit. Each pulmonary unit consists of alveolar ducts, atria, air saccules and pulmonary alveoli.

*Function:* The function is gaseous exchange takes place.

*Arterial supply:* Bronchial arteries

*Venous drainage:* Bronchial veins

*Lymphatic drainage:* Bronchopulmonary nodes.

## Nerve Supply

Parasympathetic supply by vagus nerve

Sympathetic supply: by T2-T5 nerves.

## Bronchopulmonary Segments

It is well-defined section of the lung each of which is aerated by tertiary or segmental bronchus. Each of the segment is pyramidal in shape.

In the right lung the upper lobe has apical, anterior and posterior. The middle lobe has medial and lateral, the lower lobe has superior, anterior basal, posterior basal, lateral basal.

In the left lung the upper lobe has apico-posterior, anterior, superior, inferior, the lower lobe has superior, anteromedial basal, postero basal and lateral basal.

## Clinical Significance

1. The infection to the individual segment will remain and restricted to it.
2. Bronchogenic carcinoma and tuberculosis spreads from one segment to the other.

3. Surgical removal of the segment is called segmental resection. In case of lung abscess or bronchiectasis the infection is drained by postural drainage.
4. Visualizing the interior of the bronchi through an instrument passed through the mouth and trachea. The instrument is called a bronchoscope and procedure is called bronchoscopy.

## RELATIONSHIP OF BONY THORAX AND LUNGS

### The relationship of the bony thorax and lungs to each other and to the abdominal contents

The diaphragm is divided into an upper part called the thorax and lower part called the abdomen divides the trunk of the body. The thorax is supported by a skeletal framework called thoracic cage and contains the lungs that are principal organs of respiration and heart, principal organ of circulation both are vital for life.

## THE THORACIC CAGE

It is an osseocartilaginous elastic cage that is designed primarily for increasing and decreasing the intrathoracic pressure so that air is sucked into the lung during inspiration and expelled during expiration.
*Formation:* The thoracic cage is formed

### Anteriorly by the Sternum

Posteriorly by the 12th thoracic vertebrae and the intervertebral disc.

On either side by 12 ribs with their cartilages. Each rib articulates posteriorly with the vertebral column.

### Ribs

The upper seven ribs articulate anteriorly with the sternum through their cartilages called true or vertebrosternal ribs. Eigth, ninth and tenth ribs articulate by joining the next higher costal cartilages called vertebrochondral ribs. The 7th, 8th, 9th and 10th ribs form the costal maergin. The 11th and 12th ribs are free anteriorly called as floating or vertebral ribs the last five ribs, i.e. vertebrochondral and vertebral ribs are called as false ribs because they don't articulate with the sternum.

The costovertebral, manubriosternal and chondrosternal joint permit movement of the thoracic cage during breathing.

## Shape of the Thorax

The thorax resembles a truncated cone. This is narrow above and broad below. The narrow upper end is continuous with the root of the neck from which it is partly separate by the suprapleural membrane called sibons fascia. The broad lower end is separated from the abdomen by the diaphragm that is concave downwards. The upper part of the thoracic cavity appears broad due to shoulders and lower part has abdominal cavity separated by diaphragm that is dome shaped structure with concavity downward.

The transverse section of the thorax in adults is kidney shaped and normally oval in shape. The rib are oblique and their movement alternately increases and decreases the diameter of the thorax. Because of this inspiration and expiration occurs and the respiration is called thoracic respiration. There is also abdominal respiration. In females respiration is thoraco-abdominal and in males it is abdomino-thoracic respiration and in infants below 2 years is the thorax is circular and the ribs are horizontal so the respiration occurs by diaphragm so it is purely abdominal.

## APPLIED ANATOMY

The chest wall of the child is highly elastic so fracture of the ribs is rare. In adult the direct and indirect violence, e.g. crushing injury fractures the ribs. The rib can be easily fractured at its weakest point located at the angle. The upper two ribs and lower two ribs escape from the injury because the clavicle and the lower two ribs protect upper two ribs are floating ribs.

A cervical rib is an extra rib attached to C7 vertebrae in 0.5 percent of population. This cervical rib exerts pressure on the lower trunk of the brachial plexus produces symptoms like paraesthesia along the ulnar border of the forearm and wasting of the muscles of the hand.

## The Inlet of the Thorax or Superior Aperture of the Thorax

The narrow upper end of the thorax that is continuous with the neck is called the inlet of the thorax. It is kidney in shaped the:

*Diameters:* Antero-posterior is about 2 inches, Transverse is about 4 to 5 inches.

*Boundaries:*

*Anteriorly:* Upper border of the manubrium sterni

*Posteriorly:* Superior surface of the body of the first thoracic vertebrae.

*On each side:* First rib with the cartilage.

*Diaphragm of the inlet of the thorax:* The Diaphragm is in two halves. They are right and left with a cleft in between. Each half is known as Sibron's fascia or suprapleural membrane. This is triangular in shape. It partly separates thorax from the neck.

*Structures passing through the inlet:*

*Viscera:* Trachea, Oesophagus, Apices of lungs (With pleura), Remains of the thymus.

### Large Vessels

*Arteries*

*Right side:* Brachiocephalic Artery

*Left side:* Subclavian Artery

*Veins*

*Right side:* Right Brachiocephalic vein

*Left side:* Left Brachiocephalic vein

*Nerves*

*Right and left side:* Phrenic nerve, Vagus nerve, Sympathetic trunk, First thoracic nerves.

*Muscles*

Sternohyoid, Sternothyroid, Longus colli.

## APPLIED ANATOMY

### Thoracic Inlet Syndrome

The subclavian artery and the first thoracic nerves arch over the first rib. These structures may be pulled or pressed by the cervical rib or by variation in the insertion of the scaleneus anterior, so symptoms will be vascular or neural.

### Outlet of the Thorax

*The inferior aperture:* It is the broad end of the thorax which surrounds the upper part of the abdominal cavity and is separated by Diaphragm.

### Boundaries

*Anteriorly:* Infrasternal angle between two costal margins
*Posteriorly:* Inferior surface of the body of the 12th Thoracic vertebra.
*On each side:* Costal margin formed by the cartilage of 7th, 8th, 9th, 10th, 11th, 12th Ribs.

### Diaphragm Passing through the Outlet

The outlet is closed by a large musculotendinous partition called the Diaphragm. The Diaphragm is a thoracoabdominal organ structure which separates the thorax from the abdomen.

Structures passing through the outlet-large openings in the diaphragm:

1. *Vena caval opening:* This is at T-8 vertebra level and transmits inferior vena cava, branches of right Phrenic nerve.
2. *Oesophageal opening:* This is at T-10 vertebra level and transmits Oesophagus, Gastric (Vagus nerve), Gastric artery and oesophageal veins.

3. *Aortic opening:* This is at T-12 vertebra level and transmits aorta, thoracic duct, and azygos vein.

## THE VARIATIONS IN THE BONY CAGE IN THE FOLLOWING CONDITIONS

### 1. Cervical Ribs

An extra rib attached to the C7 vertebra in 5% of the subjects. Such rib exerts pressure on lower trunk of Brachial plexus which arches over the rib produces and Paresthesia along the ulnar border of forearm and wasting of the muscles of hand supplied by T-1 nerve root. Vascular changes may occur. This extra rib is also associated with the spinal anomalies.

### Types of Anomalies

There are our main varieties

A complete rib often containing a false joint in its length articulates anteriorly with the manubrium or first rib.

1. A free end of rib expands into a large bony mass.
2. A rib ending in a tapering point.
3. A fibrous band loosely incorporated into Scaleneus medius muscle. At their exit from the neck the brachial plexus and subclavian artery pass through a narrow triangle.

### Pathology

By the interposition of a cervical rib the base of the triangle is raised by the height of one vertebra. The subclavian artery and first dorsal nerve become angulated. As they pass over the new floor of cervical vertebra rather than first thoracic rib.

### Pathology of the Vascular Symptoms

The lumen of the subclavian artery becomes constricted. Dilatation of the first 2-4 cm of the artery occurs distal to the constriction. With the post-stenotic dilatation clotting occurs. Position of the thrombus may becomes detached a give rise to an emboli or embolus. Proximal extension of the thrombus can occurs so that vertebral artery may be involved and cerebrovascular emboli episodes occur.

## Clinical Types

*Cervical Rib with Local Symptoms*

Patient will have a lump in the lower part of neck which may be visible or more commonly because of the tenderness in the supraclavicular fossa. On palpation lump is found to be hard, bony and totally fixed.

*Cervical Rib with Vascular Symptoms*

Vascular symptoms occur only when cervical rib is complete. Pain is felt in the upper arm, forearm. Pain brought by the use of arm and relieved by rest. Pain is Ischaemia muscle pain.

*Temperature and Colour Change*

This will also occur like hand on affected side tends to be colder, pale and blue.

*Radial Pulse*

Depending on collateral circulation, if circulation is good, pulse is full, if bad pulse is absent if indifferent pulse is feeble. Distal part of the subclavian artery could be auscultated. Patient complaints of Numbness of fingers, ulceration and gangrene.

*Treatment*

Extra peritoneal excision of cervical rib and bony prominence of first rib, sympathetic denervation of upper limb.

*Cervical Rib with Nerve Pressure Symptoms*

Due to the angulation of the first dorsal nerve leads to cervical spondylosis or carpal tunnel syndrome, scalene syndrome occurs.

Scalene syndrome symptoms are pain, tingling in hand, forearm, wasting of thenar and hypothenar may or may not.

### Differential Diagnosis

1. Pressure on cervical roots in the region of intervertebral foramina by lateral protrusion of intervertebral disks.
2. Paraesthesia a wasting of thenar eminence due to carpal tunnel syndrome.
3. Hypothenar wasting arises from angulation of ulnar nerve behind elbow.
4. Motor neurone disease
5. Syringomyelia.

### Treatment

#### *Mild Cases*

Sling exercises aimed at strengthening the muscles of the shoulder girdle temporarily. Dividing scaleneus anterior called scalenotomy.

#### *Severe Cases*

Cervical rib is excised with its periosteum or it will regenerate. Care must be taken to avoid damage to brachial plexus and Phrenic nerve.

### 2. Rickets–rickety Rosary

It is a metabolic disorder. Osteoid formation in the child's growing bone is normal but mineralisation is defective.

#### *Types of Rickets*

1. Nutritional rickets
2. Renal rickets.

### NUTRITIONAL RICKETS

This is more common in children below four years of age occurs because of deficiency of the vitamin D.

### Pathology

1. Defective absorption of calcium from the gut.
2. Lowering of calcium and phosphate in tissue fluid.
3. Broadening of metaphysis and widening of epiphysis in the long axis of bone.
4. There is poor deposition of calcium in zone of calcification and poor mineralisation of spongy bone.
5. Bone becomes soft, pliable, deforms easily on weight bearing and on stress.

### Clinical Features

1. Child will be irritable
2. Child sweats excessively
3. Child growth get stunned
4. Fontanelle remains unclosed after two years of age
5. There will be bossing over frontal and parietal bone called cross burn appearance
6. The chest shows pigeon chest deformity
7. Beading at costochondral junction occurs called Rickety Rosary.

### 3. Pigeon Chest or Pigeon Breast or Pectus Carinatum

*Renal rickets:* The renal rickets is caused by the inadequate phosphorus secreted by the kidneys. This results in the fall of phosphates in the blood. This leads to the malfunctioning of the kidneys as result the parathyroid hormones secretion increases that mobilizes the bone calcium making them soft causing deformities.

### Physiotherapy Treatment

1. *Ultraviolet radiation:* This provides vitamin D.
2. *Deep breathing exercise:* This improves breathing efficiency and prevents thoracic deformity.
3. Active exercise
4. Assisted–resisted exercise

5. *Resisted exercise:* All the exercises are to increase the circulation to the limb.
6. *To prevent deformity:* Correct postural alignment and non weight bearing posture or may develop deformity
7. *To prevent mild deformity:* Mermaid splint, corrective orthosis to prevent the deterioration of the condition
8. Post-operative physiotherapy management of fractures or correction of the deformity includes immobilization period physiotherapy like control of pain, oedema, proper positioning, distal parts strong movements to improve the circulation and prevention of deep vein thrombosis and isometric exercises to the glutei, quadriceps and calf muscles, mobilization period physiotherapy includes re-education of movement like exercises range form active to resisted to progressive resisted exercises and return back to the function includes training activities of daily living and strengthening exercise programme to get complete power.

### Definition

It is the forward projection of the sternum like a keel of a boat and flattening of chest wall on either side.

It is outgrowth of sternum. It comprise protrusion deformity of chest, the condition is characterized by protrusion of the sternum cause by an upward curve in the lower costal cartilage 4-8th. So sternum is moved forward.

### Causes

1. Severe asthma in the childhood
2. Rickets
3. Sometime no cause.
4. Malformation in mobility of intrauterine life and sternum comes anteriorly because of movement of Ribs.

### Symptoms

1. Exertional dyspnoea

2. Cardiac arrhythmias
3. The reduced flexibility of the chest wall limits chest expansion during inspiration by the anterior displaced sternum and abnormal cartilages.

### Deformity

It is of three types:
1. Most common is anterior displacement of the body of the sternum with symmetrical concavity of the costal cartilage.
2. Asymmetrical deformities consist of unilateral displacement of the costal cartilage.
3. The least common is Chondromanubrial deformity.

### Treatment

*Surgical Treatment*

The inferior mammary or horizontal or transverse incision is made through the route of suprasternal notch, infrasternal notch and separates sternum. The chondral pieces are taken out and pined them into a straight piece. Cartilage grows rapidly in three months. It brings the sternum down.

## 4. Funnel Chest

It is the most common congenital deformity of the sternum. It is excessive, misdirected growth of the lower costal cartilages. This is a congenital condition formed because of the rapid growth the sternum becomes depressed. The severity of the disease increases with time.

### Causes

1. Congenital
2. Malformation or misdirection of growth of ribs during intrauterine period.

### Clinical Features

1. The body and the lower end of the sternum are curved back

2. The heart is displaced to the left a compressed between the sternum and vertebral column
3. There will be disturbance of the cardiac function
4. The deformity may resist chest expansion and reduce vital capacity
5. Recurrent lower respiratory tract infection and asthma may be seen in patients with this deformity
6. Scoliosis is associated with anterior chest wall deformity
7. Paraspinal muscle imbalances are present
8. Asymmetry causes pneumatic thoracic pressure
9. The thoracic curve is involved between T4 and T9
10. Mitral valve prolapse is seen
11. Cardiac and respiratory function are reduced
12. Excessive angulation is seen
13. The problem comes own on rest
14. The severity of the problem increases on physical activity
15. This limits social life.

### Treatment

*Surgical Treatment*

Horizontal incision is made, sternum is separated, and the chondral pieces are taken out, they are pinned by keeping sternum straight, then suturing is done and then close perichondrium, muscles and skin. The cartilage grows rapidly in three months.

## SPINAL CURVE

The spine consists of two curves:

1. *Primary curve:* At birth only primary curves are present. This is concave anteriorly and convex posteriorly and present in thoracic and sacral region.
2. *Secondary curve:* In the adult this along with primary curve is present. This is concave posteriorly and convex anteriorly and present in Cervical and Lumbar region.

### Functions of Spinal Curves

1. These curves increase strength of the spine
2. They help to maintain balance in upright position
3. These helps in shock absorption.
4. These helps in protecting the spinal cord from injury.

### Applied Anatomy

1. *Abnormal curves:* These can occur because of congenital problems or due to postural differences.
2. *Scoliosis:* This is the lateral bending of the vertebral column that usually affects Thoracic region.
3. *Kyphosis:* The Thoracic curve gets exaggerated because of the rounded shoulders.
4. *Lordosis:* This is exaggeration of the Lumbar curve.

### 5. Scoliosis

A lateral curvature of the spine which exceeds by 10 degrees from the normal is termed as scoliosis.

### Types

It is basically of two types:

They are:

1. Postural or Non-structural scoliosis
2. Structural scoliosis.

### Postural or Non-structural Scoliosis

This is Grade I scoliosis. This occurs without any bony changes or muscular weakness.

*Cause*

1. Impairment of the reflex mechanism.
2. Wrong Postural habits, e.g: Standing with stress on one leg or Psychological factors.

The postural scoliosis may get organized into a structural one, due to secondary soft tissue contractures in muscles and ligaments on the concave side of the curve.

### Structural Scoliosis

This is Grade II and III. In this type there is defect in the bone which results in contractures of the soft tissue on the concave side of the curve and reciprocal stretching on the concave side.

### Classification

1. Postural or Idiopathic scoliosis
2. Paralytic scoliosis
3. Congenital scoliosis.

### Postural or Idiopathic Scoliosis

This is again divided into:

*Infantile scoliosis*: The onset of this is at the age of three years. Usually there is a spontaneous resolution of the curve. If the curve progress then need an early surgical intervention.

*Juvenile scoliosis*: The age of onset is between three and ten years. Rapid progression of the curve occurs due to the growing age. If bracing fails to control the deterioration, surgery becomes necessary.

*Adolescent scoliosis*: The age of onset is between ten and twenty years if this is detected earlier acceptable correction is achieved by bracing.

*Adult scoliosis*: The age of onset is over twenty years. Scoliosis may develop as a result of disc degeneration. When the deterioration is rapidly progressive, surgery may be indicated.

### Paralytic Scoliosis

This occurs in conditions like Poliomyelitis, Cerebral palsy or Spina bifida. This is complicated by the greater degree of the muscle imbalance and growing age complications. Scoliosis will rapidly deteriorate in these children. Surgery becomes necessary where there is rapid progression of the curve.

### Congenital Scoliosis

This scoliosis occurs by birth. It is of milder and severe forms. The milder form is treated with a brace, the severe form need a surgery.

### The Course and Prognosis

The course depends on the age of onset, time of detection, site of the primary curve and the treatment given. If the onset is at an early age, the curve tends to increase with age till the end of the skeletal growth. The prognosis will be poor if affects. Thoracic curve because it interferes with the breathing efficiency. The Thoraco-lumbar or lumbar curves will compensate well.

### Prevention

Prevention plays a very important role.

1. Early detection plays an important role in the prevention of scoliosis.
2. Screening programme of all the children between the age group of 10-14 years is necessary because they are more vulnerable.
3. Parents can also play an important role in the early detection of a scoliotic curve. So education of the parents on observational techniques may be helpful.

## TREATMENT

Curve less than 40 degrees: Conservative treatment is sufficient in growing children. This is given in the form of.

*Active correction:* This is postural correction. This is again divided for the Grades –I, II and III.

### Grade I—Management of Postural Scoliosis

The correction of the deformity is obtained by progressive reduction of the bad posture.

A. General body relaxation

B. Posture maintenance
C. Free mobility exercises to the whole spine, Spinal extensor exercises and abdominal exercises.
D. Deep breathing exercises.
E. Balance exercise
F. Stretching of the soft tissues.
G. After the correction the patient should be advised to continue with exercises avoiding especially the positions and the activities prone to produce the existing deformity.
H. The patient must report regularly for screening.

## Grade II

The curves are associated with the compensatory curves. So need a brace called Milwaukee or Boston brace to prevent deterioration of the curve and to maintain correction with active exercise. This brace immobilizes the spine and maintains a stretching effect.

*Exercise Programme*

1. Mobility exercises are important, as the spine remains immobilized in brace
2. Deep breathing exercises are also important, as the expansion of the ribs is limited due to the brace.
3. Lumbar lordosis is associated with these curves so correction of the anterior pelvic tilt is important
4. Correction of the major curve is also achieved by putting a pad over a rib hump on the convex side of the curve in the brace
5. Repeated stretching exercises for the hip flexors and hamstrings are important as these have a tendency to shorten due to the pelvic tilt.
6. Hanging in head suspension apparatus or on the stall bars can provide effective stretch to the whole spine.
7. The whole programme and the brace need to be continued for long-time. As the child grows brace needs repeated adjustment and continued till the child attains skeletal maturity. It can be taken gradually thereafter. The needed to be worn day and night

except during exercise programme of spinal mobilization and deep breathing exercise. The thoracic flexion exercise should be taught with the brace on position because this reduces vertebral rotation.

### Grade III—Severe Structural Curves

These curves are greater than 40 degree and need a surgical intervention.

#### *Passive Correction*

Hanging is the best method E.g.: suspension apparatus. Two physiotherapists give axial traction. One will be grasping the pelvis and gives traction towards the legs while the other grasps the chin and gives traction towards the occiput.

#### *Maintenance of Correction*

The most important aspect is to educate the patient to maintain the correction by active efforts or with the help of spinal brace. The patient needs education for continuous awareness an exact methodology.

### 6. Kyphosis

Kyphosis or kyphosis arcuata or round back is the exaggeration of the posterior spinal curve and is generally localized to the dorsal spine or thoracic spine. The back will be rounded, the head is carried forward and the chest is flattened. This results in typical round shoulders with excessive protrusion of the scapula.

#### *School Age*

The habitual posture at the school is the main cause. Mental and physical fatigue could also precipitate such habitual postural tendencies. It could also be developed as a result of undetected defects of vision or hearting.

#### *Adolescent Age*

This occurs as a result of arthritis, rheumatism, lung affections, e.g.: emphyema, vertebral disease and habitual bad posture.

#### *Old Age*

This occurs as a result of previous bad posture, muscular weakness, degeneration and disease of the vertebral bodies and discs.

*Deformity:* The deformity may be divided into three degrees according to the severity. They are:

*First degree:* Progress of the deformity from first to third degree. A habitual posture is the precipitating factor. There is no imbalance in the muscle, if this is not corrected at this stage; it progresses to the second stage.

The changes are:

1. The pectoral muscles become short, thereby restricting the chest expansion resulting in the reduced respiratory function.
2. The longitudinal back muscles, rhomboids and the middle trapezius are unduly stretched and weakened with the loss of tone.
3. The posterior ligaments are lengthened and the anterior structures are shortened. This causes increase in posterior laxity and a typical kyphotic deformity.
4. The wedging of the vertebral bodies may occur in the adolescent stage of the growth period. This gets organized into the third-degree deformity, which is a difficult syndrome.

Kyphosis can also occurs due to the tuberculosis, ankylosing spondylitis, Scheuermann's disease or congenital anomalies.

## PHYSIOTHERAPY MANAGEMENT

### First Degree Kyphosis

A. Relaxation
B. Stretching exercises
C. Posture maintenance.

### Second and Third Degree Kyphosis

The wrong adaptations of the soft tissues are in the advanced stage. Milwaukee brace is prescribed with pads applied on the posterior upright.

#### *Exercises*

The exercises are done with the brace on and the patient should be encouraged to put maximum pressure over these posterior pads. This stretches the shoulder, shoulder girdle and kyphotic curve. Sustainanace of the active stretching is very important.

It is difficult to achieve enough correction but it certainly helps in preventing further deterioration of the curve. Exercise to improve the mobility and respiration reduce the over all impact of the deformity.

### Surgical and Post Surgical Management

The surgical correction is done and involves gradual controlled halo-traction for several weeks. Bone grafting may be necessary to maintain the correction achieved through traction. Spinal stabilization is required through anterior approach in cases with severe kyphotic curves, tuberculous lesions and spinal cord decompression.

## THE MOVEMENTS OF THE THORAX

The movements of the Thorax are: Bucket handle and Pump handle movement.

## RESPIRATORY MOVEMENTS

The lungs expand passively during inspiration and retract during expiration. These movements are governed by the following two factors:

1. Alteration in the capacity of the Thorax are brought about by movements of the Thoracic wall. Increase in volume of the thoracic cavity creates negative intra-thoracic pressure which

sucks air into the lungs. Movements of the thoracic wall occur chiefly at the costo-vertebral and manubriosternal joints.

2. Elastic recoil of the pulmonary alveoli and of the thoracic wall, expels air from the lungs during expiration.

## PRINCIPLES OF MOVEMENT

Each rib may be regarded as a lever, the fulcrum of which lies just lateral to the tubercle. Because of the disproportion in the length of the two arms of the lever, the slight movements at the vertebral end of the ribs are greatly magnified at the anterior end.

The anterior end of the rib is lower than the posterior end. Therefore, during the elevation of the rib, the anterior end also moves forwards. This occurs in the vertebrosternal ribs. So anterior–posterior of the thorax is increased. There are up and down movements the 2nd to 6th ribs along with this body of the sternum also moves up and down called pump-handle movements.

The Thorax resembles a cone. As a result each rib is longer than the next higher rib. On elevation the larger lower rib comes to occupy the position of the smaller upper rib. This also increases the transverse diameter of the thorax. This is mainly by the bucket handle movements of the vertebrochondral (7-10) ribs, partly by elevation of the vertebro-sternal ribs. The vertical diameter is increased by the descent of the diaphragm.

### Inspiration

The drawing of air into the lungs is called inspiration this is of three types. They are:

#### *Quiet Inspiration*

In this type of inspiration the anterior-posterior diameter of the thorax is increased by elevation of the 2nd to 6th ribs. The first rib remains fixed. The Transverse diameter is increased by elevation of 7th to 10th ribs. The vertical diameter is increased by descent of the diaphragm.

*Deep Inspiration*

In this type of inspiration the movements during quiet inspiration are increased. The first rib is elevated by scalene muscle and sterno cleidomastoid muscle. The concavity of the thoracic spine is reduced by the erector spinae.

*Forced Inspiration*

In this type of the inspiration all the movements are exaggerated. The scapula are elevated and fixed by the trapezius, levator scapulae and the rhomboids muscle so that the serratus-anterior and the pectoralis minor muscles may act on the ribs. The action of the erector spinae is increased.

### Expiration

The breathing out of air from lungs is called Expiration. This is of three types. They are:

*Quiet Expiration*

In this type of expiration mainly the elastic recoil of the chest wall and pulmonary alveoli and partly expels the air by the tone of the abdominal muscles.

*Deep Expiration and Forced Expiration*

This is caused by the strong contraction of the abdominal and latissimus dorsi muscle.

## APPLIED ANATOMY

### Dyspnoea

This is also called Breathlessness or difficulty in breathing. Such patients will be more comfortable in sitting up, leaning forward and fixing the arm because the position of the diaphragm is lowest allowing maximum ventilation, whereas the height of the diaphragm is high on lying down, standing and lowest on sitting down.

## RESPIRATORY MUSCLES

The muscles respiration involved in inspiration and expiration including the accessory muscles involved.

### BREATHING

The alternate inspiration and expiration of air into and out of the lungs is called Breathing. It includes Inspiration and Expiration.

#### Quiet Breathing

*Inspiration:* Diaphragm and Intercostal muscles.

*Expiration:* Elastic recoil of the pulmonary alveoli and thoracic wall.

#### Deep Breathing

*Inspiration:* Scalene and sternocleidomastoid muscles.

*Expiration:* Abdominals and latissimus dorsi muscles.

#### Force Breathing

*Inspiration:* Diaphragm, Intercostal, sternomastoid, scalene, serratus anterior, Pectoralis minor, erector spinae, alaequae nasi muscles.

*Expiration:* Abdominals and latissimus dorsi muscles.

## HEART

The anatomy of the heart and its blood supply, the electrical activity of the myocardium and normal ECG.

The heart is a conical, hollow muscular organ situated in the middle mediastinum. It is enclosed within the pericardium. It pumps the blood to various parts of the body to meet their nutritive requirement.

The heart is placed obliquely behind the body of the sternum. It measures 12 multiply by 9 ms, weighs about 300 grams in males and 250 grams in females.

## External Features

The human heart has four chambers. These are the right and left atria and right and left ventricles. The atria lie above and behind the ventricles. Atria separated from the ventricles by atrioventricular groove. The atria separated from each other by an inter atrial groove, the ventricles separated from each other by an intra ventricular groove. Which is subdivided into anterior and posterior parts.

*Description:* The heart has:

*Apex:* This is directed downwards. It is formed by left ventricle. It is situated in the left 5th Intercostal space.

*Base:* This forms posterior surface and directed backwards. It is formed by the left atrium and right atrium.

*Surfaces:* The surfaces are:

*Anterior or Sternocostal surface:* This is formed by the right atrium and right ventricle.

*Inferior or Diaphragmatic surface:* This is formed by the left ventricle and left atrium.

*Borders:* The borders of the heart are upper, inferior, right and left.

*Grooves or sulci:* The atria are separated from the ventricles by a circular atrioventricular or coronary sulcus.

## Valves of the Heart

The valves of the heart maintain unidirectional flow of the blood and prevents its regurgitation in the opposite direction. There are two pairs of the valves in the heart, a pair of atrioventricular valves and a pair of semi lunar valves. The right atrioventricular valve is known as tricuspid valve because it has three cusps. The left atrioventricular valve is known as bicuspid valve because it has two cusps. It is also called as Mitral valve. The semi-lunar valve includes the aorti and pulmonary valve each having three semi lunar cusps. The cusps are folds of endocardium, strengthened by an intervening layer of the fibrous tissue. The first heart sound is produced by the closure of the atrioventricular valve; the second heart sound is produced by the closure of the semi-lunar valve.

*Applied Anatomy*

1. The narrowing of the valve orifice due to the fusion of the valve cusps is known as stenois. E.g: Mitral stenosis and aortic stenosis.
2. Dilatation of the valve orifice or stiffening of the cusps causes imperfect closure of the valve leading to back flow of the blood. This is known as incompetence or regurgitation. E.g. Mitral incompetence or regurgitation and aortic incompetence or regurgitation.

## Arterial Supply

The arterial supply is by the right and left coronary artery.

*Applied Anatomy*

1. Myocardial infarction and ventricular fibrillation is the thrombosis of a coronary artery that is a common cause of sudden death in persons in their middle age.
2. Anginapectoris is the incomplete obstruction of the coronary artery associated with agonizing pain in the precordial region and goes down on the medial side of the left arm and forearm.

## Venous Supply

The venous supply of the heart is by Great cardiac veins, middle cardiac veins, small cardiac veins, posterior vein of the left ventricle, oblique vein of left atrium, right marginal vein. All these drain in the coronary sinus which inturn opens into right atrium. Anterior cardiac vein and venae cordis minimae. These two drain directly into the right atrium.

## Lymphatic Drainage

The two trunks. The right trunk ends in the brachiocephalic nodes and the left trunk ends in the tracheo-bronchial lymph nodes form the lymphatic of the heart.

## NERVE SUPPLY OF THE HEART

### Parasympathetic Nerve Supply

This is by vagus nerve. The action is cardio-inhibitory. This slows down the stimulation after stimulating.

### Sympathetic Nerve Supply

This is by upper 3-5 thoracic segments of the spinal cord. The action is cardio-acceleratory. This increases the heart rate after stimulating.

Both sympathetic and Parasympathetic nerves form the superficial and deep cardiac plexus. The superficial cardiac plexus is situated below the arch of the aorta and deep cardiac plexus is situated behind the arch of the aorta.

### Clinical Aspects

1. The area of the chest wall overlying the heart is called precordium.
2. Tachycardia is increase in the heart rate.
3. Bradycardia is the decrease in the heart rate.
4. Arrhythmia is the irregular heart rate
5. Palpitation is the consciousness of the heartbeat.

### Applied Anatomy

1. Inflammation of the heart can involve more than one layer of the heart.
2. Inflammation of the pericardium is called pericarditis.
3. Inflammation of the myocardium is called myocarditis.
4. Inflammation of the epicardium is called epicarditis.
5. Right side heart failure is called congestive cardiac failure.
6. Right side heart failure due to lung disease is called as corpulmonale.
7. The apex beat is on left side normally if felt on the right side, it is called dextrocardia.

8. The incomplete obstruction of the coronary artery causes cardiac pain.

## ELECTRICAL ACTIVITY OF THE MYOCARDIUM

### Conducting System of the Heart

It is made up of myocardium that is specialized for initiation and conduction of the cardiac impulse.

#### *Sinuatrial Node (SA node)*

It is also known as pacemaker of the heart. It generates an impulse at the rate of about 70/min and initiates heart rate. It passes to atrioventricular node.

#### *Atrioventricular node (AV Node)*

This generates an impulse of 60/min.

#### *Atrioventricular Bundle (AV Bundle or Bundle of His)*

It is only muscular connection between atrial and ventricular musculature. It is divided into right and left branches. The right branch passes on the right side of the interventricular septum and divides into Purkinje fibers. The left branch descends on the left side of the interventricular septum and divides into Purkinje fibers and distributed to the left ventricle. The Purkinje fibers form a subendocardial plexus.

### Applied Anatomy

1. Arrhythmias are the vascular lesion of the heart.
2. Cardiac arrhythmias is the defect or damage in the system and in the normal rhythm of contraction.

## ELECTROCARDIOGRAM

The record or the registration of electrical activity of cardiac muscle fibers of the heart is called Electrocardiogram.

### Electrocardiography

This is the technique by which the Electrical activities of the heart are studied.

### Electrocardiograph

This is the instrument by which the Electrical activites of the heart are recorded.

# PHYSIOLOGY

## RESPIRATORY CENTERS

The physiological control of respiration and highlight the function of the medullar and pontine respiratory centers and central and peripheral chemoreceptors.

## CONTROL OF RESPIRATION

### The Respiratory Center

The respiratory center is formed by group of nerve cells that control the rate and depth of respiration. These are situated in the brainstem in medulla oblongata and pons varolii. In medulla there are inspiratory and expiratory neurons. Neurons in pons are situated in pneumotoxic and apneustic centers influence the inspiratory and expiratory neurons of the medulla. Motor impulses leaving the respiratory center pass in the Phrenic and Intercostal nerve to the diaphragm and Intercostal muscles respectively.

### Chemoreceptors

These are receptors that respond to changes of the partial pressure of oxygen, carbon dioxide in the blood and cerebrospinal fluid. These are located centrally and peripherally.

### Central Chemoreceptors

These receptor are located on the surface of the medulla oblongata and bathed in the cerebrospinal fluid. When arterial partial pressure of carbon dioxide raises even slightly, the central chemoreceptors responds by stimulating the respiratory center. When the ventilation of the lungs is increased, then arterial partial pressure of carbon dioxide is reduced. The sensitivity of the central chemoreceptors to raised arterial partial pressure carbon dioxide is most important factor in maintaining the homeostasis of the blood gases. A small reduction in partial pressure of oxygen has the same effect but less pronounced , but a sustained reduction has a depressed effect.

### Peripheral Chemoreceptors

These receptors are situated in the arch of aorta and carotid bodies. These are more sensitive to small rise in the arterial partial pressure of carbon dioxide and partial pressure of oxygen level. The nerve impulses generated in the peripheral chemoreceptors are conveyed to the medulla and the respiratory center. The rate and the depth of the breathing are increased, blood activity is increased, and pH is decreased. The stimulation of the peripheral chemoreceptors results in increased ventilation, increased carbon dioxide exertion and decreased blood pH.

## BLOOD PRESSURE

### Definition

It is the force or pressure, which the blood exerts on the walls of the blood vessels.

The blood pressure is equal to the cardiac output times the resistance against the vessel walls called peripheral resistance. The pressure in the large arteries varies as the heart contracts and relaxes. Blood pressure varies from person to person. The variables that influence the Blood pressure are age and gender.

The factors, which work together to maintain the blood pressure with in normal limits, are:

1. The amount of blood circulating in the blood vessel.
2. The force with which the heart pumps called cardiac output.
3. The elasticity of the large arteries.
4. The caliber of the small arterioles called peripheral resistance.

### The Amount of Blood Circulating in the Blood Vessel

The amount of the blood circulating will be less in shock and haemorrhage. A person injured badly or who had a major operation will have a low blood pressure is untreated. The lost blood due to hemorrhage is replaced by whole blood. The blood volume reduced because of shock will be brought back to normal by giving saline or dextrose solution.

### The Cardiac Output

The cardiac output depends on the volume of blood which returns to the heart by the veins. If the venous return is poor, the amount of blood is weak and the blood pressure is low. If a person has to stand still for long periods of time, the venous return from the lower limbs is inhibited because of gravity and lack of exercise so the heartbeat weakens, the blood pressure falls which results in a faint.

### The Elasticity of the Large Arteries

The elasticity maintains the continuous flow of the blood throughout the periphery of the body. As the arteries stretch and recoil they push the blood into the smaller vessels. In the old age the walls of these vessels get hardened so the greater pressure of the blood against the inelastic walls will be required.

### The Peripheral Resistance

This is the state of slight contraction of the muscular walls of the arterioles, producing the resistance to the flow of blood. These vessel walls can dilate or contract, depending on the amount of blood required by the organ they supply. Heat cause vasodilatation in the skin and cold causes vaso-constriction. When the vessels are dilated the pressure is lower and when they are constricted the pressure is greater.

A seriously injured person has a low blood pressure and this is compensated by the constriction of the arterioles in the skin. So the patient skin looks white and feels colder. So in such patient should not be overheated because the heat will still lower the blood pressure by vasodilating there by skin becomes warmer.

### Systemic Arterial Blood Pressure

The blood pressure is because of flow of blood from the left ventricle into the already full aorta.

### Systolic Blood Pressure

The maximum pressure is exerted upon the artery walls when the heart contrast and when the left ventricle contracts and pushes the blood into the aorta the pressure produced is called Systolic blood pressure. It is about 120 mm of Hg.

### Diastolic Blood Pressure

The force is exerted upon the vessel walls when the heart is relaxing and when complete cardiac diastole occurs and heart is resting following the ejection of blood, the pressure is called Diastolic Blood pressure and is about 80 mm of Hg.

### Pulse Pressure

This is systolic Blood pressure minus Diastolic Blood pressure. These vary from time of day, posture, gender age of the individual. During night Blood pressure is low and increases with age and in woman, Measured by sphygmomanometer. The normal range is 120/80 mm of Hg.

## CONTROL OF BLOOD PRESSURE

The control of the Blood pressure is through process called homeostasis through which the normal blood pressure is achieved. This is by the cardiovascular center. It is collection of interconnected neurons in the brain. This center is situated in medulla and pons. This center receives, integrates and co-ordinates the input from the Baroreceptors, Chemoreceptors and higher center in the brain. The output of the cardiovascualar center is through the autonomic nervous system to the Heart and Blood vessels enabling the rapid response to change in Blood pressure.

### Baroreceptors

These are situated in the arch of aorta and carotid sinuses.

*Function*

The Baroreceptors are sensitive to stretch that increases or decreases the Blood pressure. When the Blood pressure is increased in the arteries, it stretches the Baroreceptors so activates the cardiovascular center. This center responds by adjustment in output to the Heart and Blood vessels. The Blood vessels become dilated, Stroke volume and the heart rate decreases there by Blood pressure decreases.

### Chemoreceptors

These are the nerve endings situated in carotid and aortic bodies. They are primarily involved in control of respiration. These are sensitive to change in level of carbon dioxide, oxygen and acidity of Blood (pH).

### Higher Centers of Brain

The stimulation of the higher centers of the brain is by the input of fear, anxiety, pain, anger and emotional states, which stimulate the changes in the blood pressure. The hypothalamus controls the body temperature, which influences the cardiovascular center. This center responds by the adjusting the diameter of the blood vessels in the skin. So the important mechanism is determining the heat loss and heat retention.

## THE COUGH REFLEX

Coughing is a protective reflex. It is a commonest feature of all respiratory disorder. This is the commonest symptom of all respiratory disorders. The reflex occurs with the brief inspiration followed by that is closure of the glottis, contraction of the expiratory muscles (Abdominals) resulting in the rise in intra-abdominal pressure or intra-thoracic pressure. This forces the epiglottis to open and causes rapid flow of the expired air to come out with sputum and any foreign particles are present. Cough can be dry or productive and the character varies according to disorder or disease.

### Stimulus

Food, fluid, foreign bodies and cigarette smoking, pollutant.

### Receptors

The receptors are the lung irritant receptors. These have myelinated vagal innervation that is of rapidly adapting type. Located in between the respiratory epithelial cells through out the respiratory tract till respiratory bronchiole. The receptors in the large bronchi produces cough and the receptors in the small bronchi produced bronchoconstriction.

## BREATHING, LUNG COMPLIANCE AND AIRWAY RESISTANCE

The mechanical factors involve in breathing and factors affecting the lung compliance and airway resistance are:

### BREATHING

Breathing is the regular inflation and deflation of the lung which maintains a steady concentration of atmospheric gases in the alveoli, i.e. the constant intake of oxygen and output of carbon dioxide.

### Factors Affecting the Breathing

*Elasticity*

The loss of elasticity of the connective tissue in the lung necessitates forced expiration and increased effort on inspiration.

### *Compliance*

Compliance is the measure of distensibility of the lungs, i.e. the effort required to inflate the alveoli. When compliance is low the effort needed to inflate the lungs is greater than normal, e.g: In restricted lung disease the elasticity is reduced or the insufficient surfactant is present the compliance decreases.

### *Airflow Resistance*

The airway resistance is increased in broncho resistance, so more effort is required to inflate the lungs.

## LUNG COMPLIANCE

### Definition

The lung compliance is the measure of the elasticity of the alveolar walls and is measured as the changes in the volume produced by the change in the unit pressure.

Alveoli with high compliance expand more than those with low compliance for a given pressure. The lung tissue which is stiffened by disease has a low compliance and it is hard work for the patient to generate the forces to expand the lungs, therefore, there is a reduce ventilation. The lung compliance is decreased by stiff lungs or by a stiff chest wall, e.g.: the restricted lung disease or kyphoscoliosis.

### Factor Affecting the Compliance

1. The pulmonary tissue
2. The chest wall.

### *The Pulmonary Tissue*

The pulmonary tissue inturn has some factors that affect its function like:

*Elastic fibers of the lung*: The elastic recoil opposes the stretching of the lung, hence the reduction of the elastic coil causes rise in compliance and vice versa.

*The surface tension with in the alveoli:* The surfactant is the material present in the alveolus that reduces the surface tension exerted by the alveolar fluid. The surfactant is the mixture of phospholipid and the proteins. The type-II alveolar cells secrete this. In the newborn the surfactant is less and the disease is called hyaline membrane disease or respiratory distress syndrome. The surfactant is produced only in the later stages of the foetal life. So there is great inspiratory difficulty as the compliance of the lung is very low. So may lead to pulmonary edema.

*Interdependence:* Few of the adjacent alveoli starts to collapse. The neighboring alveoli starts pulling the collapsing alveoli and their collapse is opposed.

### *The Chest Wall*

The chest wall is highly elastic and springs out. The disease of the chest wall causes reduction of the compliance, e.g. ankylosing spondylitis and kyphoscoliosis.

## AIRWAY RESISTANCE

The resistance given by the airways is called Airway resistance. The place of the greatest airway resistance is in the upper respiratory tract where the total cross sectional area is narrowest and airflow is most turbulent. The nasal route gives more resistance person breathes through the mouth when breathlessness or exercising because the resistance of the airflow is less. Airway distends on inspiration and compress on expiration. The patient will have difficulty in breathing out than breathing in. On expiration the resistance rises most steeply.

The airway resistance also increases in acute cases of asthma and in chronic obstructive pulmonary disease because the airways get obstructed. The further obstruction and loss of the elastic recoil is caused in emphysema.

### The Factors Influencing the Airway Resistance

1. *The phase of inspiration and expiration:* The intrapleural and the mediastinal pressure become negative and negativity increases leads to increase in bronchial diameter. The resistance to the airflow is normally low. During expiration the intrapleural and mediastinal negativity decreases thereby bronchial diameter gets reduced. The resistance to the airflow is high. During normal breathing the expiration is approximately 1.4 times longer than the inspiration because the air requires greater time for the exit, e.g: The bronchial asthma is associated with bronchospasm, inspiration may not be difficult but expiration is very touch. So wheeze is heard during expiration.
2. *Tone of the bronchial muscle:* This is associated with bronchospasm and bronchoconstriction. The B2 adrenergic stimulation causes powerful relaxation. So diminishes airway resistance. Histamine, proteoglycans, irritant fumes and channel blockers cause bronchospasm. Broncho-constriction is caused on exposure to irritant gases, cigarette smoking. This is also seen in case of bronchial asthma.
3. *The density of the air:* If the density of the inspired air is high the resistance to flow increases and the lesser is the density of the inspired air, the resistance to the flow decreases.

## DIFFUSION, VENTILATION-PERFUSION

The factors affecting diffusion of $O_2$ and $CO_2$ in the lungs. The ventilation, perfusion and their interrelationship.

## DIFFUSION

The exchange of gases occurs when the difference in partial pressure exists across the semipermiable membrane. The diffusion occurs in both gaseous and liquid states leading to equilibrium. The gases move by diffusion from the higher concentrations to the lower concentration until equilibrium is established. In the peripheral airways the gaseous exchange occurs by gaseous diffusion between the respiratory bronchioles and the alveolar walls. The gases then diffuse through the membrane and fluid and reaches haemoglobin. This occurs by equalizing the oxygen tension and the red cells have transversed only one-third of the way and the carbon dioxide diffuse 20 times easily.

The diffusion capacity is the ability of the lung to allow gas to pass from blood to alveoli. The diffusion consist of the transfer factors which has alveolar volume, capillary blood and the diffusion of the diffusion properties. The deep breathing increases diffusion.

### The Values of the Diffusion

1. The efficiency of the ventilation.
2. The ventilation and perfusion ratio.
3. The oxygen carrying capacity.
4. The efficiency of the circulation.
5. The metabolic rate.
6. The acidity or alkalinity of the blood.

Blood gas measurement gives an indication of ventilation, gas exchange and the aid-base state.

*The $PaO_2$:* This is the partial pressure of oxygen in arterial blood. It is the amount of oxygen dissolved in plasma. The normal value is 80-100 mm of Hg or 11-14 KPa.

*The $PaC_2$:* This is the partial pressure of carbon dioxide. The normal value is 35-45 mm of Hg or 4. 7–6.0 KPa.

A low partial pressure of oxygen is normal that smoke, have COPD or an elderly. Partial pressure of oxygen is only 3% of oxygen dissolved in plasma and reflects the pressure needed to push it from air to blood and blood to tissue cells.

The $SaO_2$ is the extent to which the hemoglobin is saturated with oxygen and represents the capacity of blood to carry oxygen. Normal value is 95-98%. The $SaO_2$ describes the 97% of oxygen that is bound to haemoglobin. In anaemic person will have normal $SaO_2$ but deliver a subnormal load of oxygen.

The ventilation, diffusion and perfusion occur in sequence. The gas exchange occurs at tissue level to complete the process of respiration. The oxygen transport depends on the cardiac output and oxygen content of the blood. The oxygen delivery and utilization depends upon local perfusion, metabolic rate and oxygen demand.

## CLINICAL APPLICATION

### Hypoxia

This is causes decreased cardiac output, oxygen-carrying capacity of the blood and increased oxygen needs.

### Hypoxaemia

This is caused because of hypoventilation, diffusion abnormality. Wasted perfusion and ventilation.

### Hypoventilation

The ventilation decrease, the carbon dioxide accumulates and partial pressure of carbon dixoide rises.

### Diffusion Abnormalities

This is related with oxygen.

*The ventilation.* Perfusion and their interrelationship

### Ventilation

*Definition:* The ventilation is the supplying of oxygen through the lungs.

*Alveolar ventilation:* This is the volume of air that moves into and out of the alveoli per minute. This is equal to tidal-volume minus the anatomical dead space multiplied by respiratory rate.

*Alveolar ventilation:* (TV- Anatomical dead space) Multiplied by Respiratory rate

= (500 – 150) ml multiplied by 15 per min
= 5. 25 litre per min.

*Tidal volume:* The volume of air breathed in and out during a quiet respiration. It is about 500 ml. About 150 ml of this volume amount remains in the dead space in tracheobronchial tree where no gaseous exchange occurs. The rest 350 ml is present in the alveoli, alveolar duct where gaseous exchange occurs. This is about 350 ml called alveolar ventilation.

*Example:* The respiratory rate is about 14/min, tidal volume is 500 ml. The total ventilation rate or ventilation per minute or respiratory minute volume is about 500 multiplied by 14 ml /min = 7 liters / min. The dead space I around 150 ml then the alveolar ventilation is 500–150 ml multiplied 14 /min = 4.9 litre /min.

Most of the dead space ventilation is made up of anatomical dead space that represents the air in the conducting passages that is last in and first out this does not reach the alveoli. The alveolar dead space represents the air that reaches the alveoli but not the blood and is minimal in normal lungs. The sum of anatomical and alveolar dead space is called physiological dead space.

The alveoli in upper regions are more inflated because the lung hanging in the frame of the chest exerts expanding stress. Alveoli in lower regions are more squashed because there is less lung hanging down below them. The sponge like properties of the lung mean ventilation is greater in the poorly expanded dependent regions where there is more potential to expand.

In the horizontal position, the excursion of the dependent portion of the diaphragm is twice that of the upper portion because the lower fibers are more stretched by the abdominal pressure and therefore, contract from a position of mechanical advantage.

The rapid shallow breathing means that more tidal volume I lot to dead space, since the same air is going in and out more often. Deep breathing increase lung compliance by stretching alveoli and encouraging surfactant production. The resistance between adjacent lung segments through collateral channels decreases with increased lung volume and breath–holding at end inspiration utilizes this collateral ventilation thus, improving the distribution of ventilation, thus improving the distribution of ventilation.

### Perfusion

The perfusion is also required for gaseous exchange in the lung. The pulmonary circulation is a low resistance system and has the unusual ability to further reduce its resistance in response to a rise in pressure by increasing the caliber of capillaries and recruiting others that are closed.

Such a low-pressure system is very responsive to gravity, so there is a steep perfusion gradient from top to the bottom of the lung. In the base of the upright lung, the greater volume of blood leads to airway closure. In the apex, perfusion is minimal because the arterial pressure can't overcome alveolar pressure. These delicate vessels collapse in upper lung if the balance is disturbed.

Perfusion becomes more evenly distributed when a person lies own or takes exercise. It is more unevenly distributed in people with COPD.

### Ventilation-perfusion Ratio

*Definition:* The ventilation perfusion is the ratio of the alveolar ventilation and the amount of blood that perfuses the alveoli.

VPR = VA/Q
VA = Alveolar ventilation
Q = Perfusion or the blood flow.

*Normal values:*

Alveolar ventilation = 4200 ml / min
Perfusion = 5000 ml / min
VPR = 4200 / 5000 = 0.84.

*Significance:*

1. Gaseous exchange

*Note:* This is affected with any change of ventilation and perfusion.

### Variation

*Physiological Variation*

a. The ratio increases with increase in ventilation and no change in perfusion.
b. The ratio decreases if perfusion increases without any change in ventilation.
c. In sitting position there is reduction in perfusion and ventilation in the upper part of the lung than the lower part.
d. The reduction in perfusion is more than reduction in ventilation. So VPR increases three times.
e. The VPR ratio is decreased in the lower part of the lung because of the ventilation is reduced and the perfusion is increased.
f. The physiological shunt occurs because a part of blood does not get oxygenated.

*Pathological Variation*

In COPD like emphysema the ventilation is affected because of the obstruction and destruction of the alveolar membrane. So VPR is drastically decreased.

## ENERGY EXPENDITURE

The energy expenditure of various common activity of the daily living.

The human body requires the energy to support normal function, Physical activities, growth a repair of damaged tissue. The energy is provided by oxidation of dietary fat, protein, carbohydrate and alcohol. A Small part of energy is by breakdown of animal's own tissue. The protein energy of food provides kinetic energy of the body in form of heat and work. The unit of the energy is calorie. Calorie is the amount of heat required to the temperature of one gram of water by one degree centigrade. One kilocalorie is equal to 4.2-kilo joule.

### Measurement of Energy Values of Food

The foodstuffs like carbohydrates, fat, protein on combustion by oxygen produces heat. The heat is measured by the bomb calorimeter.

| | |
|---|---|
| 1g of carbohydrates | = 4 kilocalories |
| 1g of Protein | = 4 kilocalories |
| 1g of Fat | = 9 kilocalories |

### Energy Expenditure in Healthy Adults

This depends on the three factors

1. Body size
2. Physical activities:
   a. Light activities (sedentary) like office work with mechanical gadgets
   b. Moderate activities like printing, housewife without mechanical gadgets
   c. Heavy activities like agriculture workers, unskilled labourers.
3. Age

   Energy expenditure determined by three factors:

#### *The Basal Energy Expenditure*

This is the energy required to maintain the basic physiological function.

#### *The Thermic Effect of Food*

It is the amount of the energy expanded during and following ingestion of the food.

#### *The Physical Activity*

This has major implication on the energy expenditure.

The energy expenditure of the various activities are like sitting, standing, walking and other activities depends on the

Body mass index = Weight in kilograms / height in square meters.

## BASAL METABOLISM

The total heat produced as the energy spent by the body order conditions to perform minimum possible work is called Basal metabolism.

### Factors

1. *Surface area:* The larger is the surface area the greater is the BMR.
2. *Age:* The children have larger BMR than adults.
3. *Sex:* Males have higher BMR than adults.
4. *Emotion:* The BMR increases in the emotional stress.
5. *BMR:* This is normal in starvation, under nutrition, Hypothalamic disorders, additions disease ad below normal in fever, diabetes, leukemia and polycythemia.

### Determination of the Energy Metabolism

*Principles*

1. Measuring the volume of expired air during work for fixed period of 5-10 minutes.
2. Collection of a sample of expired air or the analysis of oxygen and carbon dioxide contents.
3. Calculation of the oxygen consumption, carbon dioxide output and respiratory quotient.
4. Calculation of energy output from respiratory quotient a oxygen consumption.

### Measurement

*Douglas Bag*

This is the lab method. The bag is made up of rubber. The capacity of the bag is 100 liters ad the procedure is the subject breathes into the bag for 5-6 minutes. The air in the bag is then measured using a gasmeter and a sample taken for the analysis of oxygen and carbon dioxide.

*Max–Planck Respirometer*

The instrument is portable. This works simultaneously by measuring directly the volume of the expired air and passing a small quantity into the rubber bladder attached to it. The air is analyzed for carbon dioxide and oxygen. Respiratory quotient is found as volume of carbon dioxide produced / volume of the oxygen consumed.

*Kofrangi-Michaelis Respirometer*

Intergration motor pneumotachygraph developed by Wolff.

## PULMONARY FUNCTION ASSESSMENT, TESTS—BLOOD GAS ANALYSIS

### PULMONARY FUNCTION ASSESSMENT

The pulmonary function tests and their use. The basis and the value of blood gas analysis.

#### Assessment of the Pulmonary Patient

*Introduction*

*Data Base*

a. Ward reports and meetings
b. Notes and charts.

*Subjective assessment*

a. Symptoms
b. Functional limitations.

*Observation*

a. Apparatus
b. Sputum
c. General appearance
d. Colour
e. Hands.

*Oedema*

a. Chest shape
b. Breathing rate
c Breathing pattern
d. Jugular venous pressure.

*Palpation*

a. Abdomen
b. Chest expansion
c. Percussion note
d. Hydration
e. Trachea.

*Auscultation*

a. Technique
b. Breath sounds
c. Added sounds
d. Voice sounds.

*Exercise Tolerance*

*Chest X-ray*

a. Systemic analysis

*Pulmonary Function Test*

*Introduction:* Assessment plays a very important role for preparation of accurate physiotherapy plan for a physiotherapist. The clinical assessment would be one in a quiet, warm and in a private place, so that patient feels comfortable and can come out with his problems well than in public. A Required plan of action is:

a. Assess the patient
b. Identify problems
c. Correlate these with the patients expectations
d. Formulate goals with the patient

e. Plan management and its time frame
f. Treatment
g. Re-assess
h. Modify management plan according to on-going assessment
i. Reviews.

*Database*

Ward reports and meetings:

The physiotherapist should take referrals from the medical staff and the nursing staff and should plan out physiotherapy treatment required and the changes in the patient conditions can be explained and a note can be written in the case–sheet.

## NOTES AND CHARTS

The details require before starting the physiotherapy treatment are:

1. History of vertigo or light-headedness
2. Swallowing difficulty or tendency to aspirate
3. Tendency to bleed
4. Social history
5. Arthritis
6. Elevated white cell count, recent infection
7. Recent cardio-pulmonary resuscitation (need an X-ray examination in case of aspiration or fracture).
8. Bony metastasis
9. Steroid therapy
10. Radiotherapy over chest (8, 9, 10 are contraindicated for percussion or vibrations over the ribs.
11. Temperature chart at every check (Infection or atelectasis)
12. Drug therapy
13. Oxygen therapy
14. Fluid balance
15. Dehydration
16. Sputum retention
17. Blood pressure
18. Heart rate.

## Subjective Assessment

### Symptoms

1. How long have symptoms been troublesome?
2. Are the symptoms better or worse?
3. What are the aggravating and relieving factors?

*Chest disease symptoms like*

a. Wheeze (Tightness of the chest on breathing out, noisy breathing and the aggravating factors like exertion and other factors.
b. Pain can be as like Chest pain which can be sharp and stabbing as pleuritic type pain. In pleurisy, severe pain on deep breathing and coughing. Paroxysmal suffocating pain due to myocardial Ischaemia Pneumonia, spontaneous Pneumothorax and pulmonary embolism, angina pectoris, raw central chest pain worse on coughing caused by tracheitis with upper respiratory tract infection.
c. Breathlessness:
   1. How does your condition affect your lungs?
   2. Do you smoke? How many times? Its effects on health?
   3. Do you become tired? Is it exhausting to clear your chest? How about exercise every day?
   4. How is your appetite, its effects, and type of food you take?
   5. Do you have problem of constipation and its solution?
   6. Are you under prescription of inhalers or tablets and their use?
   7. Is oxygen available at home, what flow rate you use. Time of use and how does it help you?
   8. Is breathlessness-becoming barrier for your activities of daily living?
   9. How breathless are you now (No breathlessness or very severe breathlessness) and feeling of it (Worried, frustrated, embarrassed, frightened and depressed)?
   10. How far can you walk, transport?

d. Cough with or without sputum:
   1. How did cough start?
   2. How is sputum like?
   3. How is the quality and quantity?
   4. Is there blood also?
   5. Does the cough make you awake?
   6. Is this also with eating and drinking?

### Functional Limitation

1. Activities of daily living
2. Finance
3. Employment
4. Housing
5. Daily exercise
6. Employment
7. Number of stairs at work place or home
8. Environment dusty, smoky
9. Habits like smoking, living alone and eating well
10. Is difficulty to shop, bathe and dressing?
11. Patient opinion on disease
12. Does patient have anxiety, depression, fatigue, frustration, embarrassment, restricted social function?

### Observation

1. Breathing rate
2. Breathing pattern.

### Apparatus

Is the patient using oxygen, humidifier, drips, drains and chest drains?

### Sputum

*Pulmonary oedema*: White or pink colour and frothy serous secretions.

*Chronic bronchitis:* Raw egg white sticky grey mucoid sputum.

*Asthma:* Tenacious, mucoid sputum, with thick plugs, excess eosinophils.

*Pseudomonas infection:* Foul smelling green sputum.

Bronchiectasis, tuberculosis, Mitral stenosis, pulmonary carcinoma lung contusion and tracheal suction cause.

*Haemoptysis:* Bright red colour blood vomited.

*Haematemesis:* Dark red blood because of nausea Melaena Digested blood passed per rectum.

*General appearance:* The patient can be observed as a whole.

### Colour

1. *Palor:* Anaemia decreased cardiac output or hypovolaemic shock.
2. *Plethoric appearance:* Excess red blood cells of Polycythaemia.
3. *Cynosis:* Bluish colouration caused by unsaturated haemoglobin in the blood because of heart or lung disease. This is of two types central cyanosis appears on the tongue and lips when Partial pressure of oxygen become below 50 or 60 mm of Hg. Peripheral cyanosis occurs at the fingers, toes and ear lobes which signifies the problem of blood circulation.

### Hands

1. Clubbing: Heart, lung disorder. Bronchial asthma and increased perfusion.
2. Hands are warm from peripheral vasodilatation. Tremor suggest carbon dioxide retention.
3. Wasting of the hand muscles is associated with recent malnutrition.

*Oedema:* Accumulation at the ankles or sacral region depending on posture. In the respiratory patient it implies inadequate venous return to the heart and associated with the heart failure and COPD.

### Chest Shape

1. Ageing
2. Kyphosis

3. COPD (ribs held horizontal position and loss of elastic recoil)
4. Scoliosis
5. Sternal deformities:
   a. Pigeon chest or pectus carinatum
   b. Barrel chest or pectus excavatum.

### Breathing Rate

1. Heart rate increased because of lung /heart disease /pain / anxiety/anaemia/fatigue
2. Sudden increase in heart rate because of pulmonary oedema, pulmonary embolus. Spontaneous Pneumothorax
3. Decrease in heart rate is because of drug overdose, brain damage, and diabetic coma and exhaustion.

### Breathing Pattern

This shows lung or chest wall pathology, dyspnoea or neurological defect.

1. Cheyne-strokes breathing
2. Laboured breathing
3. Parodoxical breathing.

### Jugular Venous Pressure

The internal jugular vein indicates the raised pressure in the right ventricle and vein will engorged visible above clavicle in COPD.

| *S.no* | *Condition* | *Palpation* | *Percussion* | *Breath sounds* | *Added sounds* | *Voice sounds* |
|---|---|---|---|---|---|---|
| 1 | Consolidation | Normal | Dull | Bronchial breathing | ——— | Increased |
| 2 | Pneumothorax | Decreased | Hyper-resonant | Decreased | ——— | Decreased |
| 3 | Pleural effusion | Decreased | Dull | Decreased | | Decreased |
| 4 | Acute asthma | Hyperinflated chest | Hyper-resonant | Silent chest | Expiratory wheeze | Normal |
| 5 | Emphyema | Pursed lip Breathing | Hyper-resonant | Blood supply decreased | ——— | Decreased |
| 6 | Chronic bronchitis | Barrel chest | Resonant | Normal | Wheeze | Normal |
| 7 | Bronchiectasis | Normal | Resonant | Normal | Inspiratory Expiratory crackles | Normal |

*Contd...*

*Contd...*

| | | | | | | |
|---|---|---|---|---|---|---|
| 8 | Pulmonary Oedema | Normal | Resonant | Normal | Wheeze | Normal |
| 9 | Interstitial lung disease | Normal | Resonant | Normal | End inspiratory-Crackles | Normal |
| 10 | Fibrosis | Expansion decreased on affected side | Dull over affected area | Normal | Localized end-inspiratory crackles | Normal |

### Exercise Tolerance

The exercise tolerance can be estimated by the subjected assessment of walking to the shops; patient calculated walking distance and objective assessment is by six-minute walk or walking upstairs. This assessment gives idea about patient's daily life, gait and fatigue.

### Chest X-rays

The radiograph provides a unique insight into the state of the lungs and the chest wall. The posterior anterior view makes and optimum view of the lungs because the patient takes a deep breath from the standing position with shoulders abducted resulting in a low diaphragm and scapula held clear of the film. For the less mobile patient A-view is taken .The film is partly obscured by the scapula, raised diaphragm and the magnified heart.

## PULMONARY FUNCTION TESTS

The Pulmonary function tests measure the lung function that can distinguish restrictive from the obstructive disorders.

### Indications

1. A narrowed airway shows reversibity to medication.
2. Asthma attack in a symptom less patient.

   The air in the lung is classified into two divisions:

*Lung volumes:* The volumes of the lung are breathed by the subjects.

They are:

*Tidal volume:* The volume of the air breathed in and out in a single normal quit respiration is called tidal volume. It is about 500 ml.

*Inspiratory reserve volume:* The additional amount of the air inspired forcefully after the end of the normal inspiration is called inspiratory reserved volume. It is about 3300 ml or 3.3 litres.

*Expiratory reserve volume:* The additional amount of the air that can be expired out forcefully after normal expiration is called expiratory reserve volume. The normal value is 1000 ml or 1 litre.

*Residual volume:* The amount of the air remaining in the lung even after the forced expiration is called residual volume. The normal value is 1200 ml or 1.2 litres.

### Importance

1. Residual volume maintains the contour of the lung.
2. Residual volume helps top aerate the blood in between breathing and during expiration.

*Lung capacities:* The lung capacities include two or more primary volumes.

They are:

*Inspiratory capacity:* This is the maximum volume of that air and be inspired starting from end expiratory position. Its value is 3800 ml (IC = TV + IRV = 500 + 3300 = 3800).

*Vital capacity:* This is the maximum amount of the air that can be expelled out forcefully after a maximal deep inpiration. Its value is 4800 ml (VC = IRV + TV + ERV = 3300 + 500 + 1000 = 4800 ml).

*Functional residual capacity:* This is the volume of the air remaining in the lungs after normal expiration. Its value is 2200 ml. (FRC + ERV + RV = 1000 + 1200 = 2200 ml.

*Total lung capacity:* This is the amount of the air present in the lungs after a deep inspiration. It includes all the volumes. Its value is TLC = IRV + TV + ERV + RV = 3300 + 500 + 1000 + 1200 = 6000 ml.

*Forced expiratory flow rate:* A Peak flow meter provides a quick and simple indication of airway obstruction. The test is performed thrice and the best of three is taken with rest in between.

### Suggestions to the Patient

1. The patient is asked to avoid tight clothes.
2. Not to have heavy meal.
3. Do not smoke.
4. Giving the explanation and technique of the test.
5. If the first reading is taken in one position other two should be taken in the same position.
6. The Physiotherapist should demonstrate the technique with mouth piece.
7. The patient should hold the mouth piece tightly.
8. The patient should take a deep breath until the lungs are completely full then blow short and sharp and as hard as possible.

### Aim

1. This is very important with patients with unstable asthma because lung function can decline to 50 or 60% of normal before symptoms are noticeable.
2. This is useful in the chronic asthma to determine the right drug.
3. To evaluate ventilation by assessing the factors affecting the movement of gas in and out of the lungs.
4. To guide for the diagnosis, treatment plan and prognosis.
5. To help therapist to plan for therapeutic goals, appropriate intervention to the pulmonary problems, identify the permanent respiratory impairment.

### Guidelines

1. The pulmonary function tests evaluate airway responsivity, ventilatory regulation and ventilatory mechanics.
2. The pulmonary function tests allows the effect of hypoxia, hypercapnia.

3. The pulmonary function tests helps in assessment of ventilatory mechanics which is measurement of lung volumes occur in restrictive diseases like Pneumonia, interstitial lung disease, Pleural effusion, Pleurisy, Pneumonia, and forced flow rates decreases in obstructive disease like chronic bronchitis, emphysema, asthma, bronchiectasis and cystic fibrosis.
4. The assessment of the ventilatory mechanics also permits evaluation of the effectiveness of therapy.
5. The pulmonary function tests helps to find out the general progress of the disease process.
6. The pulmonary function tests helps in the determination of the pulmonary impairment.

## TESTS PERFORMED BY THE PHYSIOTHERAPIST

A rough estimation of the airway obstruction can be made by asking the patient to blow out a lighted match held 6 inches from the mouth, failure to do suggest an FEV1 of less than one litre.

### Measurement of the Pulmonary Function

1. Spirometer
2. Gas transfer tests
3. Exercise testing
4. Quantitative perfusion/Ventilation scanning
5. Six minutes walk
6. Stair climbing.

### Spirometer

The method by which the lung volumes and capacities are measured is called spirometry. The simple instrument used for this purpose is called spirometer. The modified spirometer is known as respirometer.

The spirometer can be used only for a single breath. The repeated cycles of respiration cannot be recorded by using the spirometer because the carbon dioxide accumulated in the spirometer cannot be removed and oxygen or fresh air cannot be provided to the subject.

*Respirometer*

This is the modified spirometer. This has the facility of removing the carbon dioxide and supply of the oxygen. The carbon dioxide is removed by placing soda lime inside the instrument. The oxygen is supplied to the instrument from the oxygen cylinder by a suitable valve system.

*Spirogram*

The record of the lung-volumes and capacities using spirometer or respirometer is called Spirogram. The downward deflection of the Spirogram indicates expiration and the upward curve denotes inspiration.

*Computerized Spirometer*

This is a solid state electronic equipment. The subject has to respire into a sophisticated transducer, which is connected to the instrument by means of a cable.

The residual volume, functional residual capacity and the total lung capacity are measured by the Nitrogen wash out technique and helium dilution technique, not with the spirometry.

## Helium Dilution Technique

*Functional Residual Capacity*

The respirometer is filled with the air containing a known quantity of helium. Initially the subject breaths normally, then after the end of the expiration, the subject breathes from the respirometer. The Helium from the respirometer enters the lungs and starts mixing with the air in lungs. After few minutes of breathing, the concentration of Helium in the respirometer becomes equal to the concentration of helium in the lungs of the subject. This is called the equilibrium of helium. After this between respirometer and lung, the concentration of helium in respirometer is determined.

FRC = V (C1-C2) / C2

C1: Initial concentration of helium in the respirometer
C2: Final concentration of the Helium in the respirometer
V: Initial volume of air in the respirometer.
Example: V = 5000 ml, C1 = 15%, C2 = 10%
FRC = 5000 (15/100 – 10/100) ml divided by 10/100 = 2500 ml =FRC

*Residual Volume*

The subject should start breathing from the respirometer after forced expiration.

**Nitrogen Wash out Method**

The concentration of nitrogen in the air is 80%. So the total quantity of nitrogen in the lungs is measured, so that the amount of air in the lungs can be calculated.

*Functional Residual Capacity*

The subject is asked to breathe normally. After the end of the normal expiration, the subject inspires pure oxygen through a valve and expires into a Douglas bag. This procedure is repeated for 6-7 minutes till the nitrogen in lungs is displaced by oxygen. The nitrogen comes to the Douglas bag.

The FRC is calculated as:

1. Volume of air collected in Douglas bag
2. Concentration of nitrogen in the Douglas bag

FRC = C1 multiply V/C2
V = Volume of air collected = 40, 000 ml
C1= Concentration of nitrogen in the collected air = 50%
C2 = Normal concentration of nitrogen in the air = 80%
FRC = 2500 ml.

*Residual Volume*

The subject starts inhaling pure oxygen after the end of the forceful expiration.

### Gas Transfer Tests

Arterial blood gases may be used to evaluate gas transfer and ventilation. The partial pressure of carbon dioxide provides the useful information of the alveolar ventilation. If there is minimum alteration indicates severe dysfunction of gas exchange.

### Exercise Testing

Measurement of exercise capacity evaluates the combined performance of cardiac and respiratory system. The maximum uptake is preoperative outcome and used to identify surgical requirement for the patients.

### Quantitative Perfusion / Ventilation Scanning

Radio nuclide lung perfusion/ventilation scanning estimates the contribution of each lung, regions and lung function. It is used to predict pulmonary function after resection, pneumonectomy and lobectomy.

### Six-minute Walk

This is an inexpensive, easily performed test. It is for the chronic obstructive lung disease, preoperative evaluation of the thoracic surgery patient. The test procedure is the patient is instructed to walk on a pre-determined course as far and fast as they can. The distance will be over 1000 feet. This is for uncomplicated post-operative recovery.

### Stair Climbing

This is an exercise tolerance test done by climbing upstairs.

#### *Clinical Application*

1. For pre-operative evaluation.
2. For the diagnosis of the functional pulmonary disorders.
3. Obstructive ventilatory disorders like chronic bronchitis, emphysema, asthma, cystic fibrosis, bronchiectasis.

4. Restrictive ventilatory disorders like fibrosing alveolitis, interstitial pneumonitis, and sarcoidosis and chest wall deformities.

## CARDIOVASCULAR STRESS TESTING

### PRINCIPLES

1. To evaluate coronary artery disease.
2. Exercise the patient on the Treadmill bicycle ergometer.
3. To record ECG during and immediately after exercise.
4. To increase work till the patient attains the 140-170 desired level.
5. To make patient work till patient gets symptoms like chest pain, giddiness, angina and palpitation.
6. The test is effective with heart imaging with radioactive technique of Thalium 99.
7. To increase cardiac output, stroke volume.
8. The sympathetic nervous system works maximum and the para-sympathetic nervous system will be withdrawn and peripheral vasoconstriction occurs.
9. The adrenalin and the nor-adrenalin secretion causes decrease in the blood supply.
10. The cardiac output increases 4-6 times than normal.

### Contraindications

1. Unstable angina
2. Recent myocardial infarction
3. Untreated cardiac-arrhythmia
4. Congestive heart failure
5. Aortic stenosis
6. Cardiacmyopathy
7. Acute Myocarditis
8. Advanced AV block
9. Uncontrolled hypertension
10. Acute systemic illness.

### Procedure

The patient is asked to come with the empty stomach. No hot beverages should be taken. In males chest should be shaved. The procedure should be explained. ECG should be taken initially before starting in resting position in sitting and lying position. Demonstrate the technique on treadmill and simultaneously record Blood pressure, ECG and heart rate. The normal Heart rate is 140-170 beats per minute. Observe the patient if has any giddiness, chest pain. Observe the changes in the ECG, ST segment is important to diagnose the Ischaemia. ST elevation occur in the disease.

#### *Diagnosis*

The diagnosis is done on the basis of every one-minute record and check of how much time is taken to come back to normal. If 5 minutes is taken then considered as serious coronary artery disease with symptoms like Dyspnoea, chest pain and decrease in blood pressure, ischaemic ST, ventricular tachycardia, ectopic, abnormal raise in blood pressure.

1. *True positive:* Abnormal test in disease patient
2. *False positive:* Healthy patient shows positive
3. *True negative:* Healthy with normal
4. *False positive:* Patient having disease but test is negative.

### Other Tests

1. Thalium imaging or people who can't run
2. Coronary angiogram.

### Treatment

*Single block:* Balloon angioplasty

*One or Two blocks:* Stunt is done

*Multiple blocks:* Coronary artery bypass surgery or graft is done.

## ARRHYTHMIA AND SYNCOPE

### DEFINITION

The abnormal or irregular heartbeat is called as arrhythmia.

### Types

*Normotrophic Arrhythmia*

The SA node is the pacemaker. This is divided into three categories. They are:

a. Sinus tachycardia
b. Sinus bradycardia
c. Sinus arrhythmia.

*Ectopic Arrhythmia*

The pace maker is other than SA node. This is divided into three categories .They are:

*Homotrophic:* The impulse arises from the conductive system

*Heterotrophic:* The impulse arise apart form the conductive system

*Heart Block:* Arrhythmia occurs when the impulses generated by SA node are blocked while passing through the conductive system of the heart. This is divided into two categories. They are:

A. *Sino-atrial Block:* The impulses are not transmitted from SA node to AV node due to defective inter-nodal fibres.
B. *Atrio-ventricular Block:* The impulses are not transmitted from atria to ventricles due to defective conductive system. This is divided into two categories. They are:
C. *Incomplete Heart Block:* This is again divided into four types. They are:
   1. *First degree block:* There will be delayed conduction because of the AV nodal delay.
   2. *Second degree block:* There will be partial Heart block because some impulses produced by SA node fails to reach the ventricles.
   3. *Wenckebach's block :*The conduction of the impulses from atria to ventricles is gradually decreased for every beat and finally one ventricular beat is missed.

4. *Bundle branch block:* This is either right or left bundle branch block.

### Complete Heart Block or Third Degree Heart Block

Complete Atrioventricular block or third degree Heart block is the condition where impulses produced by SA node do not reach the ventricles, so the ventricles beat in their own rhythm independent of atrial beat called cardioventricular rhythm. These are two types. They are:

1. AV nodal block
2. Infranodal block.

### Extrasystole

This is divided into three categories:

a. *Atrial extra systole:* Extra P-wave appears immediately after regular T-wave.

b. *Nodal extra systole:* P-wave merged with QRS complex

c. *Ventricular Extrasystole:* Extra QRS complex follows the regular T-wave.

### Paroxysmal Tachycardia

This is divided into two categories:

a. *Atrial Paroxysmal Tachycardia:* P-wave inverted with normal QRST complex

b. *AV nodal Paroxysmal Tachycardia:* This is temporary block of one part of conductive system.
   1. Circus movement: P-wave is absent
   2. Wolff-Parkinson-White syndrome
   3. Lown-Ganong -Levine syndrome: Short P-R interval with normal QRS complex and T-wave.

### Ventricular Paroxysmal Tachycardia

The ischaemic area is excited abnormally by a series of Extra systole.

### Others

a. *Atrial flutter:* The conduction rate of the AV node is about 230-240 impulses /min
b. *Atrial fibrillation:* The conduction rate of the AV node is about 300-400 beats /min.
c. *Ventricular fibrillation:* The conduction rate of AV node is about 400-500 beats per minute.

## SYNCOPE AND ITS MANAGEMENT

### Definition

It is the sudden and temporary loss of consciousness due to inadequate cerebral flow.

### Types

#### *Emotional Syncope*

This is due to Emotional fainting, Decreased cardiac output, decreased cerebral flow, suppression of myocardium, severe vasodilatation caused by the parasympathetic division of the autonomic nervous system.

#### *Postural Syncope*

This is due to Prolonged standing causes pooling of blood in lower limbs.

#### *Micturation Syncope*

This is due to low blood pressure while standing or orthostatic hypotension causes micturition syncope.

#### *Neurocardiogenic Syncope*

This is due to cardiac arrhythmia, decrease in cardiac output, bradycardia, and Heart block.

#### *Effort Syncope*

This is due to stenosis of semilunar valves, increased cardiac output because of the exercise strain.

*Cough Syncope*

This is due to increased intra-thoracic pressure, decreased venous return cardiac output results in fainting.

*Carotid Sinus Syncope*

This is due to tight collar dress cause decrease in heart rate and vasodilatation.

## ECG

### FUNDAMENTALS OF THE ECG RECORDING AND BASIC INTERPRETATION

#### Definition

This is the record or graphical Presentation of electrical activities of the Heart, which occurs prior to the onset of mechanical activities.

#### Electrical Changes During Muscle Contraction

The muscle contracts when stimulated by a nerve.

#### Resting Membrane Potential

The potential difference between inside and outside of the cell under resting conditions is known as Resting membrane potential. In human muscle RMP is –90 MV.

#### Action Potential

When the muscle is stimulated, a series of changes occur in the membrane potential called action potential. This occur as:

*Repolarization*

The altering of the muscle polarized state by interior as positive and exterior as negative.

*Depolarization*

The coming back to normal state of negative inside and positive outside.

## Electrographic Grid

The electrocardiograph or ECG machine amplifies the electrical signals from the heart. This is recorded on strip of paper. The ECG paper consist of 1mm size vertical and horizontal lines.

## Time

The Time duration is measured by vertical lines and time duration between 2 thick lines 5 mm is 0.2 seconds and the time duration between 2 thin lines 1 mm is 0.04 seconds.

## Amplitude

The Amplitude is Measured by Horizontal lines and the interval between 2 thick lines 5 mm is 0.5 MV and between 2 thin lines 1 mm is 0.1 MV.

## Speed of the Paper

Normal recording is 25 mm/sec. If the Heart rate is very high, the speed of the paper is changed to 50 mm /sec.

## Waves, Intervals and Segments of Normal EGC

| S. no | Wave, Segment, Interval | From – To | Cause | Duration Sec | Amplitude (MV) | Significance |
|---|---|---|---|---|---|---|
| 1 | P-wave | First wave, Positive wave, Called Atrial Complex | Atrial Depolarization | 0.1sec | 0.1-0.12 MV | ———— |
| 2 | QRS complex | Initial ventricular complex<br>Q wave is small negative<br>R wave is tall positive<br>S is small Negative | **Q**: Depolarization of the basal portion of IV septum<br>**R:** Depolarization of the apical portion of the IV septum<br>**S:** Depolarization of the basal portion of the basal portion near atrioventricular ring. | 0.08 to 0.10 | 0.3 | —— |

*Contd...*

*Contd...*

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | T-wave | Final ventricular complex | Repolarization of the ventricular musculature | 0.2 | 0.3 | —— |
| 4 | U-wave | Insignificant wave of ECG | Repolarization of the papillary muscle | —— | —— | —— |
| 5 | P-R interval | Onset of P wave to the onset of the Q wave | —————— | 0.18 (0.12 to 0.2) More than 0.2 is called AV nodal delay | —— | Atrial depolarization (Impulse from SA node to ventricles, Atrial muscle and AV node. |
| 6 | QRS Duration | Onset of Q wave to the End of S wave | ——————— | 0.08 to 0.10 sec | —— | Ventricular depolarization |
| 7 | Q-T interval | Onset of Q wave to the End of T wave | ——————— | 0.4 to 0.42 seconds | ——— | Ventricular depolarization, ventricular repolarization which signifies electrical activity in ventricles. |
| 8 | S-T segment | End of S wave to Onset of T wave | This is iso-electric | 0.08 seconds | —— | ——— |

## ECG Leads

The surface of the body is connected to the ECG machine by means of two electrodes called ECG leads.

These are of two types:

They are

a. Bipolar leads

b. Unipolar leads.

## Bipolar Leads

The electrodes are active and taken from two limbs. These are called Standard limb electrodes. Each lead has two electrodes. These are:

*Lead-I*

This is connected to right arm and left arm. Right arm is connected to the negative terminals of the instrument and the left arm is connected to the positive terminal.

*Lead-II*

This is connected left arm and left leg. The left arm is connected to the negative terminal of the instrument and the left leg is connected to the positive terminal.

*Lead-III*

This is connected to the left arm and the left leg. The left arm is connected to the negative terminal of the instrument and the left leg is connected to the positive terminal.

## Unipolar Leads

The active electrode is from one of the limbs. The indifferent electrode is obtained by connecting the other two limbs through a resistance. Unipolar leads are of three types. These leads are called augmented limb leads. These leads are:

### 1. avr

- Active electrode is from Right arm
- Indifferent electrode is from left arm and left leg.

### 2. avl

- Active electrode is from left arm
- Indifferent electrode is from right arm and left leg.

### 3. avf

- Active electrode is from left leg (foot)
- Indifferent electrode is obtained by connecting the two upper limbs.

### Unipolar Chest Leads

The indifferent electrode is obtained by connecting the three limbs– left arm, left leg, right arm through a resistance of 5000 ohms.The active electrodes is placed at six points over the chest are called V1, V2, V3, V4, V5 and V6. All the leads are arranged over intercostal space

V1: Near right sternal margin
V2: Near left sternal margin
V3: In between V2 and V4
V4: On the mi-clavicular line
V5 : On the anterior axillary line
V6 : On the mid-axillary line.

# Cardiac Surgery

CHAPTER 2

## CLOSED HEART SURGERY

The cardiac conditions requiring closed heart surgery are:

1. **Acquired Heart Disease**
   a. **Mitral stenosis**
   b. **Aortic stenosis**
2. **Congenital Heart Disease**
   a. **Patent ductus arteriosus**
   b. **Coarctation of aorta**

## ACQUIRED HEART DISEASE

### A. MITRAL STENOSIS

#### Definition

Mitral Stenosis is the narrowing of the Mitral valve opening and results in the reduced blood flow through the Mitral valve and backpressure into the chamber behind the valve.

#### Causes

1. Rheumatic heart disease
2. Lutembacher's syndrome (Acquired mitral stenosis + Atrial septal defect)

3. Atherosclerosis
4. Endomyocardial fibrosis
5. Hurters syndrome (Cardiomyopathy, mental retardation).

## PATHOLOGY

The obstruction to the left ventricular inflow resulting in a rise in pressure in the left atrium and pulmonary circulation. The pulmonary blood flow need a pressure gradient of 10 mm Hg between pulmonary arteries and veins. To maintain the pressure gradient the pressure will be above 20 mm Hg and vaso constriction occurs. This affects the muscular arteries of the lower lobe, which shows medial hypertrophy. The area of the Mitral valve is 5 cm square. In stenosis it is reduced to 1 cm Square. The pressure in the left atrium is about 6-12 mm of Hg. In stenosis to maintain adequate Cardiac output, the left atrial pressure increases to 30 mm or higher and the left atrial dilatation occurs results in pulmonary oedema, pulmonary hypertension, Right ventricular hypertrophy and failure and tricuspid regurgitation occurs.

### Types of Mitral Stenosis

1. *Leaf let type:* The valves are stiff, rigid and calcified.
2. *Commisural type:* The valves look like fusion of commisures.
3. *Chordae type:* The valves look like chordae and are thick.

### Clinical Features

1. *Pulmonary hypertension:* Dyspnoea, cough with frothy sputum, haemoptysis.
2. *Right heart failure:* Weakness, fatigue, oedema of feet.
3. *Atrial fibrillation:* Embolism, blindness, hemiparesis.
4. *Vulvular lesions:* Mitral regurgitation, aortic regurgitation and aortic stenosis.

### Complications

1. Pulmonary oedema
2. Right ventricular hypertrophy and failure

3. Tricuspid incompetence
4. Atrial fibrillation
5. Infections like subacute bacterial endocarditis, broncho-pulmonary infections
6. *Embolism:* Cerebral (Hemiplegia, aphasia), pulmonary and renal hypertension
7. Enlarged left atrium.

## INVESTIGATIONS

### X-ray Chest

1. Enlarged left atrium
2. Enlarged right ventricle
3. Enlarged pulmonary conus
4. Lung changes like pulmonary congestion, pulmonary oedema, pulmonary infarction, pulmonary venous hypertrophy.
5. Calcification of the Mitral valve.

### ECG

1. Early stage will be normal
2. Later stage: P wave will be absent.

### Echocardiogram

This is one of the most valuable investigations to diagnose and assess the severity of muscles.

### Diagnosis

1. Loud first heart sound is heard
2. Murmur heart in the mitral area
3. Backward displacement of the left ventricle by the enlarged right ventricle.
4. Diastolic heart murmur.

## Treatment

The treatment will be either of medical and surgical.

### Medical Treatment

In the mild cases or in the cases where surgery is contraindicated, treatment is by

1. Bedrest
2. Salt free diet
3. Diuretics like furosemide
4. Anticoagulants for embolism.

### Surgical Treatment

*Valvotomy*

a. *A closed valvotomy:* The procedure is an instrument is inserted through a ventricle, passed up through the mitral valve and dilated with in it.
b. *An open valvotomy:* The procedure is the heart is opened and the cusps of the valve mobilized under direct vision.

*Balloon Vuloplasty*

Transcutaneous balloon dilatation of stenosed valves is being done with good success in cases of noncalcified, mobile mitral valve, Pregnancy, when cardiac surgery is contraindicated in the older patients with severe valvular deformity.

*Advantages*

1. Avoids major surgery
2. The restenosed of the valve can be repeated.

## B. AORTIC STENOSIS

### Definition

Aortic stenosis is the narrowing of the opening of the aortic valve and results in reduced blood flow through the aortic valve and back pressure into the chamber behind the valve.

*Causes*

1. *Valvular stenosis:* Rheumatic fever, atheroscelerosis and congenital malformation.
2. *Subvalvular stenosis:* Congenital
3. *Supravalvular stenosis*

## Pathology

Obstruction to the left ventricular outflow in aortostenosis leads to left ventricular hypertrophy. Myocardial Ischaemia occurs without coronary artery lesions which, may lead to arrhythmias and sudden death. On exercise the increase in cardiac output is not possible due to the obstruction to the left ventricular outflow and symptoms like dyspnoea, angina and syncope are aggravated.

## Symptoms

1. Angina
2. Syncope
3. Exertional dyspnoea
4. Fatigue
5. Pulmonary oedema
6. Sudden death.

## Signs

1. Pallor: Pale, greyish white
2. Cerebral anaemia: Headache, faintness, giddiness, insomnia, irritability and depression.
3. Chest pain

## Diagnosis

1. *Pulse:* Raises slowly and falls slowly
2. *Blood pressure:* Low systolic pressure
3. Systolic murmur
4. Second heart sound is soft and absent.

## INVESTIGATIONS

### X-ray Chest

1. Normal in mild cases
2. Dilated ascending aorta
3. Aortic valve calcified
4. Left ventricular enlargement.

### ECG

1. ST-T changes occur
2. Arrhythmia occurs
3. Heart block or left bundle branch block is seen.

### Echocardiogram

1. Thickened, calcified and immobile aortic valve cusps
2. Left ventricular hypertrophy.

### Complications

1. Pulmonary oedema
2. Right ventricular hypertrophy and failure
3. Tricuspid incompetence
4. Atrial fibrillation
5. Infections like subacute bacterial endocarditis, broncho-pulmonary infections
6. *Embolism:* Cerebral (hemiplegia, aphasia), pulmonary and renal hypertension
7. Enlarged left atrium.

### Treatment

*Medical*

a. Avoid strenuous exertion and competitive sports
b. Rest and Beta-blockers–for angina.

*Surgical*

a. Balloon dilatation of aortic valve gives temporary relief from obstruction
b. Aortic valve replacement with a prosthetic or tissue valve should be one for every one with aorto stenosis.

## CONGENITAL HEART DISEASE

### A. PATENT DUCTUS ARTERIOSUS

#### Definition

The ductus arteriosus is a vessel which during fetal life connects the aorta with the pulmonary artery. Normally it closes with in a few hours of birth. When it remains open blood from the aorta flows through to the pulmonary artery resulting in two main effects.

1. Reduction of blood flow to the systemic circulation
2. Over filling of the pulmonary circulation.

#### Symptoms

The child will be prone to the—

1. Respiratory infections
2. Bacterial endocarditis
3. Dyspnoea
4. Angina.

#### Signs

1. The child is undersized
2. Heart failure if the duct is very large
3. Heavy apex beat
4. Mild diastolic Mitral flow, murmur may be heard.

#### Clinical Features

If the shunt is small then no symptoms are seen, when the ductus is large, growth development may be retarded. No disability in infancy but cardiac failure with dyspnoea may be the first symptom. The blood flow from aorta to pulmonary artery is 10-12 liters per minute.

### Investigations

*ECG*

a. Normal in infancy
b. Left ventricular and left atrial hypertrophy
c. Pulmonary hypertension associated with right ventricular hypertrophy
d. Prolonged PR interval.

*X-ray*

a. Left atrial and left ventricular hypertrophy
b. Calcified ductus

*Echocardiogram*

Demonstrates the patent ductus

*Colour Doppler*

Suggests the direction of the blood flow

### Complications

1. Pulmonary hypertension
2. Infective endocarditis
3. Congestive cardiac failure.

### Contraindications for the Surgery

1. Transposition of great vessels
2. Tricuspid or pulmonary atresive
3. Infective endocarditis
4. Congestive cardiac failure.

## Treatment

*Surgical Treatment*

Surgery is performed to remove the restricted portion and either sewn together or put in a Dacron graft.

## B. COARCTATION OF AORTA

### Definition

Constriction of the aorta is called the coarctation of the aorta.

### Types of Coarctation

1. Preductal or infantile
2. Post ductal or adult or juxtaductular
3. Pseudo coarctation.

### Causes

The common site of the constriction is just distal to the origin of the left subclavian artery and the constriction is in the upper region of the ductus.

### Sex

More common in males

### Symptoms

1. Usually no symptoms are seen.
2. Symptoms may occur due to the hypertension like headache
3. Intermittent claudication and coldness of feet occur
4. Shoulder pains due to the dilated collaterals.

### Signs

1. Upper part of the body may be well developed and lower limbs are under developed.
2. Left ventricular hypertrophy is seen.
3. Continuous murmur are heard.

## Investigations

1. *X-ray:* Docks sign: Rib notching due to the dilated collateral are seen.
2. *ECG:*
   a. *Infants:* The ECG will be normal
   b. *Adults:* The left ventricular Hypertrophy and left atrial enlargement occurs
3. *Echocardiography and colour Doppler:* Delineate the coarct
4. *Digital subtraction angiograph:* Delineate the coarct and distinguish real from pseudo coarct.

## Diagnosis

1. Left arm is under developed
2. Left radial pulse is weak
3. Rib notching on the right side only occurs.

## Associated Anomalies

1. Patent ductus arteriosus
2. Ventricular septal defect
3. Bicuspid aortic valve defect
4. Congenital aortic stenosis

## Complications

1. Infective endocarditis
2 Congestive cardiac failure
3. Hypertension and its complications
4. Subarchnoid hemorrhage
5. Aortic rupture
6. Premature coronary artery disease.

## Treatment

### *Medical*

1. Sedation
2. Antihypertensives

3. Prophylaxis for infective endocarditis
4. Treatment for Left ventricular hypertrophy.

*Surgical*

Between five and twenty years of age:
1. Balloon angioplasty (Dilatation of the coarctation)
2. Dacron or Teflon graft and end-to-end anastomosis
3. Aortic valve repair
4. Restrict energetic activities for six months postoperatively
5. Postsurgical Hypertension is common
6. Follow-up for premature coronary artery disease.

The cardiac conditions requiring open heart surgery and briefly describe the following:

### Congenital Conditions

a. Atrial septal defect
b. Ventricular septal defect
c. Pulmonary stenosis
d. Tetralogy of fallot
e. Transposition of great vessels
f. AV malformation.

### Acquired Conditions

a. Mitral stenosis
b. Mitral regurgitation
c. Aortic stenosis
d. Aortic regurgitation
e. Coronary artery disease.

## OPEN HEART SURGERY CONDITIONS

The following are the cardiac conditions requiring Open Heart Surgery

1. Congenital conditions
   a. Atrial septal defect

b. Ventricular septal defect
c. Pulmonary stenosis
d. Tetralogy of fallot
e. Transposition of great vessels
f. AV Malformation.

2. Acquired conditions
a. Mitral stenosis
b. Mitral regurgitation
c. Aortic stenosis
d. Aortic regurgitation
e. Coronary artery disease.

## Associated Lesions

1. Pulmonary stenosis
2. Mitral stenosis.

## Complications

1. Pulmonary hypertension
2. Infective endocarditis
3. Eisenmengers complex (Pulmonary hypertension).

## Treatment

### *Surgical Treatment*

*Indications*

1. *Pulmonary:* systemic blood flow greater than 1.5 : 1.
2. *Pulmonary:* systemic valvular resistance < 0.7 :1.

## Contraindications

1. Small defects
2. Pulmoary hypertension
3. Associated malformations
4. Coronary artery disease.

### Management

Operative repair by closure of the atrial septal defect by implantable closure devices by cardio pulmonary bypass.

## CONGENITAL

### ATRIAL SEPTAL DEFECT

### Definition

The opening in the inter atrial septum or hole in the heart due to the deficiency in the septal tissue because of which blood passes between the two sides of the Heart is called Atrial septal defect. This is the most common form of the Congenital Heart defect.

### Types

1. Fossa ovalis defect
2. Sinus venosus defect
3. Partial atrioventricular canal defect
4. Coronary sinus defects.

*Aetiology:* Sex: Female

### Signs and Symptoms

Children with moderate defects often do not develop signs and symptoms until late teens. The chief signs and symptoms are:

1. Failure to thrive
2. Tendency to develop chest infections
3. Untreated patients develop pulmonary hypertension in their late twenties to thirties.

### Clinical Features

1. Dyspnoea
2. Chest infections
3. Cardiac failure
4. Arrhythmias.

### Investigations

*X-ray*

1. Dilatation of the pulmonary arteries
2. Enlargement of the heart
3. Right ventricular and right atrial hypertrophy.

*ECG*

1. Right ventricular hypertrophy
2. Right atrial hypertrophy
3. Right bundle branch block
4. Atrial fibrillation.

*Echocardiogram shows defects in the septum.*

### Diagnosis

1. Right ventricular hypertrophy
2. Wide fixed split of second heart sound
3. Systolic murmur on pulmonary ejection and mid-diastolic murmur on tricuspid flow.
4. Pulmonary hypertension.

## VENTRICULAR SEPTAL DEFECT

### Definition

The opening in the ventricular septum that leads to the contact between the two ventricles is called Ventricular Septal Defect.

### Sites

1. Membranous portion
2. Muscular portion
3. Infundubular portion.

### Causes

1. Pulmonary atresia
2. Tricuspid atresia

3. Transposition of the Great vessels
4. Pulmonary stenosis
5. Patent ductus arteriosus
6. Atrial septal defect
7. Coarctation of aorta
8. Mitral valve deformities like mitral stenosis and Mitral incompetence.

## Clinical Features

1. Pan systolic murmur is heard at the left sternal edge.
2. A small defect produces a loud murmur
3. A large defect produces a softer murmur.

## Investigations

*X-ray*

1. Normal
2. Pulmonary plethora
3. Cardiomegaly
4. Biventricular hypertrophy.

*ECG*

1. Normal
2. Biventricular hypertrophy
3. Right bundle branch block.

*Echocardiogram with Doppler*

Shows the ventricular septal defect and associated anomalies.

## Associated Lesions

1. Aortic regurgitation
2. Complete heart block
3. Infective endocarditis
4. Eisenmenger's complex.

### Diagnosis

1. Recurrent respiratory infections of childhood a failure to thrive.
2. Moderately collapsing pulse
3. Biventricular hypertrophy
4. Pansystolic murmur.

### Complications

1. Complete heart block
2. Infective endocarditis on the right ventricular side
3. Pulmonary embolism
4. Lung abscess
5. Pulmonary hypertension.

### Management

*Treatment*

30-50 % close spontaneously if it is muscular or membranous.

*Indication*

1. Failure to thrive
2. Large defect less than 1cm
3. Left to right shunt
4. Cardiomegaly
5. Right systolic pressure less than 65%
6. Pulmonary to systemic blood flow ratio is greater than 1.5:1
7. Pulmonary to systemic vascular resistance is less than 0.5:1.

### Contraindications

*Eisenmenger's Syndrome*

*Prognosis:* This is good in congenital ventricular septal defect, except Eisenmenger's syndrome. Most patients with this syndrome die with in 2nd or 3rd decade. So heart lung transplantation is done. Few survive without transplantation till 5th decade.

*Surgical treatment:* Suturing apatch of Dacron or pericardium closes Closure of the ventricular septal defect by cardiopulmonary bypass. The defect. Mortality rate is about 10%.

## PULMONARY STENOSIS

### Definition

Pulmonary stenosis is the narrowing of the pulmonary valve resulting in diminished blood flow to the pulmonary circulation. This is the congenital condition.

### Aetiology

1. Congenital
2. Carcinoid syndrome
3. Associated with Fallots tetralogy.

### Signs and Symptoms

1. Dyspnoea
2. Cyanosis
3. Fatigue.

### Clinical Features

1. Loud harsh murmur
2. Right heart failure
3. Right ventricular hypertrophy
4. Right ventricular dilatation.

### Investigations

*X-ray* Prominent pulmonary artery

*ECG* Right atrial and right ventricular hypertrophy.

*Echocardiogram* abnormal pulmonary vein, Pulmonar y valve thickening.

*Cardiac catheterization:* Elevated right ventricular systolic pressure with low pressure in pulmonary artery.

### Complications

1. Atrial fibrillation
2. Infective endocarditis.

### Treatment

Pulmonary valvotomy

## TETRALOGY OF FALLOT

### Definition

The condition which consist of the pulmonary stenosis, ventricular septal defect, dextra position of the aorta and hypertrophy of the right ventricle is called Tetralogy of Fallot.

### Aetiology

Abnormal development of the bulbar septum which separates the ascending aorta from the pulmonary artery.

### Clinical Features

1. Cyanosed
2. Apnoeic and unconscious are called Fallots spells.

### Signs

1. Clubbing of fingers or toes
2. Stunting of growth
3. Polycythaemia

### Symptoms

*Cyanosis*

The cyanosis is due to the venous blood entering the left ventricle through the septal defect and entering the aorta from the right ventricle and circulating in the systemic arterial circulation.

### *Syncope*

The syncope is due to the cerebral anoxia during the emotional upsets.

### *Squatting*

The child tends to adopt a squatting position. This compresses the abdominal aorta and femoral arteries and raises the resistance in the systemic circulation which decreases the shunt of blood from right to left through the septal defect.

### *Dyspnoea on Exertion*

On exertion the oxygen content of the blood gets diminished in the systemic circulation.

## Investigations

*X-ray:* Dilatation of pulmonary arteries, boot shaped heart

ECG Right Ventricular Hypertrophy

*Echocardiogram* Aorta is not continuous with Atrio-ventricular septum.

## Treatment

The treatment is of two types:

### *The Pallative Treatment*

The treatment is from age of few weeks to the five years. Blalock-Taussig operation that connects a subclavian artery to the pulmonary artery.

### *Curative Treatment*

This is for the age group of 5 years to 10 years. The septal defect is repaired, the pulmonary stenosis is released.

### Prognosis

The prognosis is good.

### Follow up

1. To identify pulmonary stenosis.
2. Recurrence of the septal defect.

## TRANSPOSITION OF THE GREAT VESSELS

### Definition

The aorta and the pulmonary arteries are reversed so that the venous blood circulates round the body and oxygenated blood circulates round the lungs.

### Types

1. With intact ventricular septum
2. With ventricular septum defect

### Clinical Features

1. Congestive cardiac failure by 4 to 10 weeks of age
2. Increase in the left atrial pressure
3. Pulmonary venous hypertension
4. Ventricular septal defect
5. Pulmonary vascular obstructive disease
6. Cyanosis
7. Hypoxaemia in the first week of life
8. Heart enlargement by 2 weeks

### Investigations

ECG *Biventricular hypertrophy*

*Treatment:* By 6 to 12 weeks of age the balloon atrial septostomy by cardiac catheterization and angiocardiography.

## AV-MALFORMATION OR ARTERIO- VENOUS MALFORMATION

### Definition

The malformation that occurs in the systemic or pulmonary circulation is called Arterio-venous malformation.

### Types

1. Single
2. Multiple

### Location

Brain, Neck, limbs, Thoracic wall, Heart and liver.

### Clinical Features

1. Prominent pulsations on inspection of the neck
2. Hepatomegaly if liver site
3. Intracranial bleeding
4. Epilepsy because of parietal lesion
5. Progressive neurological deficits cause Hemiparesis
6. Headache.

### Investigations

1. *Echocardiogram:* Heart failure with structurally normal heart
2. Angiograph
3. Cerebral or abdominal ultrasonography
4. MRI.

# ACQUIRED

## MITRAL STENOSIS

See page 69

## MITRAL REGURGITATION

### Definition

The regurgitation or incompetence is the valve which does not fully close when the chamber receives blood through the valve the blood goes back to chamber.

### Aetiology

1. Rheumatic fever
2. Aortic valve disease
3. Ischaemic heart disease
4. Cardiomyopathy
5. Myocarditis
6. Mitral valve prolapse
7. Infective endocarditis
8. Damage to papillary muscle
9. Endomyocardial fibrosis
10. Congenital
11. Myocardial infarction.

### Pathology

When the left ventricle contracts, most of the blood goes into the aorta but some regurgitates back through the partially open valve. Less blood reaches the systemic circulation. There will be gradual dilatation of left atrium, Breathlessness and pulmonary oedema, Left atrial pressure increases and over load occurs.

### Signs and Symptoms

1. Cyanosis
2. Dyspnoea
3. Cough and haemoptysis
4. Oedema in ankles, feet and abdominal area.

### Investigations

*X-ray*

1. Enlarged left atrium, left ventricle
2. Pulmonary venous hypertension
3. Pulmonary oedema.

*ECG*

Left atrial and ventricular hypertrophy.

*Echocardiogram*

Dilated left atrial and left ventricle
*Doppler's effect:* Detects regurgitation

### Cardiac Catheterization

1. Dilated left atrium, left ventricle
2. Mitral regurgitation
3. Pulmonary hypertension
4. Coronary artery disease.

### Diagnosis

1. Water hammer pulse (Low collapsing pulse)
2. Loud third heart sound
3. Systolic murmur
4. Pulmonary hypertension
5. First heart sound is weak.

### Complications

1. Embolus formation occurs, enters aorta then coronary artery and leads to occlusion.
2. Carotid artery embolism causes obstruction of the cerebral circulation leads to hemiplegia.

### Treatment

*Medical Treatment*

1. Dieuretics
2. Vasodilators
3. Anticoagulants
4. Antibiotics
5. Regular review.

*Surgical Treatment*

*Indication:* Deterioration of left ventricular function

### Procedure

The mitral valve repair or replacement is done under cardio-pulmonary bypass valve, papillary muscle and chordae are totally removed. A prosthetic valve in the form of Starr–Edward ball –valve or disc valve of Bjork is sutured with the rim of the original valve with mattress sutures.

### Postoperative Complications

Thromboembolism

### Treatment

Anti-coagulant therapy.

## AORTIC STENOSIS

See page 72

## AORTIC REGURGITATION

### Definition

The Aortic regurgitation is the incompetence of the aortic valve which does not fully lose when the chamber receives blood through the valve the blood goes back to the chamber.

### Causes

1. Rheumatic fever
2. Syphilis
3. Infective endocarditis
4. Congenital disorders e.g.: Bicuspid aortic valve
5. Conective tissue disorders e.g.: Rheumatoid arthritis
6. Hypertension
7. Trauma.

### Pathology

The blood flows back through the valve into the left ventricle. Blood pressure falls because of the reduced volume. The left ventricle dilates then Hypertrophies.

### Signs and Symptoms

1. Pallor
2. Cerebral anoxia.

### Complications

1. Pulmonary oedema
2. Right ventricular hypertrophy and failure
3. Tricuspid incompetence
4. Atrial fibrillation
5. Infections like subacute bacterial endocarditis, broncho-pulmonary infections
6. *Embolism:* Cerebral (Hemiplegia, aphasia), pulmonary and renal hypertension
7. Enlarged left atrium.

### Investigations

*X-ray*

1. Cardiac dilatation
2. Left heart failure.

*ECG*

1. Left ventricular hypertrophy
2. T-wave inversion.

*Echocardiogram*

Dilated left ventricle
*Doppler effect:* Pressure gradient can be detected.

### Diagnosis

1. Diastolic murmur
2. Left ventricular failure
3. Water hammer pulse.

### Management

*Medical*

1. Endocarditis
2. Syphilis
3. Vasodilator to prevent progressive left ventricular dilatation.

*Surgical*

Aortic valve replacement or repair.

### Indications

1. Cardiac failure
2. Cariomeghaly
3. Deterioration of the left ventricular function.

## CORONARY ARTERY DISEASE OR ISCHAEMIC HEART DISEASE

### Definition

Coronary artery disease is a condition where the coronary blood flow is insufficient for the needs of the heart or Ischaemic heart disease occurs whenever there is an imbalance between myocardial oxygen demand and its supply.

*Sex:* Males are more prone than females

*Age:* Above 45 years are more vulnerable

*Site:* The most common site is left coronary artery.

## Aetiology

1. Atherosclerosis
2. Coronary artery spasm
3. Embolism
4. A-V malformation
5. Aortic stenosis
6. Aortic regurgitation
7. Mitral valve prolapse
8. Cardiomyopathy
9. Collagen disease
10. Syphilis
11. Anaemia
12. Beri-beri disease.

## Signs and Symptoms

### *Pain*

a. *Angina pectoris:* Pain spreads across anterior chest wall radiates to arms due to lack of blood supply leading to accumulation of metabolites stimulates nerve ending of myocardium.
b. *Myocardial infarction:* Pain is more severe and long-lasting.

### *Dyspnoea*

Breathlessness, Pulmonary oedema, Anoxia of the tissue

### *Alteration of Skin Colour*

a. *Bluish:* The colour is because of Peripheral cyanosis decreases cardiac output.
b. *Grey and white:* The colour is because of poor arterial supply.

### *Clamminess and Sweating*

Palms and face because of sympathetic nervous system reaction.

### *Decreased Blood Pressure*

This decreases cardiac output.

### *Altered Pulse*

a. *Tachycardia:* Heart rate is increased
b. *Bradycardia:* Heart rate is decreased
c. *Heart block:* 40 beats per minute.

### *Pyrexia*

The increase of temperature for one or two days after occlusion leading to infarction. This is due to necrosis of myocardium.

### *Pericardial Rub*

The inflammation of the pericardium causes a sound is heard through a stethoscope called pericardial rub.

### *Oedema*

Heart failure leads to excess tissue fluid cause oedema in feet and ankles because of retention of sodium and water by the kidneys.

### *Haemoptysis*

Coughing of the blood because of rupture of the pulmonary vessel.

### *Cerebral Symptoms*

a. *Cardiac syncope:* Reduction of blood supply to the brain cause loss of consciousness.
b. *Cerebral anoxia:* This causes faintness, giddiness, depression and irritability.

*Abdominal Symptoms*

Nausea, indigestion and constipation are caused due to venous congestion anoxia and lack of arterial supply to the abdominal organs.

*Altered Blood Gases*

Sluggish flow of blood causes decrease in exchange of gases in pulmonary circulation and increase in systemic circulation.

*Cardiac Asthma*

This occurs in night. Patients will be suffocating, coughs, frothy and pink sputum because of left ventricular failure produces pulmonary congestion leads to pulmonary oedema.

## Clinical Features

1. Angina
2. Acute myocardial infarction
3. Ischaemic cardiomyopathy
4. Cardiac arrest
5. Sudden cardiac death
6. Silent ischaemia.

## Pathology

*Sudden Occlusion*

If a large embolus or a thrombus blocks the left coronary artery, the myocardium of the left ventricle cannot pump blood with an adequate force to maintain the systemic circulation. The inadequate blood supply to the brain and the vital centers in the brain stem leads to unconsciousness and death.

*Gradual Occlusion*

The collateral circulation is established or the heart muscle may be hypertrophied.

## Complications

### *Disorders of the Cardiac Rhythm*

Disruption of the smooth transmission of contraction through atrial and ventricular muscles and produce arrhythmias.

### *Heart Block*

Coronary arteries supply the inter-ventricular septum. Infarction occurs at this site causes partially or complete interruption of impulses, so the disruption of impulse transmission is called heart block. SA node is impaired so ventricles and atria function independently.

### *Heart Rupture*

The severe infarct replaces muscle by fibrous tissue and get ruptured by pressure of the blood by two weeks called heart rupture.

## ANGINA PECTORIS

### Types

### *Stable Angina*

The predisposing actors are physical effort, cold weather, smoking, emotional upset, high altitude, sexual intercourse, straining at stool, etc.

*Treatment:* Rest, nitrates.

*Nocturnal angina:* This occurs in the middle of the night due to the left ventricular failure. The predisposing factors are dreams that cause release of the catecholamines, full bladder, hypoglycemia.

### *Unstable Angina*

This is also called as preinfarction angina. The predisposing actors are recent angina less than 60 degrees, stable angina with severe symptoms, angina at rest, angina following myocardial infarction.

*Prinzmetal Angina*

The causes for this are coronary spasm, smoking, platelet aggregation beta-blockers.

*Post Infarction Angina*

This occurs after 2 days to 8 weeks of the myocardial infarction.

## CARDIAC FAILURE

### Acute Cardiac Failure

The sudden inability of the heart to maintain an adequate circulation is called acute cardiac failure.

*Causes*

a. Main artery occlusion
b. Decreased blood pressure
c. Reduced peripheral resistance
d. Hemorrhage.

### Chronic Cardiac Failure

The left coronary artery disease causes left ventricular function diminishes, left ventricular failure and congestion in the pulmonary circulation. The back pressure occurs in right ventricle, right atrium and congestion in systemic circulation, causes decrease nutrition to tissues, oedema in lungs, feet and ankles.

### Congestive Cardiac Failure

Failure in the both ventricles. First in the left ventricle followed by the right ventricular failure causes congestive cardiac failure.

### Risk Factors

1. Hypertension
2. Cigarette smoking
3. High serum cholesterol
4. Obesity

5. Anxiety, stress
6. Heredity
7. Life style
8. Occupation
9. Lack of regular exercise
10. Diabetes mellitus.

### Diagnosis

a. *ECG:* ST segment depression or elevation

b. *Stress testing:* Done on treadmill or bicycle ergometer. The work load increased till ECG change occur with symptom like pain, fatigue and dyspnoea.

c. *Thallium stress test:* This test is done by injecting thallium while the patient exercises. Thallium is picked up only by normal myocardium ischaemic areas would appear as perfusion defects.

d. *Echocardiography and Doppler effect:* Left ventricular thrombus and mitral regurgitation.

e. *Coronary Angiogram:* Diagnose blockage coronary arteries, its location ad severity.

### Prevention

Reducing the risk factors like stop smoking, lose weight, reduce animal fat intake, decrease egg consumption advised regular, moderate exercise and to reduce work related stress.

### Management

*Conservative*

a. Rest in bed in coronary care unit for two days to reduce the work of the heart.
b. Drugs like analgesics (Morphine), sedatives (Pethidine), anticoagulants (Heparin), Defibrillating (Lignocaine), Diuretics, vasodilators, antiarrhythmia and a light diet.

*Surgical*

a. Pace maker
b. Coronary artery bypass graft (Saphenous vein as graft)
c. Heart transplant.

## PHYSIOTHERAPY REHABILITATION PROGRAMME FOR THE CARDIAC REHABILITATION PROGRAMME

Physiotherapy plays an important role in the cardiac surgery patient before and after the surgery. The physiotherapy cardiac rehabilitation programme is suggested according to the requirement of the individual specific needs. Few of the factors are considered before exercise programme is prescribed like:

a. Age
b. Occupation
c. Precious history of the patient
d. Mental status of the patient
e. Severity of the disease.

The physiotherapy rehabilitation programme is divided into two subdivisions:

a. Preoperative physiotherapy
b. Postoperative physiotherapy.

### Preoperative Physiotherapy

The preoperative physiotherapy programme is started as soon as patient is admitted one week prior to the surgery so that the patient can meet the medical team including physiotherapist, all the tests are conducted thoroughly. During this period the role of physiotherapy is:

**Aims and Plans of Preoperative Physiotherapy are:**

| *S. no* | *Aims of Physiotherapy* | *Goals of Physiotherapy* |
|---|---|---|
| 1 | To improve breathing efficiency | Breathing exercises are taught |
| 2 | To ensure clear lung fields | Shaking, clapping, postural drainage and intermittent positive pressure breathing are taught |
| 3 | To teach effective coughing and huffing | Coughing and huffing techniques are taught |

*Contd...*

*Contd...*

| | |
|---|---|
| 4 To teach correct technique of supporting the incision site | Using bed sheet and pillow |
| 5 To prevent deep vein thrombosis | Ankle and toe movements are taught |
| 6 To maintain the range of motion of upper limb | Shoulder girdle, shoulder elbow hand exercises are taught |
| 7 To teach postural awareness | Position sense training by shoulders are at level, weight equally taken on both the buttocks |
| 8 To teach turning in bed, sitting, standing and walking | Turning from supine lying to side-lying to sitting in bed and out of bed to standing and walking are taught |

## Postoperative Physiotherapy Management

The patient after under going cardiac surgery will be in the intensive care unit for the first 48 hours after the surgery under supervision to deal with the emergency situation. Physiotherapy is started once the patient is stable.

### Aims and Plans of Postoperative Physiotherapy are:

| *S. no.* | *Aims of Physiotherapy* | *Plans of Physiotherapy* |
|---|---|---|
| 1 | To prevent deep vein thrombosis for about 48 hours to two weeks | Ankle and toe movements should be done |
| 2 | To maintain clear airway | Breathing exercises |
| 3 | To maintain good posture | Position sense training by shoulders are at level, weight equally taken on both the buttocks |
| 4 | To maintain mobility of shoulder, neck and trunk and legs | Shoulder and shoulder girdle exercises, neck exercises, trunk exercises and lower limb exercises like hip, knee and foot exercises |
| 5 | To restore the patient confidence | Psychological counseling |
| 6 | To increase the patient exercise tolerance | Sets of exercises with frequent repetition and relaxation periods |
| 7 | To teach patient the home exercise programme | Complete rehabilitation programme includes diet management, regular walking and exercises. |

## Postoperative Physiotherapy

The physiotherapist must start with the rehabilitation programme immediately after the surgery. The programme is as follows:

*Day of Operation*

1. Regular monitoring of the temperature, blood pressure, ECG, pulse rate, respiratory rate and administration of the drugs are done.
2. The physiotherapist helps the patient to sit in half lying position. The incision is supported by the patient with a pillow and is encouraged to take deep breaths three times and
3. The patient is asked to try huffing at least once or twice
4. The patient head and trunk are fully supported with pillows.

*Day 1*

1. Breathing exercises
2. Coughing and huffing
3. Position sense training
4. Relaxation
5. Elevation of arm on the operated side and if Incision is medial sternotomy elevation of bilateral arms
6. Ankle and toe movements
7. Hip and knee bending and stretching.

*Day 2*

1. Same as day one followed by:
2. A rope tied to end of the bed and patient is trained to sit up himself
3. Practice elevation of arm on oeperated side and if the incision is medial sternotomy then bilateral shoulder movements are prescribed.

*Day 3*

1. The patient is shifted to the cardio-thoracic unit
2. Breathing exercises
3. Huffing
4. Arm and trunk exercises
5. Short walk with in ward
6. Posture correction and arm swinging exercises during walking.

*Day 4*

1. Patient goes to the toilet independently on his own
2. Chest expansion exercises are taught
3. Group therapy with other patients in the ward are taught arm, trunk, leg exercises.

*Day 5-14*

1. By 5-7 days patient should ascend stairs of about 8-10
2. Exercise programme.

*Before discharge:* The patient should be confident of his ability to cope his situation at his own.

*Home Programme*

1. Breathing exercise
2. Thoracic expansion exercise
3. Walking
4. Activities of daily living
5. Return to work
6. Follow up.

# Thoracic Surgery

CHAPTER 3

## FRACTURE RIBS

### Definition

The break in continuity of the rib bone is called fracture ribs.

### Cause

Direct violence

### Clinical Features

1. Pain
2. Cough
3. Inhibit deep breathing.

### Complications

1. Chronicbronchitis
2. Associated injury, e.g: Kidney and spleen with lower rib fracture
3. Pneumothorax
4. Haemothorax
5. Damage to air passage
6. Pneumonia.

### Diagnosis

1. *Radiograph:* This shows the level of the fracture.

### Treatment

#### *Medical*

Analgesics for the pain relief for Intercostal nerve block.

#### *Physiotherapy*

Breathing exercises are taught to the patient.

## FLAIL CHEST

### Definition

Flail chest involves multiple rib fractures broken anteriorly and posteriorly so that segment of the chest wall will be floating.

### Clinical Features

1. Involved segment of the chest wall will be floating.
2. Segment is sucked in during inspiration and driven out during expiration so breathing is called paradoxical breathing.
3. One side of the heart will be moving in while the other side moves out.

### Signs and Symptoms

1. Hypoxia
2. Restriction in breathing
3. Severe pain
4. *Paradoxical Respiration:* The sucked in segment during inspiration compresses the homolateral lung and drives out the air from it into the contralateral lung. This reverses during expiration called paradoxical respiration and results in high degree of carbon dioxide retention.

### Treatment

1. Immediate hospitalization of these patients
2. Relaxant drug is administered

3. Endotracheal tube is introduced
4. Intrapleural drains are given
5. Positive pressure respiration is started
6. Bronchial toilet may be required through bronchoscopy
7. 10-14 days are required for union of fractured ribs
8. Tracheostoly is performed. This is internal pneumatic fixation and is capable of managing many patients with this injury
9. Patient should be under prolonged period of mechanical ventilation
10. So old technique of operative fixation is preferred.
11. A long curved incision is made over the affected side and the pleural pace is entered by stripping the upper border of one of the ribs.
12. The bleeding from Intercostal or internal mammary artery should be secured.
13. The flail segment are stabilized by inserting Kirchners wires or short rush nails through the meduallary cavities of the ribs. Additional fixation by stout sutures through the Intercostal muscles. Finally thoracotomy is closed with tube drainage of the pleural cavity.

## STOVE IN CHEST

### Definition

This is the condition with the multiple injuries to the ribs.

### Complications

1. Contusion
2. Laceration of lung
3. Penetration of the pleural cavity
4. Injury to the air passages increases.

*Care:* Watch on air or blood in the pleura and mediastinal shift should taken care.

### Diagnosis

1. Repeated radiographs
2. Blood gas analysis.

## PNEUMOTHORAX

### Definition

The air present in the pleural cavity is called pneumothorax.

### Causes

1. Lung laceration of a fracture rib.

### Clinical Features

1. The air escapes from the broncho-pulmonary tree into the pleural cavity
2. The air in the pleural cavity will compress on the lung and produce difficulty in proper aeration.

### Complications

Surgical emphysema associated when air may escape into the subcutaneous tissue on the chest to produce crepitus.

### Types

1. Closed Pneumothorax
2. Open Pneumothorax
3. Tension Pneumothorax
4. Spontaneous Pneumothorax
5. Chronic Pneumothorax.

## CLOSED PNEUMOTHORAX

The condition where the air comes out of the lung to enter the pleural cavity and no more air enters as the lung tissue is closed is called closed Pneumothorax.

### Causes

Contusion of the lung by fractured ribs.

### Clinical Features

Closed Pneumothorax is absorbed and lungs reexpand. The time required for the normal resorption depends on size of the Pneumothorax.

### Treatment

1. Air evacuated from the pleural cavity by direct aspiration.
2. Pushing an Intercostal tube through the second Intercostal space anteriorly.

## OPEN PNEUMOTHORAX

### Definition

This is the condition where air enters into the pleural cavity through a penetrating wound in the chest wall.

### Clinical Features

The negative pressure in the pleural cavity will draw more air from outside, which will prevent proper aeration of the lung. Seriousness depends on the size of the opening. If it is bigger than trachea, the lung completely collapses as air is coming in through the wound than through the trachea.

### Diagnosis

Listening to the second of air being sucked in and by the discharge of frothy blood from the wound.

### Treatment

Closure of the wound in the chest wall.

### Procedure

This is done by a piece of gauze covered with elastoplast or with one or two skin stitches. Later proper exploration of the wound and debridement should be carried out. Thoracotomy incision through the wound of the chest wall is done if required.

## TENSION PNEUMOTHORAX

### Definition

Air enters the pleural cavity through a rent in the lung tissue.

### Clinical Features

Air enters the pleural cavity during inspiration and exit is prevented during expiration. So the volume of air is increased gradually in the pleural cavity cause or produce collapse of the lungs and a shift of the mediastinum to the opposite side.

### Treatment

Immediate intervention as the condition is fatal. A wide bore needle is inserted through the second Intercostal space of the pleural cavity one and half inches lateral to the sternum to avoid injury to the internal mammary artery. Later replaced by water-seal drainage if leakage present after five days a thoracotomy is done.

## SPONTANEOUS PNEUMOTHORAX

### Definition

This is the condition due to rupture of a bullous cyst.

### Cause

1. Congenital
2. Emphysematous
3. Tuberculous
4. Heavy weight lifting
5. Muscular strain.

*Onset:* Sudden.

### Clinical Features

1. Chest pain
2. Sensation of compression.

### Treatment

*Mild Cases*

Pneumothorax is gradually absorbed. If Pneumothorax persists an Intercostal tube may be inserted.

*Surgical Treatment*

*Indication:* 3 or 4 recurrent attacks of Pneumothorax on the same side. If the other lung has already been involved the surgery is urgently advised for fear of bilateral Pneumothorax.

*Procedure:* Postero-lateral thoracotomy the bleeding is controlled by hot packs. The lung is properly inspected to determine the site of air leak. A large cyst should be unroofed and sutured. The chest wall is closed with under water seal drainage.

## CHRONIC PNEUMOTHORAX

This is also called as persistent or recurrence of Pneumothorax.

### Treatment

A thoracotomy is performed and partial pleurectomy is done, so that the visceral pleura will adhere to the chest wall obliterating the pleural space. If broncho-pleural fistula is noticed, it should be sutured. The thoracotomy wound is closed with underwater seal drainage.

## HAEMOTHORAX

### Definition

Accumulation of blood in the pleural space is called Haemothorax.

### Causes

1. *Chest trauma.* The sources of bleeding are Intercostal vessels, internal thoracic vessels, lung parenchyma, bronchial arteries, Major pulmonary vessels, heart or great vessels.
2. Blunt or penetrating injury associated with rib fractures.
3. *Iatrogenic:* Postoperative thoracotomy by injury to inferior pulmonary ligament vessels, chest-wall adhesions, Bronchial vessels or Intercostal vessels, Thoracentesis, laceration of intercostal vessels, Needle lung biopsy, Core biopsy techniques, Pulmonary vessels or tumour may bleed.
4. *Spontaneous pneumothorax:* Tear of a vascular adhesions.
5. *Pulmonary embolus:* Bleeding occurs following pulmonary infarction.
6. Tuberculosis
7. *Neoplasm:* Lung carcinoma with pleural or chest-wall invasion, Metastatic lung or pleural disease, Mesothelioma.

### Diagnosis

This depends on the type, location and extent of the injury need to be considered. Physical signs suggest pleural-fluid, Confirmation by X-rays, Upright and lateral view, Thoracentesis.

### Management

1. *General:* Airway is maintained, placement of appropriate monitoring lines, IV access. Blood should be sent for group and cross match, Haematocrit analysis and associated injury.

#### *Specific*

Placement of chest tube at the 5th or 6th Intercostal space. Thoracotomy is required if the initial chest tube output is >1500 ml blood with hypotension, ongoing chest tube output is > 300 ml / hour or 3 hours. If drainage is inadequate thoracotomy is required to manage associated intrathoracic injuries or pathology.

### Complications

1. Empyema
2. Fibrothorax with trapped lung.

### Treatment

1. Thoracotomy and drainage
2. If fibrothorax leads to decortication.

## HAEMOPNEUMOTHORAX

### Definition

The presence of blood and air with in the pleural cavity is called haemopneumothorax. This is a complication of the thoracic injuries.

### Clinical Features

1. Breathing problems
2. *Infection*: If not treated or removed a deposition of organized fibrin will prevent proper expansion of the lung. The bleeding occurs from laceration of the lung, surface, damage to the intercostal artery or rupture of an intra-pleural adhesion.

### Complications

Pneumothorax

### Treatment

Transfusion to restore blood volume, aspiration of blood from the pleural cavity requires sedation of the patient. Tube drainage is indicated at 7th or 8th intercostal space on the midaxillary line, second tube is inserted at 2nd intercostal space. Both connected to an underwater seal drainage, if patient does not respond to this treatment thoracotomy should be carried out.

### Indications

If bleeding continues then it is a internal haemorrhage or if bleeding occurs 200 ml of blood per hour through the intercostal tube, it is a large haemothorax.

### Procedure

The surgery is performed with endotracheal anaesthesia combined with muscle relaxants. The incision through 5th or 6th intercostal space is done and chest is opened. The pleural cavity is cleared off blood fibrin. A dense envelope that covers the lung, which does not allow the lung to inflate is carefully dissected and lung will start to reexpand. Chest is closed with water sealed bottle drainage connected. Drainage is continued till radiograph shows the lung to be fully expanded.

## LUNG CONTUSION AND LACERATION

Lung is the intrathoracic organ and most commonly injured.

### Causes

1. Pneumothorax
2. Haemothorax
3. Pulmonary contusion
4. Pulmonary haematoma
5. Systemic air emboli
6. Acute respiratory distress syndrome.

### Complications

1. Continued haemothorax of more than 1500 ml.
2. Massive air leak
3. Development of non-healing lung abscess.
4. Pulmonary necrosis.

### Treatment

1. Tube thoracotomy
2. Ventrilatory support
3. Pneumorrhaphy
4. Suturing
5. Stapling.

## INJURY TO HEART, GREAT VESSELS AND BRONCHUS

This topic includes following contents:

a. Rupture of aorta

b. Ascending aorta/Main pulmonary artery injury.
c. Aortic arch—Thoracic outlet vascular injury, distal innominate artery and vein
d. Subclavian vascular injury
e. Descending thoracic aorta
f. Bronchial injury
g. Penetrating cardiac injury
h. Stab wound of heart
i. Coronary artery injury.

### Rupture of the Aorta

It is a fatal injury. A part of the arch of the aorta, which lies distal to the origin of the left subclavian artery near its junction with the descending aorta, is affected by injury.

### Diagnosis

*X-ray* Widening of the mediastinum due to accumulation of blood
*Aortography:* This will give a definite due as which part of aorta has been injured.

### Complications

1. Brain ischaemia
2. Spinal cord ischaemia.

## ASCENDING AORTA / MAIN PULMONARY ARTERY INJURY

### Cause

Gun shot injury.

### Complication

Pericardial tamponade and death.

### Treatment

1. Thoracotomy
2. Cardiopulmonary bipass with reconstruction.

## AORTIC ARCH-THORACIC OUTLET VASCULAR INJURY, DISTAL INNOMINATE ARTERY AND VEIN

### Cause

Blunt injury.

### Treatment

Bypass grafting.

## SUBCLAVIAN VASCULAR INJURY

### Treatment

Saphaneous vein and to end anastomosis is done.

## DESCENDING THORACIC AORTA

### Cause

Penetrating or blunt trauma.

### Clinical Features

1. Intrascapular murmur
2. Pulse or blood pressure discrepancy between upper and lower extremities.
3. Palpable fracture of clavicle or sternum
4. Presence of lower extremity pulse deficit
5. Paresis or paralysis
6. Presence of stering wheel imprint on anterior chest-wall.

### Treatment

1. Lateral aortorrhaphy.

## BRONCHIAL INJURY

### Causes

1. Injury is secondary to penetrating, blunt

2. Iatrogenic occurs during intubation, tracheostomy and bronchoscopy.
3. Traumatic.

*Location:* Right and left stem bronchus.

### Complications

1. Pneumothorax
2. Pneumomediastinum
3. Atelectasis
4. Subcutaneous enphysema.

### Treatment

1. Control and repair by a double –lumen endotracheal tube
2. Posterolateral thoracotomy
3. Bronchial resection.

## PENETRATING CARDIAC INJURY

### Site

Anterior surface is most frequently injured. Coronary arteries are injured.

### Treatment

Coronary artery bypass is required.

## STAB WOUND OF HEART

### Causes

Large hole in the heart.

### Clinical Features

1. Haemothorax
2. Pericardial tamponade occur.

### Treatment

1. Median sternotomy or antero-lateral thoracotomy to expose the injury and repair is done by cardiorrhaphy.

## CORONARY ARTERY INJURY

Requires mattress suture, Foley catheter balloon placed through the injury into heart, inflated and pulled back against the wall may achieve haemostasis and allow time for resuscitation and proper placement of sutures. Posterior cardiac wounds required cardiopulmonary bypass for repair. Patients who reach the hospital alive with cardiac wound and blood pressure less than 90 mmHg have 90% chance of survival.

## EMPYEMA

The causes of Empyema and its Treatment. Intercostal drainage, Rib resection, Decortication, Window operation.

### Definition

It is the collection of the pus in the pleural cavity.

### Types

1. Acute
2. Subacute
3. Chronic.

### Causes

1. Secondary to pulmonary infection, e.g.: Pneumonia
2. Infective process, e.g.: Tuberculosis, Lung abscess, and Bronchiectasis
3. Inflammatory conditions, e.g.: Osteomyelitis of rib
4. Trauma
5. Spontaneous pneumothorax

6. Iatrogenic
7. Osteomyelitis of dorsal spine.

## Pathology

The pleural infection occurs, development of a serious effusion causes inflammatory changes, exudation of fluid, fibrin is deposited, intrapleural clotting leads to Empyema. Fusion of lung to chest wall at the periphery of collection of fluid, formation of granulation tissue and later plaques of fibrous tissue are formed, adhesion is formed, fluid becomes thick and Empyema is localized. A mature Empyema consist of visceral and parietal layers of the fibrous tissue on the lung. The fibrous tissue contracts, the ribs are drawn together and lose their mobility. The diaphragm is elevated and fixed, Mediastinum drawn towards the affected side. Lung becomes immobile and functionless called chronic Empyema or frozen chest.

## Causes

1. Perforation of the oesophagus
2. Rupture of a lung abscess.

## Clinical Features

1. Toxaemia
2. Shock with pleural pain
3. Rapid and hallow breathing.

## Diagnosis

Needle exploration confirms signs of pleural fluid.

## Treatment

1. Early thoracotomy is required
2. Repeated aspiration
3. Antibiotics to control the infection
4. Intercostal catheter inserted through a cannula and connected to an underwater seal.

### Sub Acute

*Causes*

1. Develop suddenly

*Clinical Features*

1. Fever
2. Pneumonia
3. Diminished chest movement
4. Dullness
5. Absent breathe sounds
6. Displacement of viscera.

### Chronic

*Causes*

1. Empyema of more than three months duration
2. Mismanagement of one and two stages of Empyema
3. Failure to diagnose the original condition
4. Complication of an underlying condition of lung, bronchiectasis, lung abscess and tumour
5. Foreign bodies
6. Actionomycosis
7. Chronic infection
8. Carcinoma lung
9. Bronchopleural fistula
10. Inadequate drainage of subphrenic abscess.

*Present as*

1. *Latent empyema:* A closed collection of pus separated from its surrounding.
2. *Bronchopleural fistula:* Empyema discharging continuous or intermittently into a bronchus.
3. *Persistent empyema:* Empyema discharging continuous or intermittently through a sinus in chest wall.

*Symptoms*

1. Pleuritic chest pain
2. Heavy sensation on the side
3. Fever
4. Dyspnoea
5. Tachycardia
6. Cough with purulent sputum
7. Decreased chest exertion
8. Pain on percussion
9. Friction rub
10. Absent blood supply.

*Complications*

1. Chronicity
2. Septicaemia
3. Rupture of bronchus
4. Metastasis abscess in vertebrae and brain
5. Pyopneumothorax
6. Empyema necessitas.

*Diagnosis*

1. Exploration of pus by needle
2. Iodised oil should be injected into the empyema to locate the lowest point and to know which rib has to be resected.

## TREATMENT

### Aim

1. To control infection
2. Evaluation of pus
3. Obliteration of pleural space
4. Re-expanion of lung
5. Restoration of normal pulmonary function.

## Stage-I

*Acute Empyema*

1. Pus aspiration on alternate days
2. Antibiotic treatment
3. Intercostal tube drainage if aspiration failed.

## Stage-II

*Rib Resection*

*Indication*

1. When conservative method fails because of infection by resistant organism.
2. Loculated Empyema
3. Bronchopleural fistula or oesophageal fistula
4. Bronchiectasis or tumour.

*Procedure*

The surgery is carried under local anaesthesia. An oblique incision through skin and muscles is made over the rib to be resected. The periosteum of the rib is elevated by 5 cm and segment exercised. The rib bed is incised. Care to be take to avoid damage to the intercostal vessels. The opening is enlarged to permit complete evacuation of the Empyema, through inspection and biopsy of the pleura should be done. Drainage should be closed at first using an underwater seal. If drainage gets reduced to 60 ml daily, open drainage should be started. The drainage should be maintained till the empyema cavity gets completely obliterated which takes as long as 6-8 weeks. If tube is removed prematurely it leads to chronicity of the condition. Using does regular checks are done by using serial pleurogram with radio opaque oil injected into the empyema cavity at interval of 3 weeks. The projection of tube should be 2.5-5 cm into the empyema cavity initially, later adjusted to 4 cm.

Intercostal drainage if pus is there

Postoperative physiotherapy plays an important role.

## DECORTICATION

### Definition

This surgery is removal of the cortex or external covering from any organ or structure and removal of the thickened pleura.

### Procedure

Patient is in the lateral position. An incision is made in the 5th Intercostal space. The blood clots are removed and any adhesions between the parietal and visceral pleura are divided. The anaesthesiologist inflates lung to know the site and extent of entrapment by the fibrinous membrane over the visceral pleura. The lungs are deflated slightly, the incision made transversely or longitudinally and separation of the peel is began. The peel may vary from a fraction of a millimeter to several cms in thickness. The lung bulges once visceral pleura is reached through the incision. The edges of the incision are elevated and separated. Finger tip is inserted and separated rapidly. If Haemothorax has been present for many weeks or months or when Decortication is done for chronic empyema then the membrane may be adherent to the visceral pleura and sharp dissection is required. The entire visceral membrane is removed then lung expands completely, parietal membrane is also removed. Lung expands completely, parietal membrane is also removed.

Lung expansion should be maintained during the postoperative period is essential to prevent recurrence of 2 or 3 drainage tubes are inserted and constant suction of 10-15 cm of water is applied. Air leaks may persist for several days when multiple injury to the superior alveoli are present.

## WINDOW OPERATION/OPEN FLAP PROCEDURE

Eloesser introduced in 1935.

### Indication

1. Unsuccessful open drainage
2. Improper closed drainage.

### Uses

1. Chronic Empyema
2. Drain post pneumonectomy Empyema.

### Procedure

The U shaped flap of skin is made with abase of 10-12 cm long and parallel to the superior border of the first uninvolved rib above the bottom of the Empyema cavity. The full curved end of the flap is 6-7 cm long, the rib underlying the base of the flap is resected, turned into chest and taken to pleura. The skin defect is allowed to heal by secondary intention.

## THE MANIFESTATIONS OF FOLLOWING CONDITIONS

**A. Pulmonary tuberculosis**
**B. Tuberculoma,**
**C. Bronchiectasis sicca**
**D. Bronchostenosis**
**E. Massive haemoptysis**
**F. Destroyed lung.**

## PULMONARY TUBERCULOSIS

### Predisposing Factors

1. Close contact with patient suffering from tuberculosis
2. Malnutrition, overcrowded houses, poverty, alcoholism, drug addiction, Heavy smoking, corticosteroid therapy.
3. HIV infection
4. Diseases such as Diabetes mellitus, Cirrhosis of liver, Pneumoconiosis, Congenital Health disorder, Leukemia, Hodgkin's disease long term corticosteroids or immuno-suppressive drugs.

### Types

1. Primary
2. *Postprimary:* This is divided into acute pulmonary. This inturn has a
   a. Pneumonic: This affects upper lobe
   b. Bronchopneumonia: Abrupt onset following influenza, children measles or whooping cough
   c. Miliary: Blood affected with spread of disease to spleen, liver, kidneys, meninges and lymph nodes.
   d. Acute disseminate: This has pyrexia, sputum is absent or scanty, ARDS, Tachypnoea, dysfunction of multiple organs.
   e. Haematogenous.
   f. Surgical
   g. TB adenoma
   h. Lupus vulgaris.

### Chronic Pulmonary TB

Loss of weight, evening rise of temperature, cough, influenza, haemoptysis, pneumonia, hoarseness of voice, pleural effusion, amenorrhoea or oligomenorrhea in young women, Mental symptoms like difficulty in concentrating, HIV.

### Causes

*Mycobacterium tuberculosis* is the bacillus responsible by droplet spread of infection. So the infection can be spread very easily.

### Pathology

The irritation and inflammatory changes of the mucous lining in the bronchioles or alveoli by the bacillus. The bacillus are ingested by leukocyte. These are absorbed by macrophages. The leukocytes forms a barrier around the collection of cells to form tuberculous follicle. The center area undergoes necrosis called caseation. This material goes to bronchus. Cavity formation and calcification are the features of tuberculosis. This is the source of infection and becomes reactivated and causes post primary pulmonary tuberculosis.

### Clinical Features

1. Malaise
2. Lassitude
3. Irritability
4. Loss of weight
5. Loss of appetite
6. Tachycardia
7. Pyrexia
8. Night sweats
9. Procuctive cough
10. Haemoptysis
11. Dyspnoea
12. Pain

### Diagnosis

*Radiograph:* Snow storm appearance and cavity formation and calcification are seen.

*Tuberculin test:* This test should be done with in six weeks of infection.

### Complications

*Early*

1. Pneumonia
2. Empyema
3. Haemoptysis
4. Laryngitis
5. Pneumothorax.

### Late Complications

1. Bronchiectasis
2. Mycetomas in cavities
3. Colonization of fibrotic lung with non-tuberculous mycobacterium
4. Non-Respiratory disease, Bone disease and genito-urinary disease.

## Treatment

*Prevention*

1. Vaccination of people who are at risk
2. Pasteurization of milk prevents transmission of the tubercle to humans from cows milk.
3. Sputum must be disposed carefully to avoid cross-infection.
4. The doctors, physiotherapist and nurses are more prone for the droplet infection.

*Drug Therapy*

1. Rest
2. Rifampicin
3. Isoniazid
4. Ethambutol
5. Para-aminosalicyclic
6. Streptomycin.

*Surgery:* Indicated for the resistant tubercle and lobectomy is done.

## TUBERCULOMA

Tuberculoma is a common intra-cranial mass lesion. It is a mass of cheese like material resembling a tumour seen in some cases of tuberculosis. Tuberculoma are found in a variety of sites including the lung, Brain. A single mass may be the only clinical evidence of disease. The clinical features relate to the site of mass, its nature and its rate of expansion.

*Age:* More common below 10 years and can be any age group.

*Site:* Posterior fossa in the paediatric age group and supratentorially in the adults.

## Clinical Features

1. Local effects will be on adjacent brain tissue.

2. Raised intracranial pressure causes Headache, Impairment of conscious level, Papilloedema, Vomiting, Bradycardia, Arterial Hypertension
3. False localizing signs.

### Investigations

1. CT scan
2. Angiography (both from the site of the lesion)
3. NMRI: Nuclear Magnetic Resonance Imaging
4. ESR, X-ray chest, Tuberculin test. (For the evidence of tuberculous diathesis).

### Management

1. Anti-tuberculous therapy
2. Measure to relieve intracranial tension
3. Surgial excision of tumour mass.

## BRONCHIECTASIS SICCA

### Definition

It is a chronic permanent dilatation of the bronchi with impaired damage of secretions and recurrent lower respiratory tract infection. It is dry form of the Bronchiectasis.

### Causes

1. Cystic fibrosis
2. Hypo gamaglobulanemia
3. Kartegners syndrome in adults: Infection by *Myobacterium tuberculosis*, Pneumonia, Sinusitis.

### Children

1. Foreign body obstruction of the bronchus.
2. Following Measles and whooping cough.

### Symptoms

1. Cough with copious expectoration in the morning
2. Haemoptysis
3. Breathlessness.

*Signs* Finger clubbing.

### Investigations

1. X-ray Linear opacities at base as it is common in all the lower lobes
2. Sputum culture must be done.

### Complications

1. Lung abscess
2. Pleural effusion
3. Empyema
4. Brain abscess
5. Amyloidosis.

### Treatment

1. Removal of secretions by postural drainage
2. Antibiotics.

#### *Surgery*

Segmentectomy or lobectomy.

## BRONCHOSTENOSIS

*Site:* Right main stem bronchus.

### Causes

1. *Congenital:* This is very rare. Secondary to inflammatory changes following improper frequent suctioning of the infant on ventilatory support. Lung distal to stenosis becomes chemically infected as emphysematous.

2. *Traumatic:* Partial bronchial tears may go unnoticed to the initial examination. When these tears hear by fibrosis stricture may form. Lung distal to the stricture may collapse and may or may not give rise to symptoms.
3. *Infectious:* The main causes are
   a. *Tuberculosis:* Chronic infection leads to progressive destruction of bronchus and when healing occurs it heals by fibrosis resulting in stricture.
   b. *Histoplamosis:* Causes mediastinal or hilar lymphadenopathy. At times it can lead to excessive fibrosis following healing of primary lesion. This enhanced fibrogenetic response may cause stenosis of adjacent bronchi.
4. Post-surgical or Iatrogenic:
   a. Following Lobectomy
   b. Following Lung transplantation.

## Diagnosis

1. Chest x-ray shows distal collapse
2. Bronchoscopy
3. CT scan of the chest.

## Treatment

1. *Congenital:* By repeated bronchial dilatation, control of infection followed by bronchoplasty surgery.
2. *Traumatic:* Depends on presence of distal infection or not
   a. If no infection is present resect the stricture or primary repair of bronchus.
   b. If infection present lung resection.
3. *Infection:* Surgical resection or reconstruction
4. Iatrogenic:
   a. Lobectomy: Endoscopic shunt placements, Pneumonectomy
   b. Right main stem stenosis repeated dilution and endobronchial stunts are done
   c. Left main stem stenosis, endobronchial stunts are done.

## MASSIVE HAEMOPTYSIS

### Definition

The coughing up blood from lower respiratory track or the coughing of about 600-800 ml of blood in 24 hours is called Massive Haemoptysis.

### Pseudo-Massive Haemoptysis

Coughing of blood from oral cavity or gastrointestinal track.

### Contents

Blood stained sputum and Frank Haemoptysis.

### Causes

1. Pulmonary infection
2. Mitral stenosis
3. Left ventricular failure
4. Tumours like carcinoma, Adenoma, Endobronchial metastasis
5. Pulmonary infarction
6. Trauma: Iatrogenic causes like pulmonary contusion, Transbronchial biopsy, Transthoracic needle biopsy.
7. Haemorrhagic diathesis: Purpura, leukemia, Haemophilia
8. Pulmonary Haemorrhage: Haemorrhagic fevers, good pastures syndrome, Idiopathic pulmonary haemosiderosis, Pulmonary vasculitis and Behcet's syndrome.
9. Vascular abnormalities: A-V malformations, Heriditary Haemorrhagic telangiectasia.
10. Anticoagulant
11. Idiopathic
12. Inflammatory like acute bronchitis
13. Pulmonary infarction like a presence of a foreign body.

### Investigations

1. Sputum: Malignant and tuberculous bacilli

2. X-ray Pulmonary tuberculosis
3. Blood: RBC count
4. Larynx: For ulceration
5. Bronchoscopy: Exclude foreign body and malignant growth
6. Bronchography: Bronchiectasis
7. Neddle aspiration biopsy: Intrapulmonary lesions
8. Pulmonary Angiography: Anomalies of vascular structure
9. CT scan: Pulmonary infarction and lung carcinoma
10. Thoracotomy: If all of the above fails.

### Treatment

1. Hospitalization in Intensive care unit.
2. If the site of the bleeding is located patient must be put in semi-reclining dependent position.
3. Fluids: Colloids or crystalloids and blood transfusion if profuse bleeding occurs.
4. Antitussives: If cough is troublesome
5. Antibiotics: Preventing secondary infection
6. Balloon Tamponade for 24-48 hours
7. Selective embolization of bronchial arteries and supplying the affected area.
8. Thoracotomy and surgical resection.

### Indications

1. Severe Haemoptysis with site of bleeding in lung segment or lobe
2. If embolisation can't be performed or unsuccessful
3. Patient is Haemodynamically unstable but has good pulmonary function.

### Laser Therapy

This is done as a pallative measure of Massive Haemoptysis and non-resectible lung cancer.

# SUPPURATIVE LESIONS OF THE LUNG

## MANAGEMENT OF SUPPURATIVE LESIONS OF THE LUNG

**A. Bronchiectasis**
**B. Lung Abscess**
**C. Broncho-Pneumonia**
**D. Aspergillosis**

## BRONCHIECTASIS

### Definition

The bronchiectasis is the destructive lung disease characterized by the chronic dilatation of the bronchi associated with persistent variable inflammatory process in the lungs.

### Causes

1. Infection
2. Inflammation
3. Bronchial obstruction
4. Pulmonary fibrosis.

### Signs

1. Bronchitis
2. Fibrosis
3. Consolidation
4. Cavitation
5. Collapse.

### Symptoms

1. Bronchiectasis sicca
2. Haemorrhage
3. Cough
4. Obstruction by foreign body.

### Complications

1. Pulmonary like pneumonia, lung abscess, haemoptysis
2. Pleural: Pleural effusion, Empyema
3. Pericarditis
4. Sinusitis
5. Cerebral abscess.

### Investigations

1. Sputum
2. X-ray
3. Lung function tests.

### Treatment

1. *Medicine:* Tetracycline
2. *Physiotherapy:* Postural Drainage for the lower lobes. The patient in the prone lying with head tilted down, Deep breathing, Coughing, Percussion and clapping. The expectoration is by cough mixture or inhalation of bronchodilator with inhalation of water or steam and postural drainage. This should be done early in the morning for 15-20 minutes because the secretions accumulate during night. The procedure must be done twice daily.
3. *Chemotherapy:* Intermittent therapy for the mild cases and continuous therapy for severe cases.

### Surgical Treatment

1. Surgical resection—One segment or lobe are resected and in cases of haemoptysis the excision of the bronchial artery and embolisation are done.

### Contraindications

1. Old age
2. Poor cardio-respiratory function
3. Bilateral extensive disease (only 7-8 segments must be removed).

## LUNG ABSCESS

### Definition

The localized formation of pus surrounded by a fibrous capsule with in the lung tissue is called lung abscess.

### Aetiology

This is secondary to bronchial carcinoma
*Age:* Over 40 years.

### Causes

1. Inhalation of a foreign body
2. Bacterial entering through the air passage because of broncho-pneumonia
3. Knife stab or bullet cause wound, the bacteria enters through the open chest wall
4. Blood stream
5. Secondary to bronchial carcinoma and abscess forms where secretion accumulate distal to the tumour.

### Clinical Features

1. Fever
2. Dyspnoea
3. Malaise
4. Pain
5. Cough which is irritable, unproductive. Initially productive of foul smelling sputum with bad taste in the mouth.
6. Haemoptysis
7. Halitosis.

### Pathology

Inflammation of the lung tissue and suppuration occurs by invading organisms. Necrosis occurs in the centre of the lung tissue with liquefaction and suppuration. The area becomes distended and fibroblasts lay down fibrous tissue around the area. Capsule contracts, abscess bursts resulting in the foul smelling sputum. Healing occurs with the formation of a fibrous scar.

### Complications

1. Empyemaused when pus drains into pleura
2. *Bronchiectasis:* If the drainage spills into adjacent into lung tissue causes bronchiectasis
3. *Septicaemia:* Toxins from the pus can be absorbed into the blood stream.

### Diagnosis

1. *Radiograph:* Shows a fluid level

*Treatment:* Antibiotics for 6 weeks

*Prognosis:* The patient will recover if treated.

## BRONCHO-PNEUMONIA

### Definition

It is a patchy and scattered lung condition in the lower lobes.

### Aetiology

*Age:* First 2 years and elderly.

### Predisposing Factors

1. Weak and marasmic children
2. Rickets and infective fevers like measles and whooping cough

*Onset:* The patient may feel week in the early stages.

### Signs

1. Dullness to percussion
2. Fine crackles.

### Symptoms

1. Fever
2. Vomiting

3. Convulsions
4. Inflammation of nasal, pharyngeal or Tracheo-bronchial passages
5. Dyspnoea
6. Cough
7. Cyanosis
8. Child lies with half open eyes called prostration
9. Gastro-Intestinal symptoms in infants like vomiting, diarrhoea
10. Nervous symptoms like convulsions and meningitis.

### Treatment

1. Diet
2. Sedatives for distressing and restless patient
3. Antibiotics like penicillin
4. Bronchodilators to reduce broncho-spasm
5. Cyanosis: Humidified oxygen with blood gas monitoring.
6. Metabolic acidosis: $NaHCO_3$
7. Fever: Paracetamol
8. Fluids: If the respiratory rate is more than 60 per minute
9. Other measures: Increase in the lung volume, improve gas exchange and clear secretions.

## ASPERGILLOSIS

### Definition

Aspergillosis is a suppurative lesion of the lung occurs due to filamentous fungi is called Aspergillosis.

### Causes

The agriculture workers are a specific risk.

### Pathology

The fungus may infect a lung that is previously damaged by a tuberculous cavity, unsclerosed pneumonia, pulmonary pneumonia and bronchiectasis.

### Types

1. Allergic broncho-pulmonary aspergillosis-Type -I
2. Aspergilloma –Mycetoma-Type –II
3. Invasive aspergillosis –Type-III.

### Clinical Features

*Type – I*

a. Individuals will be hypersensitive, High titres of IgE, IgG
b. Inflammation of medium size bronchi
c. In asthma patients worsening of the air low obstruction and cough
d. Proximal Bronchiectasis.

*Type –II*

a. Cavities with Tuberculosis will become colonized by *Aspergillus fumigatus*. A ball like fungal mass mixed with inflammatory debris and blood forms in the cavity which becomes lined with highly vascular granulation tissue.
b. Haemoptysis
c. Severe Bleeding.

*Type –III*

a. Severe Neutropenia
b. T-Lymphocyte deficient
c. Acute or sub acute illness
d. Fever
e. Local Cavitary pneumonia or disseminated pneumonia.

### Treatment

*Type-I*

Prednisolone 20-30 mg/day from 4-6 weeks followed by maintenance with inhaled corticosteroids.

*Type-II*

Lobectomy for severe haemoptysis.

*Type-III*

Amphoterin.

## LUNG CARCINOMA

### CARCINOMA OF LUNG

#### Aetiology

1. Smoking: Active smokers chances are 85% and passive smokers 3%.
2. Enviromental risk factors from radon, asbestos, chromium, silica, nickel and arsenic.
3. Pre-existing lung disease: COPD, Pulmonary fibrosis.

#### Clinical Features

1. Cough
2. Haemoptysis
3. Dyspnoea
4. Chest pain
5. Wheeze
6. Nerves affected:
   a. Phrenic nerve cause cough and paresis of diaphragm
   b. Recurrent Laryngeal nerve causes Hoarseness of voice
   c. Cervical Sympathetic: Horner's syndrome
   d. Vagus nerve: Gastric symptoms
   e. Brachial plexus: Lower part will be involved
   f. Oesophagus: Dysphagia
7. Vessels:
   a. Superior vena cavae: Venous engorgement of head and neck
   b. Azygos vein: Dilatation of superficial veins on thorax
   c. Thoracic outlet: Effusion

   d. Axillary vessels: Loss of peripheral pulses and Oedema of arm.
8. Erosion of rib: Local pain and bony tenderness
9. Invasion of Heart and pericardium
10. Bony metastasis in ribs and vertebrae
11. Hepatic metastasis
12. Suprarenal metastasis results in Addison's disease
13. Endocrine abnormalities:
   a. Cushing's syndrome
   b. Hyponatremia
   c. Hypercalcemia
   d. Hypoglycemia
   e. Hyperthyroidism
   f. Gynaecomastia
14. Skeletal:
   a. Finger clubbing with painful swelling of the wrists, ankles.
   b. The periosteal new bone formation occurs on tibia, fibula, radius and ulna
15. Skin: Eczematoid, Bullous rashes
16. Neurological:
   a. Encephalopathy with dementia
   b. Cerebellar damage
   c. Cerebellar degenerating syndrome
   d. Extra pyramidal syndrome
   e. Myelopathy
   f. Neuropathy
   g. Myasthenic syndrome
   h. Motor neuron disease
17. Muscular:
   a. Polymyositis
   b. Dermatomyositis
18. Vascular:
   a. Thrombophlebitis migrans
   b. Non bacterial endocarditis
19. Haemotological:
   a. Haemolytic anaemia

b. Thrombocytopenia
c. Red cell Aplasia.

## Diagnosis

1. History and physical examination
2. Sputum cytology
3. Chest –x-ray: Localize the primary lesion. This can be central or peripheral.
4. Computed Tomography: Assessing the primary tumour
5. Magnetic resonance imaging: Assessing tumour, invasion into the spinal cord, vertebral bodies and brachial plexus.
6. Bronchoscopy: This is one by either rigid or flexible bronchoscope. This allows the visualization upto third order bronchus and plays an essential role in the diagnosis, staging and treatment of lung cancer.
7. Percutaneous needle biopsy: Fluoroscopic or CT–guided needle biopsy successfully diagnose lung cancer with at least 85-90% of accuracy.

## Management

### *Radiotherapy*

*Indications*

1. Early stage of disease
2. Refuse surgery
3. Medically unfit for surgery.

### *Uses*

1. Haemoptysis, cough, chest-pain are reduced
2. Temporarily relieve superior vena cava obstruction
3. Compression of the Oesophagus or major bronchus is relieved.

### *Pre-operative Radiotherapy*

1. For Pancoast tumours
2. Prior to surgical-resection.

### Post-operative Radiotherapy

Given accordingly.

### Pallative Radiotherapy

This gives good symptomatic relief for malignant bronchial obstruction and haemoptysis from endo-bronchial tumour.

### Brachy Therapy

This involves the treatment of a tumour by the direct application of radioactive sources, so permits the delivery of a localized, high dose of radiotherapy. The radioactive source may be placed interstitially (directly into the tumour) or intracavitary (with in the airway using a bronchoscopically placed after loading catheter).

### Complications

1. Oesophagitis
2. Pneumonitis
3. Pericarditis
4. Myelitis.

### Chemotherapy

The Chemotherapy has taken on increased importance in the overall management of lung cancer.

### Chemotherapeutic Agents

Cisplatin, Mitomycin C, Vindesine, Vinblastine, Ifosfamide.

### Combination Therapy

The combination therapy improves quality of life.

### Post-operative Chemotherapy

1. Cisplatin and Vinorelbine
2. Taxol and carboplatin are administered.

### Induction Chemotherapy

This type of chemotherapy requires the tumour should have an intact blood supply, hence, better delivery of chemotherapeutic agents before surgery or radiotherapy.

### Concurrent Chemoradiotherapy

The chemoradiotherapy offers systemic and local control.

### Surgical Treatment

This is the most effective treatment for early stages because primary tumour can be resected completely perioperative risk is low.

*Pre-operative evaluation must be done:*

1. Cardiovascular assessment
2. Pulmonary assessment
3. Prediction of postoperative morbidity with regard to:
   a. Cardiovascular disease
   b. Pulmonary disease
   c. Age
   d. General Medical condition
   e. Nutritional status
   f. Diabetes
   g. Immunosuppression
   h. Tumour stage
   i. Extent of resection
   j. Psychological factors.

*Pre-operative Preparation*

1. Improve cardio-pulmonary function
2. Cessation of smoking
3. Treatment of Broncho-spasm with broncho-dilators and steroids
4. Reduction of the pulmonary secretions by chest physiotherapy and antibiotics
5. Correction of the anaemia
6. Rehydration and the nutritional support
7. Correction of specific disorders like congestive cardiac failure and cardiac dysrhythmias.

## Surgical Principles

A complete resection of the primary tumour and its intrapulmonary lymphatics is essential. This is by anatomic resection like lobectomy or pneumonectomy, segmentectomy is appropriate in selected situation but has a high incidence of local response.

### *Stage-I and II*

Lobectomy, Bilobectomy and Pneumonectomy are the surgical treatment of choice in these patients. Lesser resections like wedge, segmentectomy should be reserved for high risk patients who will not tolerate lobectomy.

### *Surgical Options*

1. *Wedge or segmental resection:* The indications like peripheral lung tumours in patient with poor pulmonary reserve. Recurrent rate are higher and survival is reduced.
2. *Lobectomy or bilobectomy:* This is complete resection of hilar lymph nodes draining the primary tumour and allows preservation of the lung function.
3. *Pneumonectomy:* This accounts for 20% of all lung resection.
4. *Main stem bronchus or main pulmonary artery:* This procedure causes loss of lung parenchyma with significant chronic respiratory impairment.

## THORACIC INCISIONS

## EXTENT, USE AND COMPLICATIONS OF THE THORACIC INCISIONS

**A. Antero-lateral Thoracotomy**
**B. Postero-lateral Thoracotomy**
**C. Median Sternotomy**

The thoracic incisions depends on the operation to be performed as well as the underlying pathology. Before planning or the surgery the correlation with the pre-operative radiographic imaging is essential. The most common incisions used in the thoracic surgery includes are:

1. Anterio-lateral Thoracotomy
2. Postero-lateral Thoracotomy
3. Median sternotomy.

The knowledge of the thoracic cage and musculature is necessary.

## Thoracic Cage

The thoracic cage consist of sternum anteriorly, the thoracic vertebrae posteriorly and 12 pairs of the thoracic ribs connecting the both.

## Thoracic Cage Musculature

This consist of two layers of muscles. They are:

1. The intrinsic Musculature consist of three intercostal muscle layers which are used for the respiration and protection. The extrinsic musculature consist of pectoralis major, Serratus anterior, Latissimus dorsi and the sternocleidomastoid and the scalene muscles. This helps in stabilization, mobilization and accessory muscles of respiration.

## Thoracotomy

A thoracotomy is a thoracic cavity incision for lungs, bronchi and heart.

This is of two types:

### *Lateral Thoracotomy*

This inturn divided into:

a. Anterolateral thoracotomy
b. Posterolateral thoracotomy

### *Anterior Thoracotomy*

This is divided into

a. Transverse thoracotomy
b. Vertical thoracotomy

## LATERAL INCISIONS

### Antero-lateral Thoracotomy

This incision is close to midline in front follows along the line of a rib below the breast to the posterior axillary line. The muscles involved are Pectoralis major, Pectoralis minor, Serratus anterior, Internal Intercostal and external Intercostal.

*Indications*

1. Pleurectomy
2. Mitral valvotomy
3. Open lung biopsy
4. Mobilization of the thoracic oesophagus for resection
5. Lung resection.

*Operative Technique*

The patient is placed in the supine position with a roll placed vertically under the back and pelvis to raise the operated side by 45 degrees. The ipsilateral arm is placed at the side. The incision is in the fourth or fifth intercostal space. The musculature are divided and a portion of the costal cartilage may be removed for extra exposure.

*Advantages*

1. Few muscles are divided
2. Few operative time is required.

*Disadvantages*

1. Limited exposure
2. Painful exposure
3. Higher incidence of the lung herniation since the intercostal space is more difficult to close.

### Postero-lateral Thoracotomy

The incision is at vertebral border of the scapula and the line of a rib like 5, 6, 7 or 8 to the anterior angle or costal margin. The muscles involved are Trapezius, Latissimus dorsi and rhomboids major, Serratus anterior, Intercostal and erector spinae. To assess to the thorax if required a rib may be removed or some are retracted.

*Indications*

1. Lung operation
2. Unilateral lung resection
3. Oesophageal surgery
4. Chest-wall tumour resection
5. Unilateral lung volume reduction surgery/Bullectomy
6. Tumours of the posterior mediastinum.

*Technique*

The patient is placed in the lateral decubitus position with careful attention to padding pressure points such as the elbows and knees and the lateral position is maintained by the adhesive tape, sandbags or a vacuum bean bag. The incision is made two finger widths below the tip of the scapula along the line of the ribs and be extended posteriorly in a vertical direction between the scapula and the spine. Some muscles incised others are retracted according to the requirement. Fifth space is selected for the lung resections.

### Advantages

1. Good access to all regions of the thoracic cavity
2. Uncommon postoperative infections.

### Disadvantage

Increased postoperative pain secondary to muscle transection or displacement of the ribs.

## MEDIAN STERNOTOMY

This is the subdivision of anterior thoracotomy incision and also called as the vertical anterior thoracotomy.

### Indications

1. Open Heart surgery
2. Mediastinal tumour resection
3. Bilateral lung volume reduction surgery /Bullectomy
4. Resection of the multiple pulmonary lesions
5. Transpericardial access to trachea /Bronchus
6. Trauma.

### Technique

The patient is placed in the supine position with a roll placed under the shoulders. A vertical incision is made from the sternal notch to the xiphoid process or upper abdomen and the retrosternal space beneath the Manubrium and the xiphoid process is mobilized. Pectoral fascia is incised in the midline and the sternum is split in the midline and mediastinal connective tissue is divided. The sternum is re-approximated using a tout stainless-steel wire and the pectoralis fascia is closed with a heavy absorbable suture.

### Advantage

1. Decreased postoperative pain because the incision is stable and muscles are not involved leading to improvement of the respiratory function and mobilization.

### Disadvantage

1. Osteomyelitis
2. Sternal dehiscence
3. Posterior thoracic cavity on the left side is difficult to access.

## POST-OPERATIVE-COMPLICATIONS

### ATELECTASIS

### Definition

The incomplete expansion of the lung and collapse of the alveoli is called Atelectasis.

### Clinical Features

Low grade temperature rales on inspiration.

### Treatment

Deep diaphragmatic breathing, Postural drainage with percussion and vibration if secretions are present.

## CARDIAC ARREST

### Definition

The cessation of the function of the heart is called cardiac arrest.

### Clinical Features

Breathlessness, Pulse less Pale and unresponsive.

### Treatment

Cardio-pulmonary resuscitation, immediate medical attention, no Trendelenburg position, segmental breathing, bed at or deep breathing in cardiac position 45-60 degrees head elevated.

## CARDIAC DYSRHYTHMIA

### Definition

The irregularity in the normal rhythm of the heart is called cardiac dysrhythmia.

### Clinical Features

Irregular pulse.

### Treatment

Modified deep breathing, Bed flat drainage.

## CARDIAC TAMPONADE

### Definition

The fluid present in the pericardial sac is limiting the ventricular filling.

### Clinical Features

Decrease in cardiac output, Blood pressure, Increased Heart rate and there will be shortness of the breath.

### Treatment

In cases of severe distress, no treatment is required, Modified postural drainage.

## CONGESTIVE CARDIAC FAILURE

### Definition

The effusion of the serous fluid in the interstitial tissues of the lungs.

### Clinical Features

Shortness of breath, Diaphoresis, Peripheral Oedema.

### Treatment

Modified postural drainage, Avoid head–down position, relaxation exercises.

## EMPYEMA

### Definition

The accumulation of the pus in the pleural cavity is called empyema.

### Clinical Features

Fever, Weight loss, Malaise, Decreased breath sounds and dull percussion over area.

### Treatment

Segmental breathing, deep diaphragmatic breathing, Increased mobility.

## HEMOTHORAX

### Definition

The presence of the blood in the pleural cavity. If this is seen with Pneumothorax, it is called Haemopneumothorax.

### Clinical Features

Pain, Dyspnoea, Hypertension, Diaphoresis and Shortness of breath.

### Treatment

When stabilized segmental breathing on the involved side.

## HYPERCAPNIA

### Definition

The increase of the carbon dioxide in arterial blood.

### Clinical Features

Change in the mental status.

### Treatment

Oxygen therapy.

## HYPOXIA

### Definition

The low oxygen content in the body from Hypoventilation, ventilation–perfusion ratio imbalance or underlying pulmonary disease is called Hypoxia.

### Clinical Features

Headache, Mental fatigue, Poor judgement, Decreased breath sounds.

### Treatment

Medical treatment and effective breathing.

## PLEURAL EFFUSION

### Definition

The presence of the fluid in the pleural space is called pleural effusion.

### Clinical Features

Shortness of breath, Pain, Dyspnoea, Decrease breath sounds, Tubercular breath sounds from one or two Intercostal spaces above effusion.

### Treatment

Increase mobility, deep diaphragmatic breathing and segmental breathing. If shortness of breathing is present, postural drainage is contraindicated.

## PNEUMONIA

### Definition

The inflammation of the alveoli usually from the blood borne organisms.

### Clinical Features

Fever and rales, Chills and tubercular breath sounds, dyspnoea and dull percussion and painful inhalation.

### Treatment

Deep breathing and coughing, Postural drainage, Percussion and vibration.

## PNEUMOTHORAX

### Definition

The presence of the air in the pleural cavity is called Pneumothorax.

### Clinical Features

Shortness of breath, dyspnoea, diaphoresis, absence of breath sounds over the upper lobe area.

### Treatment

The chest tube must be inserted. If secretions are present Segmental breathing and postural drainage is given.

## POST CARDIOTOMY SYNDROME

### Definition

This condition is the combination of the pericarditis, Pleurisy, Pneumonitis and the pleural effusion.

### Clinical Features

Thoracic pain, dyspnoea and shortness of breathe.

### Treatment

Percussion is contraindicated because of the pleuritic pain, segmental breathing is given for pleural effusion.

## PULMONARY EMBOLISM

### Definition

The obstruction of the pulmonary artery or one of its branches by a clot.

### Clinical Features

a. Acute: Pain, shortness of breath, dyspnoea, tachycardia.
b. Sub acute: Hemoptysis, pleural effusion, friction rub and decreased breath sounds over the involved area.

### Treatment

Deep breathing, Segmental breathing, Postural drainage if the patient is stable, Increase mobility, anticoagulant therapy, percussion and vibration after 6 days after therapy.

## RESPIRATORY ARREST

### Definition

The cessation of the respiratory function is called Respiratory arrest.

### Clinical Features

Increased or no respiratory rate, Hypoxia, Diaphoresis.

### Treatment

Immediate medical treatment and Cardio-pulmonary resuscitation.

## RESPIRATORY DISTRESS

### Definition

The noticeable difficulty in breathing is called Respiratory distress.

### Clinical Features

Increased respiratory rate, Secretions in the lungs, Diapheresis, hypoxia, anxiety.

### Treatment

Oxygen therapy, Drug therapy, suction, Intubation and extubation.

## SUBCUTANEOUS EMPHYSEMA

### Definition

The collection of the air in the subcutaneous tissue is called subcutaneous emphysema.

### Clinical Features

Swelling and crackles are heard on palpation.

### Treatment

Deep breathing should be avoided with large air leak, percussion is contraindicated over the swollen area.

## CARDIOGENIC SHOCK

### Definition

The sudden diminution of the cardiac output is called cardiogenic shock.

### Clinical Features

Cardiac damage decreases cardiac output, Hypotensive.

### Treatment

Medical and drug therapy.

## DEEP VEIN THROMBOSIS

### Definition

The coagulation or the clot of the blood that remain at the site of the origin is called deep vein thrombosis.

### Clinical Features

The clot if gets detached can travel to the right side of the heart and enters lung called pulmonary embolism.

### Causes

Venous stasis, Trauma, Dehydration, Increased platelet counts.

### Prevention

Ankle pumps pre- and post-operatively about 10-15 every hour.

### Treatment

Flexion of the hip and knee are contraindicated. If the leg shows thrombophlebitis the excessive movement, rolling should be avoided till the required anticoagulant therapy is given for about 4-5 days.

## SOME OTHER COMPLICATIONS

### Respiratory

1. Infection of the lung tissue
2. Collapse of the remaining lung
3. Bronchopleural fistula: This occurs when the stump of the bronchus from which the lung tissue has been removed breaks down.
4. Pain is the major factor in reducing the lung volume causes guarding spasm of the trunk muscles and inhibits breathing. The reduced volume causes closed airways and absorption of the gas.
5. Prolonged recumbence affects the amount of the distribution of ventilation and cause intra-thoracic pooling of blood that displaces a proportion of air in the lung.
6. Nausea because of the certain drugs, which inhibit deep breathing
7. Fatigue
8. Anxiety causes diaphragmatic splinting, increases surgical risks and prolongs hospitalization.
9. Depression if the surgery causes altered body image.
10. Empyema
11. Local gangrene: Pyrexia and haemoptysis.

### Circulatory

1. Cardiac Tamponade
2. Haemorrhage

3. Chest infection
4. Cardiac herniation
5. Cardiac failure
6. Myocardial infarction.

### Wound

1. Infection
2. Failure to heal
3. Adhesion scar.

### Joint Stiffness

1. Shoulder and shoulder girdle
2. Thoracic spine
3. Costovertebral joint.

### Muscle Weakness

1. Latissimus dorsi
2. Serratus anterior
3. Leg muscles if excised.

### Postural Deformity

The tendency to protect the scar leads to the scoliosis and forward flexion.

### Digestive Complications

1. Hiccups cause sharp pain at the wound site.

### Renal Complications

1. Decreased urine output
2. Oliguria causes renal failure
3. Anuria causes urinary tract obstruction
4. Renal vascular obstruction or acute cortical necrosis.

## POST-OPERATIVE MANAGEMENT OF THE FOLLOWING

Post-operative management of the patients
- Segmentectomy
- Lobectomy
- Pneumonectomy
- Pleuro-pneumonectomy
- Tracheostomy.

## SEGMENTECTOMY

### Definition

This is the removal of the broncho-pulmonary segment.

### Complications

Broncho-pleural fistula, Empyema.

## LOBECTOMY

This is the more difficult operation because the anatomic relationships are complicated.

### Definition

It is the dissection of the secondary hilar structures.

### Indications

1. Bronchiectasis
2. Tuberculosis
3. Lung abscess
4. Carcinoma
5. Fungus infection
6. Congenital anomalies.

### Complications

1. Peripheral adhesions
2. Incomplete fissures

3. Bronchopleural fistula
4. Post lobectomy empyema
5. Chronic empyema.

## PNEUMONECTOMY

### Definition

It is the removal of the entire lung.

### Indication

Bronchogenic carcinoma in males, Breast cancer in females.

### Complications

1. Cardio-vascular instability
2. Empyema
3. Bronchopleural fistula
4. Damage to the Phrenic nerve
5. Damage to the recurrent laryngeal nerve.

### Pleuropneumonectomy

It is the removal of pleura and the entire lung.

## TRACHEOSTOMY

### Definition

This is a procedure performed either as a emergency procedure or as a planned operation.

### Indications

1. Upper airway obstruction
2. Tracheobronchial outlet
3. Airway assess for mechanical ventilation
4. Elimination of the dead space.

### Procedure

The patient in supine position with neck hyper extended and a transverse skin incision below the cricoid is made. Thyroid isthmus is retracted superiorly or inferiorly. A Vertical incision of the second and third tracheal rings are used. A tracheostomy tube of appropriate size is inserted with the obturator in place and the cuff deflated. Tracheostomy tube is in place and the cuff deflated. Tracheostomy tube is in place, the obturator is removed and a suction catheter is introduced through the tube. Free passage into the lower airway and the aspiration of tracheal secretions confirms proper placement. Cuff is inflated and the inner cannula placed prior to ventilation. The tube is sutured to the skin and a tracheostomy tape tied around the neck to prevent dislodgement in the cavity post-operative period.

### Complication

1. Intra-operative:
   a. Bleeding
   b. Pneumothorax
   c. Hypoxia leading to cardio-respiratory arrest (Misplacement of the tracheostomy tube into the pretracheal space).
2. Post-operative:
   a. Bleeding
   b. Wound infection
   c. Tube obstruction or displacement
   d. Swallowing difficulty
   e. Tracheo-stenosis
   f. Tracheoesophageal fistula
   g. Tracheo inominate artery fistula
   h. Tracheocutaneous fistula.

### Post-operative Management

Post-operative care of a thoracic surgical patient begins in the operating room. A catheter is positioned in the radial artery for monitoring arterial blood pressure and blood gas analysis. Oxygen saturation monitors and end tidal carbon dioxide mass spectrometry are used to monitor pulmonary function. Large central venous lines also are placed for the instillation of fluids and for monitoring of right heart pressures. If history of cardiac or pulmonary disease. A catheter should be positioned in the pulmonary artery for monitoring of pulmonary capillary wedge pressure.

After completion of the intra-thoracic operation procedure large pleural drainage tubes are inserted into the thorax for suction and drainage from several different areas within the pleural cavity.

The pleural space should not be drained routinely following Pneumonectomy. Intrapleural pressure should be regulated approximately – 4 to –10 cm of water to prevent shifting of the mediastinum. This is done by a Intercostal catheter connected to a manometric system or a needle simply inserted through a skin into the pleural cavity after procedure is completed. Once the intended pressure in the supine lying is achieved the tube or the needle is removed.

After Pneumonectomy suction should not be applied to the chest tubes because mediastinum may shift. Following closure of the thoracic wound post-operative care is divided into:

a. Immediate Management
b. Early Management
c. Late Management.

## Immediate Management

The immediate post-operative care is also performed in the operating room and the principal consideration is:

a. Protection of the wound
b. Connection of the pleural drainage tubes to an under water seal.
c. Maintenance of the adequate airway
d. Transportation of the patient.

### *Protection of the Wound*

A light dressing is applied to the wound supported by elastic adhesive tape. The adjacent skin is first rescrubbed with an antiseptic agent followed by an application of tincture of Benzoin, when allowed to dry, makes a sticky surface to which the elastic adhesive easily adheres without undue skin traction. This type of dressing avoids restriction of motion in the thoracic cage and allows coughing and deep breathing in the immediate postoperative period and this is removed next day after operation exposing the closed incision to the air.

*Connection of the Pleural Drainage Tubes to an Under Water Seal*

Classical three bottle suction system is used. The first bottle is for collection and measurement of fluid drained from the chest. Aspiration of air back into the pleural space is prevented by an underwater seal in the second bottle. The negative intrapleural pressure is maintained by the third bottle which has a water column for regulating the amount of suction applied to the pleural space.

*Maintenance of the Adequate Airway*

Prolonged endotracheal Intubation and mechanical ventilation is because of central nervous system depression due to anaesthetic agents, hypoxemia, possibility of continuing bleeding, Inadequacy of cardiac performance.

*Transportation of the Patient*

Oxygen administration by a facemask if the patient is extubated. If patient cannot be extubated, using an anesthetic bag and a portable oxygen delivery system must assist ventilation. Chest tubes should not be clamped during transport, if assisted ventilation is required, connect to an under-water seal.

The complications are:

a. Tension Pneumothorax
b. Cardio-pulmonary collapse.

## Early Management

Following arrival of the patient in the recovery room or intensive care unit, the arterial blood pressure, electrocardiogram and oxygen saturation should be monitored continuously. This helps in immediate recognisation of the problems. Heart and the respiratory rate should be recorded every 15 minutes until the patient is stable. Urinary output, chest drainage tubes, central venous pressure and temperature are measured hourly. Body weight is recorded daily. Chest roentgenograms are obtained the evening of surgery and every morning, thereafter until the day following chest tube removal.

### *Pulmonary Care*

The patients with thoracic operations have abnormal function due to chronic obstructive lung disease. Post-operative pulmonary complications are reduced by chest physical therapy, aerosolized broncho-dilators, mist, hydration, antibiotics and the avoidance of bronchial irritants.

### *Pleural Space*

Pleural drainage tubes must remain patent an frequently examined. The tube should be irrigated with 30 ml of sterile saline, milked through out their length at frequent intervals to prevent clotted blood from occluding them. The amount of pleural drainage should be recorded at hourly intervals. Blood loss should be replaced by blood administered intravenously.

### *Medications*

Following operation intermittent epidural administration of either local anesthetics such as morphine relieves pain, improves pulmonary function and allows early ambulation.

### *Fluids and Electrolyte*

Intra-venous fluid therapy consists of the administration of daily maintenance fluid plus fluid replacement of any losses. Administration of 1000 ml of 5% dextrose and 0.2% NaCl per square meter of body surface area during the first 24 postoperative hours and 1500 ml/square meter for each subsequent 24 hours period is adequate to maintain fluid balance.

*Gastric Distention*

Mechanical ventilation by mask or mouthpiece frequently forces air and anesthetic gases into the stomach. Nasogastric tube is passed into stomach to evacuate the gases and important after a right pneumonectomy where a distended stomach may interfere with movement of the left hemidiaphragm.

## Late Management

The problem of bronchial secretions reduces and coughing is no longer painful. The wound support is not required and dressing can be removed. The wound can be covered with a light gauze dressing or not required. If the wound is left open care must be taken to avoid its irritation by rubbing against bedsheets, e.g: Posterior thoracotomy wound. So irritation reduced by a frequent change of position and placement of the patient on a sheep skin cover. The patient should be up and out of bed.

Prolonged sitting especially with legs crossed should be avoided to prevent venous stasis. The patient should be encouraged to eat his meals sitting in a chair. By the third post-operative day the patient should be on a general diet. The patient should be encouraged to take frequent warm showers after the drainage tubes are removed. Gentle bathing of the wound has a mild analgesic effect and provides relaxation.

Skin stitches may be removed on the 7th or 8th postoperative day. The use of absorbable subcuticular sutures greatly facilitates wound care post-operatively.

The medication should be stable and the patient should not have any complications for the patients, should be ambulatory and able to care for themselves, who are ready for hospital dismissal. An exercise Programme should be outlined that will prepare these patients for resumption of normal life activity and return them to their previous occupation without producing excessive fatigue or undue stress upon the operative wounds. Strenuous physical activity or lifting objects heavier than 10 lbs is prohibited for 6 weeks. Patients are encouraged to walk or perform light exercise immediately upon discharge.

Oral narcotic analgesics are usually required at discharge and reduce after one month long term pain occurs in about 1% of patients and referred to as post-thoracotomy pain syndrome. It is usually from Intercostal nerve irritation and is effectively treated by local injection; Transcutaneous Electrical Nerve Stimulation is helpful.

## VENTILATORS

### PRINCIPLES OF THE VARIOUS VENTILATORS AND THEIR USES

#### Definition

Ventilators are the devices used for artificial ventilation.

#### Indications

1. Respiratory failure
2. Crush injuries of the chest, severe scoliosis, major surgery
3. Muscular cases like Tetanus, Myasthenia gravis. Muscular dystrophy
4. Pulmonary: Acute respiratory distress syndrome, Chronic obstructive pulmonary disease, Bronchial asthma and drowning.
5. CNS: Drugs, overdose of morphine, poisoning, epilepsy, Cerebrovascular accident and poliomyelitis.

#### Types of Ventilators

1. *Negative pressure:* The whole body below neck is kept in a large negative tank and a negative pressure is set in tank and this induces pressure.
2. *Positive pressure:* Air is sent into the lungs with pressure more than atmospheric pressure, i.e. supra atmospheric pressure is set up and air is driven through trachea.
3. *High frequency positive:* This is of two types:
   a. Jet High frequency positive: 350 breathes /min
   b. Oscillator High frequency positive: 1300 breathes /min.

#### Modes of Ventilation

This is two types. They are:

a. Full ventilatory support
b. Partial ventilatory support

The following provides both of the above

1. *Controlled Mandatory ventilator:* This is the fixed ventilation for definite time intervals, no provision for spontaneous ventilatory effort, limited to intra-operative and immediate post-operative ventilation.
2. *Assist control mode:* This acts like Controlled mandatory ventilator and when the patient takes a spontaneous breathe, the ventilator is triggered to reach a preset level of ventilation.
3. *Intermittent mandatory ventilator (IMV) and Synchronized IMV:* In IMV the patient are free to breathe spontaneously between set ventilator breaths. Mandatory breathes may be synchronized with the patients spontaneous efforts.

## Advantages

1. Better gas distribution
2. Lower mean airway pressure
3. Less Haemodynamic disturbance
4. Less sedation is required
5. Weaning is easier.

## Pressure Support Ventilator

A preset inspiratory pressure is added to the ventilator circuit during inspiration in spontaneously breathing patients.

## Controlled Mechanical Ventilator

Tidal volume and the respiratory rate are set in machine.

## Assisted Mechanical Ventilator

Tidal volume is set and useful in weaning.

## Assisted Controlled Ventilator

The tidal volume is set, the patient is allowed to respire himself.

### Intermittent Mandatory Ventilator

The patient breathes by himself and in between breath rate is calculated. So machine is set.

### Synchronised Mandatory Ventilator

When patient makes his effort the machine itself calculates his requirement.

### Pressure Ratio Mandatory Ventilator

This sets pressure and with inspiration it is sent in by machine.

### Inverse Ratio Ventilator

*Normal inspiration:* Expiration ratio is 1:1.5 to 1:2. So inspiration time is increased a useful in Acute respiratory distress syndrome.

### Independent Lung Ventilator

Bifid endotracheal tubes are used in patient when one side of lung affected is more than other.

### Setting up the Ventilator

1. Ensure the airway is secure
2. Ensure adequate sedation, opioids and muscle relaxants
3. Tidal volume: Normal (10 ml/Kg Body weight)
4. Respiratory rate: 14-16/min
5. Fraction of inspired oxygen: Usually 100% oxygen to start with there decreases slow.

### Factors to be observed in case of ventilation

1. Vital signs like blood pressure, heart rate
2. Consciousness of patient
3. Secrection should be removed periodically
4. Checks alarm function of the ventilator
5. Oxygen saturation in the blood.

### Classification of ventilator on Phases

1. *Inspiratory phase:* This phase has
   a. Pressure generators: Exposes the lung to a pressure
   b. Flow generators: Exposes the lung to the low of gas
2. *Cycling or change over to expiration:* This phase has
   a. Pressure-cycled: This phase pre-sets the pressure
      E.g.: Bird, Blease, Aarlow, Cyclator
   b. Volume-cycled: This phase pre-sets the volume.
      E.g.: Bear, Bennett, Monaghan, Bromptom
   c. Time-Cycled: This phase sets the length of the time
      E.g.: Servo, Clape, Phillips, Engstrom.
3. *Expiratory phase:* PEEP and NEEP allow expiratory restriction or choice to be used so that expiration is slowed. PEEP is a positive pressure and NEEP is a negative pressure.
4. *Cycling to inspiration:* This phase sets function independently without patient so called controlled ventilation.
   a. IMV: Intermittent mandatory ventilation: The gas supplied to the patient so that he can take what ever sized breathe he wishes and is able to.
   b. MMV: Mandatory minute volume: This gives the patient slight assistance to her own spontaneous efforts.
   c. CPAP: This phase is or mil to moderate acute respiratory insufficiency, median sternotomy and CABG. This increases functional residual capacity and improves oxygenation.

### Complications

1. Due to endotracheal tube
2. Barotrauma increases pressure—Surgical emphysema, Pneumothorax
3. Fluid retention
4. Stress ulcers—Gastric or duodenal.

## THORACOTOMY

### PRE-OPERATIVE ASSESSMENT AND MANAGEMENT OF A PATIENT POSTED FOR THORACOTOMY

The Pre-operative preparation of the patient includes:

## Pre-operative Assessment

1. *Chart-review:* The chest should be reviewed with special attention to tests and studies related to the surgery to be done.
2. *Patient interview:* The patients interview can contribute useful information regarding a patient
   a. Family History
   b. Occupation
   c. Habits such as smoking, use of alcohol
   d. Pulmonary symptom, Frequency and pattern
   e. Functional activities must be assessed for determination of appropriate post-operative goals for the patients.
3. Physical Assessment:

### *a. Observation*

Colour
Breathing pattern: Rate, amplitude, Rhythm
Mental state
Posture
Body build
Supportive equipment
Secretion
Patient ability to move
Skin
Scars

### *b. Palpation*

Bilateral palpation of the thorax allows comparison of the symmetry of the following physical signs:

1. Equality of thoracic movement
   a. Lateral costal expansion
   b. Apical Expansion
   c. Posterior thorax: Basal expansion
   d. Diaphragmatic Excursion
2. Vocal Fremitus.

*c. Auscultation and Percussion*

This is important to establish a baseline assessment of chest sound, adventitious breath sounds are noticed, treatment pre-operatively to improve pulmonary status before surgery.

*d. Range of Motion*

The pre-operative range of motion is necessary to observe pre-operative range of motion and to determine goals of post-operative mobility, emphasis should be given to joints that will be affected by incised musculature.

### Pre-operative Condition

The pre-operative course decreases

1. The patients length of stay from surgery to discharge
2. The number of post-operative complications
3. The number of physical therapy treatment required post-operatively.
4. The pre-operative sessions afford the therapist the opportunity to prepare the patient from the surgery.

Major points to be covered during pre-operative session are the following:

### Rationale for Treatment

Explanation about the treatment in detail about

a. Effect of bed rest
b. Immobility on pulmonary status
c. Respiratory depression from anesthesia
d. Appropriate lung response to the surgeries
e. These may decrease aeration and increased mucous production.

### Surgical Procedure

A brief description of the surgical procedure is offered

a. Incision placement
b. Length of surgery
c. Details depends on the patients level of understanding.

## Monitoring and Supportive Devices

Explanation of the monitoring and supportive devices, the patient except to encounter postoperatively is very important and may include the following:

a. Foley-cathetor: To collect urine output and monitor kidney function
b. Chest tubes to drain the thoracic cavity of any accumulation of air or fluid
c. Intravenous tubes to maintain nutrition and hydration
d. Cardiac monitor and electrodes to follow cardiac status.
e. Arterial line to provide an access for arterial blood samples or blood gas analysis and for injection of medication.
f. Left arterial pressure line to measure cardiac function
g. Endotracheal tube to provide an artificial airway for respiratory assistance by a ventilator.
h. Naso-gastric tube to drain gastric secretion.

## Pre-operative Treatment

The post-operative treatment is demonstrated with the patient rolling, positioning for bronchial drainage, percussion, vibration, splinting, coughing are practiced. This provides the patient the required treatment after surgery. The therapist can divide the treatment part into five areas. They are:

### *Deep Breathing*

a. Improves alveolar ventilation which is very important.
b. Prevents post-operative pulmonary complications.
c. Taught in semi-fowlers position where abdominal muscles are slack.
d. This position allows greater diaphragmatic excursion.
e. This is emphasized as a modality for post-operative pulmonary hygiene.
f. Depending upon the patients problems it is taught accordingly. E.g: Some patient can breathe effectively with their diaphragm so need only encouragement to full to aerate their lungs. Some

find technique difficult, so need additional cues. This promotes relaxation and reduces anxiety.

*Rolling*

Rolling technique minimizes trunk movement and allows patient mobility. The patient is encouraged to flex at the hips and knees and roll with the shoulders and hips.

*Coughing*

Anesthesia and surgery causes decreased cough effectiveness. The cough with bronchial drainage, shaking percussion accelerates central and peripheral lung clearance. There are two stages of cough. They are 1. Full –Raises secretion 2. Deep Diaphragmatic facilitates expectoration. Bigger is the breathe stronger will be cough. Patient are instructed to apply pressure over the incision by using pillows or their hands or it may cause pain near the incision area. The patient will be taught huffing. Huffing is an effective mode of secretion mobilization and may be used as an alternative in patient who has an ineffective cough.

Huffing is a accomplished by forceful expiration through an open glottis. The patient is asked to say the word huff and attempt to elongate the word H. Repetition of the maneuver stimulate spontaneous cough.

*Incentive Spirometry*

It is an adjunct to breathing exercises that provides the patient with visual feed back of the volume of inspired air during a deep breathe. The patient are encouraged to practice deep inspiration every hour, chest physical therapy session. Maximum inhalation with incentive spirometry inflates alveoli and decrease post-operative complications. Others are IPPB (Intermittent positive pressure breathing) and PEEP (Positive end expiratory pressure).

*Ankle Circles*

Use of ankle pump to minimize the incidence of phlebitis facilitates venous return.

These pre-operative session strengthen the patient therapist relationship. The patient feels confident meeting the therapist who will tract them through their hospital course.

## MANAGEMENT OF THE FOLLOWING

Management of endotracheal/Endonasal tubes
Tracheal suction,
Weaning the patient from the ventilator
Extubation technique
Post extubation care.

*Endotracheal tube:* The tube passed through mouth or nose when the patient cannot maintain his /her own airway then Endotracheal tube is used.

The tube passed through mouth is called oral endotracheal tube and the tube passed through nose is called nasal endotracheal tube.

## TRACHEOSTOMY

### Definition

An operation to create an opening or stoma into the trachea.

### Oral Intubation

The oral Intubation is easy to perform but patient may clamp his teeth on tube and totally obstruct his airway.

### Nasal Intubation

The nasal Intubation overcomes the problem but longer tube of smaller diameter has to be used. There is a risk of sinusitis as tube may block the nasal sinus.

### Tracheostomy

The patient will be more comfortable. This is one by 7 days.

### Functions of Endotracheal or Tracheostomy Tube

1. To facilitate access to pulmonary secretion.
2. To prevent substances from the mouth entering and soiling the lungs.
3. To help to maintain positive pressure ventilation by preventing air from escaping round the tube.
4. To pass by an obstruction preventing ventilation. All Endotracheal tube and Tracheostomy tube decrease anatomical dead space by half size. Neonatal is 2.5 mm, Adult is 0.5-11.0 mm. The silver tracheostomy tube is used in intermediate stage before finally closing the tracheostomy. It is an important feature for patients following laryngectomy. It has an inner tube which can be removed for cleaning. Some tubes have a value which allows the patient to speak.

### Disadvantages

1. Increase danger of infection
2. Loss of Humidification
3. Dry gases can cause blockage of respiratory passage.

### Description of Tube

The tube is simple made of plastic, has a right angle curve so that it fits over the tongue and pharynx. Airway vary in size, facilitates artificial ventilation.

### Uses

1. The suffocation of the unconscious patient is prevented by the tongue falling backward.
2. Tube gives clear way for suction in unconscious and conscious patient.

### Arrangement

Mouth rotated through 180 degrees and put the airway into the mouth with curved end pointing upwards, direct to pharynx.

*Types:* Plain type for adults and cuffed types for children and babies.

To maintain in position, place a piece of cotton tape is tied round the tube, for early release tie to side of neck. This is a temporary measure for 3-4 days to 1 week and has safe usage.

## ENDONASAL TUBES

### Definition

Endonasal tube is a Tube to assist ventilation.
*Material:* Rubber, silicon, Teflon. PVC.

### Variety

Two varieties are available. They are:
1. Disposable
2. Autoclaved.

### Types

Two varieties, they are cuffed for adults and uncuffed for children.

*Mode of Intubation:* Nasal

*Size:* Internal diameter:

*Adults males:* 9 mm

*Adults Females :* 6-8 mm

*Children:* 4 mm (Age till plus four)

*Length:* Adults males and females: 23-25 cm

*Endotracheal tube:* Age: 2 years – 12 to 15 cm

## Steps of Intubation

### *Endotracheal Tube*

Anesthesia locally given with hallolhane 4%, suxamethonia muscle relaxin through right side of mouth through glottis below vocalcord with pressure 25-30 mm of water.

### *Endonasal Tube*

Passed through the Floor of nose.

*Uncuffed Endotracheal tube:* Pushed 3-4 cms behind the vocalcords, infants: less than 6 months : 2 cm, only neonates : 1 cm

## Complications

1. Injury to lips, teeth, oral cavity
2. Injury to nose, para-nasal cavity
3. Eustation tube infection leads to autitis, sinusitis, epitaxis, laryngitis, sore throat, tracheal stenosis, kinking of tube, foreign body aspiration, tracheal tube obstruction can be kinking, biting, foreign body like dried mucous, blood loss, pus, debris, granulation and defective tubes.
4. Airway oedema
5. Vocal cord dysfunction
6. Nasal damage
7. Dental or oropharangeal complications.

## Naso-gastric Tube Complications

1. Ulceration and necrosis of nares
2. Oesophageal reflex, oesophagitis, erosion, stitcher formation
3. Mouth breathing
4. Interference with ventilation and cough
5. Loss of fluid
6. Otitis media
7. Sinusitis
8. Traumatic laryngitis
9. Hoarseness.

## SUCTION

### Definition

Suction is a procedure that facilitates removal of bronchial secretion.

### Suction Equipment

Suction apparatus like electrical and portable, foot pump.

### Suction Tubing

Connections, catheters, suction trolley.

### Suction Technique

Suction catheter introduced through nose and mouth.

### Aim

To stimulate cough reflex.

### Types

Naso-pharyngeal, oropharyngeal, tube suction, minitracheostomy.

### Minitracheostomy or Tracheal Suction

This is performed under local anesthesia on the ward. A narrow cannula is inserted surgically into the trachea then left in place for as many days as required. Suction with tube size 10 catheter can then be performed through the aperture with the patient breathing normally throughout. The minitracheostomy preserves the function of the glottis so that coughing, speaking and eating are safe guarded, while spontaneous breathing and natural humidification are usual.

*Uses*

1. This is a simple procedure.
2. Bronchoscopy and Intubation are not required.

## WEANING

### Definition

Weaning is the disconnection from the ventilator.

Some patients its very easy others need a protracted period of weaning with presence of lung disease or after long-term ventilatory support. This period includes a trial of spontaneous breathing through the artificial airway during which the patient is assessed or extubation.

Difficulties in weaning are due to:

1. Damage of inspiratory muscles occur due to lung disease
2. Fear of suffocation.

### Weaning is Successful

1. When maximum ventilatory reserve is present or airway is clear and baseline values or vital capacity, respiratory rate, inspiratory force and blood gases.
2. Optimal nutritional status, fluid, metabolic and cardiovascular status are present.
3. The maximum mobility, endurance are facilitated by practice in standing and walking.
4. Minimum sputum, maximum ability to cough are present.
5. Previous good night sleep is must.

### Method

1. Explanation of the procedure is given to the patient.
2. Gradual reduction of ventilatory support can be achieved by decreasing the frequency of breathes during IMV or SIMV reducing the pressure during the assist control mode.
3. The patient sits in a chair with arm rests or sit upright in bed.
4. Humidified oxygen or CPAP is prepared if oxygen is connected by a T- piece, extension tubing of 30 cm long should be attached to the exit to prevent entrainment of room air in case the patients inspiratory flow exceeds the system flow rate.
5. The air is suctioned.
6. The patient is disconnected from the ventilator, given oxygen or CPAP, encouraged to breathe and monitored for signs of laboured breathing, anxiety, desaturation, fatigue or drowsiness.

7. Difficulty in weaning may be due to undetected diaphragmatic paralysis, anxiety or inspiratory muscle fatigue. Reassurance and relaxation feed back can be used for anxiety and periods of rest for fatigue.
8. Preparation with inspiratory muscle training or incentive spirometry is helpful in appropriate patient.

## EXTUBATION

After weaning from the ventilator, the endotracheal tube should be removed at the earliest because breathing through an artificial airway can double the load applied to the system. Patients can be extubated once they are alert, able to control their airway, show a stable breathing pattern. The ability to straight leg raise indicates that they have the strength for an effective cough.

### Steps for Extubation

1. Physiotherapy or airway suction is required.
2. Check for the cough reflex.
3. Ensure that re-intubation equipment and personnel are available.
4. Explain the procedure.
5. Suck out the mouth and throat to clear secretions that they have pooled above the inflated cuff.
6. Cut the tape holding tube in place, insert a fresh catheter to reach just distal to the tip of the tube deflate cuff, remove tube at peak inspiration when vocal cords are dilated, suction is done during drawal.
7. Encourage patient to cough out secretions that have accumulated around the distal end of the tube.
8. Given oxygen or CPAP, observe monitors, listen for stridor.
9. Enjoy the patients delight at renewed voice.
10. If sputum retention is anticipated, it is better go for mini-tracheostomy or lead to respiratory distress.

Removal of the Tracheostomy tube-post extubation care.

Weaning for tracheostomied patient is to replace the cuffed tube with an Uncuffed or fenestrated tube both of which can be played for increasingly longer periods to test for adequate breathing and coughing. The fenestrated tube has an inner and outer cannulae opening in their posterior walls allowing air to pass through the larynx for speech.

Another device is the speaking tube, which is an inner cannula with a flange that closes on expiration thus forcing air through the cords for speech. When the tube has been removed, the patient is taught to hold a sterile dressing firmly over the stoma when coughing.

## CARDIO-PULMONARY RESUSCITATION

**Basic Life support**
**Advanced life support (DEF)**
**Prolonged life support (GHI)**
**Cardiac massage**
**Defibrillation**
**Artificial Ventilation**
**Mechanical Respirators**

### Definition

Cardio-pulmonary resuscitation is the re-establishing of Heart and lung action after cardiac arrest or apparent sudden death resulting from electric shock, drowning, respiratory arrest and other causes.

1. Basic life support (ABC)
2. Advanced life support (DEF)
3. Prolonged life support (GHI).

### Basic Life Support (ABC)

*Airway*

Airway Ensure patient has patent airway, remove fluid and debris from mouth.

*Breathing*

Breathing is the maintenance of a patent airway. So inflate the patient lungs rapidly 3.5 times using following methods. They are:

1. Use mouth to mouth or nose to mouth ventilation

2. Insert an airway give mouth to airway ventilation
3. Ventilate the patient using a bag and mask.

*Circulation*

Control bleeding by applying pressure on bleeding point an elevate.

### Advanced Life Support (DEF)

*Drugs*

- Adrenalin—0. 5-1 mg repeated 3-5 minutes.
- Sodium bicarbonate 1 m equivalent per kg body weight, repeated every 10 minutes of arrest time.
- Intravenous fluid as required, e.g.: Blood or plasma.

*ECG*

As soon as possible ECG must be monitored.

*Fibrillation Treatment*

- External defibrillation using 100-400 joules. Repeat shock as necessary
- Convert Fine fibrillation to coarse fibrillation using adrenalin
- Lignocaine 1-2 mg /kg intravenously as necessarily.

### Prolonged Life Support (GHI)

*Gauging*

- Gauge the likely outcome of resuscitation
- Gauge the cause of the cardio-respiratory arrest and treat it.

*Human Mentation*

- Preserve cerebral function by maintaining normal cerebral blood low and oxygenation.
- Reduce and control Intracranial pressure
- Monitor cerebral function.

*Intensive-care*

- Provide intensive therapy
- Intensive nursing

- Intensive monitoring.

The two major components of the cardio-pulmonary resuscitation are

## Cardiac Massage

*Indications*

- Cardiac arrest causes cessation of heart beat will lead to cerebral anoxia and patient will die within three minutes
- Circulatory arrest, Disappearance of the carotid pulse indicates cerebral anoxia.

*Procedure*

Airway must be clear and oxygen must reach the lungs. The surgeon begins external or internal cardiac massage.

## External Cardiac Massage

In this heart is compressed between the sternum anteriorly and vertebral column posteriorly. The pericardium restricts lateral movement. The natural elasticity of the thoracic cage permits 4-5 cm depression or the sternum before any damage is done to the ribs or the costal cartilages. As the compression is released, the natural elasticity of heart sucks blood from the great veins, blood flow is seen in the ventricles.

The patient is placed supine on a firm surface. The surgeon places the heel of one hand over the lower part of the sternum but superior to xiphisternal joint. The other hand is placed on the top of this hand pressure is applied vertically downwards on the sternum approximately every second. After each pressure the surgeon allows the chest to re-expand fully. 60 compressions are attempted in one minute. In small children only one hand is used and sternum is depressed with the thumb. After immediate threat to the life is removed ECG is taken, cardiac monitor is attached. In ventricular fibrillation, electrical defibrillator should be carried out.

### Internal Cardiac Massage

If the external cardiac massage has failed to reactive the heart, internal cardiac massage should be tried and this is done with speed by thoracic or abdominal approach. The transabdominal route can be opted preferably positive pressure ventilation and endotracheal Intubation are absent.

Trans-thoracic approach: The patient left arm is abducted and surgeon stands on the left side of the patient. Spirit is poured on skin, incision made of the 4th Intercostal space starting from the border. If the sternum to the posterior axillary fold. It is deepened through the muscles. The pleura is opened but the dilated heart should be protected. The right hand of the surgeon is insinuated into the thoracic cavity and by placing the palm beneath the heart it is compressed against the sternum at the rate of about once a second.

This is continued till the surgeon gets pain in his hands when the hands are withdrawn and the costal cartilages are divided above and below. A mechanical rib retractor is used to retract the ribs apart.

Preliminary internal massage will allow the time for this retraction and proper exposure. Pericardium is opened as quickly possible in front of left Phrenic nerve. The cardiac massage is re-started with the right hand behind the heart and left hand in front of it. The compression should be gradual and relaxation abrupt. The heart must be full before it can emptied again. The compression should be made evenly with the palmar surfaces of the fingers and care must be taken not to injure the heart by using the tip of the fingers.

For continuous a systole 5-10 ml of 1% calcium chloride is injected directly into left ventricle if the heart is blue and flaccid. For continuing a systole and if the heart is pink and has tone or above measured has failed 1-2 ml of 1: 1000 adrenaline can be injected into left ventricle (This needs electrical defibrillation as this will induce fibrillation). Intravenous sodium bicarbonate is given in the dose of 100-150 ml. The suturing I done, pericardium repaired internal mammary arteries are ligated. Strong sutures are placed around the adjacent ribs. Chest drainage is connected to a water-seal drainage.

### Sub-diaphragmatic Cardiac Massage

A mid-line upper abdominal incision is made. The hand is introduced and compression is carried out through the diaphragm. The massage can be improved if the diaphragm is opened. The triangular ligament of the left lobe of liver is divided. The diaphragm and pericardium are incised to expose the Heart. The opening is enlarged. The fingers are insinuated through this opening and with palmar surface of fingers the heart is compressed against the sternum. The required is 80 minutes of cardiac massage.

### Defibrillation

Ventricular fibrillation, ECG will show irregular low amplitude wave line in place of regular QRS complex. Once this is recognized electrical defibrillation should be attempted. One electrode is applied to the anterior chest wall to the right side of the sternum other over the cardiac apex. Direct current of 200 joules is used and shock is given or alternate current of 300-750 volts are used. After a brief period of a systole the heart will revert to the normal rhythm. If heart is failed to revert, higher voltages are required. A further period of massage may convert fine fibrillation into coarse one. 5 ml of calcium chloride (10%) given directly to the heart will improve myocardial tone. Normal contraction of the heart persistently reverts to ventricular fibrillation then procaine amide or Lignocaine (1 ml/kg body weight) should be injected.

The heart should be observed for a sufficiently long time for about 20 minutes.

## ARTIFICIAL VENTILATION / RESPIRATION: ARTIFICIAL RESPIRATION IS A LIFE SAVING MEASURE

### Indications

- Acute Asphyxia due to drowning
- Gas poisoning
- Electrocution
- Anesthetic accidents.

### Importance

Respiration stops before heart stops.

### Method

Mouth to mouth breathing.

### Advantages

Simple method, works by expanding the lungs.

### Procedure

The victim should be in supine position, opens the airway by placing a hand under the neck and lifting. Keeping pressure on forehead with the other hand extend the neck and lift the tongue away from the back of the throat. The victims mouth is covered by the operators mouth. The operator blows about 12 times a minute into the victims mouth. The tidal volume becomes twice, elastic recoil of lungs occur causes passive expiration. The victims neck is kept extended. In apnea patients along with artificial respiration, cardiac massage is given.

## MECHANICAL RESPIRATORS

### Indications

- Chronic respiratory insufficiency
- Pulmonary Oedema
- Acute respiratory distress syndrome.

The mechanoreceptors are airtight metal or plastic containers that are used to enclose the body except head. Portable covers only chest. It has a motor which creates negative pressure is applied to the chest at regular intervals which brings movement in the chest wall. Breathing against PEEP impress oxygenation in Acute respiratory distress syndrome.

### Complications

- Weak and malnourished Patients

- When respirometer takes over the work of breathing there is disuse atrophy of the respiratory muscles.

## PHYSIOTHERAPY MANAGEMENT FOR THE THORACIC SURGERY

The incisions include lateral incisions, anterior incisions, pneumonectomy, lobectomy, throcoplasty and segmental or wedge resection, etc. The Physiotherapy rehabilitation programme plays a very important role pre-operatively and post-operatively for early recovery of the patient.

*Physiotherapy is divided into*

a. Pre-operative Physiotherapy
b. Post-operative Physiotherapy

## PRE-OPERATIVE PHYSIOTHERAPY

The Aims and Plans of the Physiotherapy are:

| *S. no* | *Aims of physiotherapy* | *Plans of physiotherapy* |
|---|---|---|
| 1 | To gain patients confidence | Explain the patient the importance of physiotherapy pre-operative and post-operative rehabilitation programme and about the surgery and its complication. Answer the questions of the patient to reduce the fear of the surgery |
| 2 | To clear lung fields | The manipulations like shaking, Clapping, vibrations with postural drainage both for affected and normal lung. Huffing and coughing techniques. Huffing is preferred than coughing after post-operatively. Wound supporting after surgery. The arm of the effected side is placed across the front of the thorax and round the affected side just below the incision site and give firm pressure with forearm and hand. The affected side upper arm gives pressure and the hand holds the opposite elbow. |

*Contd...*

*Contd...*

| | | |
|---|---|---|
| 3 | To teach respiratory control and inspiratory holding | Inspiratory exercises are taught for the sound lung together with inspiratory holding. The patient is asked to deep breathe in, hold again, breathe in again and hold and breathe out. |
| 4 | To teach breathing control | Breathing exercises are taught to expand the lung tissue on the affected side. Breathing control expanding the remaining lung and other techniques are forced expiration technique and coughing are also taught |
| 5 | To teach postural awareness | Posture correction exercises |
| 6 | To teach arm, trunk and leg exercises | Shoulder girdle, shoulder, trunk and lower extremity exercises are taught |
| 7 | To teach bed mobility | Turning from supine to side lying to sitting and standing are taught which are useful post-operatively |

## POST-OPERATIVE PHYSIOTHERAPY

The Physiotherapy rehabilitation programme given post-operatively. The physiotherapist must check whether the patient is on oxygen therapy, drains are in the thorax as it is used to control the amount of fluid in the cavity left by the lung. The rate of respiration is checked and recorded. The patient shouldn't cough as this puts risk on the sutures of the bronchial stump.

The Aims of Post-operative physiotherapy are:

1. To maintain good posture
2. To clear secretions from the remaining lung
3. To avoid circulatory complications
4. To gain exercise tolerance
5. To avoid wound complication
6. To get full expansion of the lung tissue
7. To achieve arm and spinal movement
8. To prevent deep vein thrombosis.

The plans of Physiotherapy are according to the:

### Day of Operation

a. The patient is in the half lying position, the neck, back and forearm are well supported with pillows and forearm on the thighs of the patient.

b. Breathing exercises should be practiced by the patient for lung expansion
c. Foot and ankle exercises to prevent Deep vein thrombosis
d. To loosen the secretions the Vibrations are given on the unoperated side
e. Incisions supported by the physiotherapist and patient is asked to practice huffing.

*Day –1*

a. The patient is in half-lying position Breathing exercises are practiced, shaking is given and the patient is asked to huff and the wound is supported initially by the physiotherapist and later by the patient himself.
b. Foot and ankle exercises are done by the patient
c. Correction of the posture to prevent faulty posture on the incision side
d. Patient sits out of the bed for diaphragmatic breathing
e. Arm exercises are done like full elevation, hand behind the head, hand behind the back, hand touching the opposite shoulder are done
f. A rope and ladder are provided for the patient to pull on it and move around the bed and sit up
g. Breathing exercises and inspiratory holding are done
h. Vibration and percussion are given on the operated side
i. Patient is side lying on the unoperated side.
j. Patient positions, drains are free, patient is in side-lying on unaffected side is supported by pillow. The other shoulder should not be on the pillow supporting the head. Top knee is flexed and on pillow and other knee is extended and on mattress. Expansion breathing exercises for remaining lung tissue with vibration and percussion.
k. Postural drainage is given for the foot end of the bed
l. Position sense of patient in half-lying, check the level of shoulders and weight taken equally on both buttocks
m. Operated side arm exercises are Assisted arm elevation, Assisted arm movements to touch the back of the neck, Assisted arm

movements to touch the opposite shoulder. Leg exercises are foot and ankle movement, Quadriceps isometric contraction, alternate hip and knee bending and stretching.

*Day –2*

a. The treatment is same as the Day –1
b. Sitting on the edge of the bed
   i. Trunk turning to the right and left side
   ii. Trunk bending to side and left side
   iii. Trunk bending backwards
c. Bilateral breathing exercises by sitting in the chair
d. Trunk erect and arm swinging
e. Self supported huffing
f. Arm exercises in full range of elevation and must be done every hour
g. Trunk exercises in sitting:
   i. Hands on shoulders bends side to side
   ii. Hands on shoulder turn side to side
   iii. Abdominal contraction
h. Breathing exercises, coughing
i. Postural awareness of head, neck and trunk are straight
j. Patient can walk if drains are present but pulling drain on trolley. The drain will be removed by 2nd day if fluid drain is equal or more than 200 ml or drain is retained
k. Patient has chances of getting deep vein thrombosis if sits cross-legged because of occlusion of popliteal artery and popliteal vein.

*Day –3*

a. Breathing exercises
b. Huffing
c. Group therapy in the ward with trunk and arm exercises performed
d. Walking is extended
e. Going up and down stairs.

*Day –4*

a. Group therapy in the ward with trunk and arm exercises performed
b. Patient gets dressed himself
c. Patient walks further distance
d. Going up and down the stairs
e. Trunk exercises in sitting.

*Day–5-7*

a. Trunk exercises in standing
b. Posture correction in walking
c. Bilateral breathing exercises.

*Day–8-10*

a. Going up and down stairs with breathing control
b. Bilateral breathing exercises
c. Trunk and arm exercises
d. Stitches come out usually by 7-10 days after operation.

*Day–10-12*

a. Discharge from hospital
b. Strict instruction to continue exercise programme like exercises to maintain trunk mobility, thoracic cage mobility, good posture which have to be continued at home for three months after discharge.

*Review and follow up:* The physiotherapist should check the patient posture and thoracic expansion.

### Modification of this Programme

Postural drainage is necessary if the lung remaining secretions does not clear properly because patient positioned on the opposite side.

If the air entry to left lung is not sufficient intermittent positive pressure breathing is used to improve ventilation.

Oxygen therapy and humidification are necessary. If the recurrent laryngeal nerve is injured breathing exercises and huffing clears the secretions.

If Phrenic nerve is damaged, the paradoxical movement of the diaphragm makes coughing ineffective so intermittent positive pressure breathing can be used to mobilize secretions and increase air entry.

Inspiratory capacity can be improved by incentive spirometry. This is a technique used for thoracic or high abdominal surgery patients with pain or retention of secretions.

Patient is asked to take deep breathe in through a tube which attached to a device that shows or demonstrates the volume of the inspired air.

E.g.: A plastic ball is present inside which rises with inspired air in the column. Low lung volume rises to top of a column, mid lung volume rises a second ball, high lung volume a third ball rises.

The patient holds a deep breathe the balls remain at the top of the column. These are few devices which operate by a light coming on when the volume of breathe reaches a level of preset. A few work on the expiratory phase rather than inspiratory phase.

# Miscellaneous

CHAPTER 4

## MYOCARDIAL INFARCTION

### MANAGEMENT A PATIENT AFTER A MYOCARDIAL INFARCT

#### Definition

The infarction occurring due to thrombolic occlusion or prolonged spasm of the blood vessels. The entire process taken 6 hours to complete.

#### Clinical Features

*Symptoms*

- Chest pain: This is abrupt in onset
- Breathlessness
- Vomiting
- The patient collapse and look pale, cyanosed, restless, excited and unconscious.

#### Signs

- Pulse: Fast and feeble
- Blood pressure: Increases
- Heart sounds: Muffled
- Murmurs

- Fever
- Pericardial rub may appear.

### Investigations

*Non-Specific Tests:* Poly-morphonuclear leucocytosis occurs and will be high because of tissue necrosis.

*ECG changes:* ST segment elevation occurs and T-wave inverts.

*Serum enzymes:* Elevated in blood

*Echocardiography:* Helps to detect myocardial Ischaemia.

### Treatment

*ICCU*

The patient is admitted to ICCU to deal with disturbance of cardiac rhythm and pump function. This is for three days.

*Activity*

Bed rest should be or 1-2 days because early mobilization precipitates arrhythmias and Heart failure causes extension of the infarction and leads to development of ventricular aneurysm and rupture. If Myocardial infarction is uncomplicated causes mobilization can be started by the second day and patient discharged after 7 days. Prolonged bed rest can cause Thrombophlebitis and pulmonary embolism and risk can be reduced by anti-coagulants.

*Oxygen*

The patients who suffer from arterial Hypoxemia are given oxygen (Nasal mask through Woulfes bottle) at the rate of two liters per minute for at least 4-6 hours per day.

*Diet*

A diet of 1500 calories of soft food with increased bulk to prevent constipation and no salt is added. Obese patients are made to loose extra fat during this time. First 24 hours only liquids and fruit are advised. Oral fluids intake should be around two liters per day.

### *Control of the Chest Pain*

A. Sublingual Nitroglycerine 0.3–0.4 mg every 5-10 minutes till pain is relieved.
B. Morphine Hydrochloride 15 mg sub-cutaneously or 2-4 mg intravenously.

### *Anti-coagulation*

Administration of anti-coagulant helps to reduce thrombophlebitis and pulmonary embolism. A mini-dose of heparin 2000-5000 units every 6-8 hourly for first 4-5 days.

### *Prevention of Ventricular Fibrillation*

Lidocaine drug is administered if cardiac failure and shock are not present and slow intravenous drip of 50-300 mg with a maintenance dose of 2-5 mg per minute is given.

### *Left Ventricular Failure*

Diuretics Vasodilators, Digitalis, Beta- Adrenergic agonists

Hypotension can be treated with Dopamine.

Common methods of death are :

1. First few hours –Ventricular fibrillation
2. First few days: Pump failure
3. First few months–Reinfarction.

## Complication

1. Left ventricular failure
2. Hypotension.

## Surgery

1. Percutaneous Trans-luminal Coronary angina (PTCA)
2. Coronary artery Bi-pass graft (CABG).

## MYOCARDIAL INFARCTION—PHYSIOTHERAPY MANAGEMENT

The myocardial infarction patients are given a systematic physiotherapy management right from the moment the patients health condition is stable. The management is as follows:

### Physiotherapy During First 48 hours of the Attack

*Aim*

a. To prevent chest infection by accumulation of the secretions in the lung
b. To prevent deep vein thrombosis
c. To improve the breathing efficiency.

*Plans*

a. Breathing exercises
b. Ankle and toe movements every hour.

*Day -3*

The patient health condition will completely stable by the 3rd day. The patient will be active. The patient will be out of intensive care unit. The patient must be encouraged to go for a short walk in the ward because early mobilization prevents the after effect of the prolonged bed rest. The patient should continue the same programme till he gets discharged from the hospital.

*Day -7*

This is the discharge from the hospital. In the first week the patient will be at home, takes rest of about 8 to 10 hours at night, 1 or 2 hours in the afternoon.

*Second week:* By second week the patient can walk in the garden

*Third week:* After third week daily walk is must.

*Sixth week:* By six weeks the patient walks 3 or 4 miles a day. The patient can only travel by car after 6 weeks and by foot after 3 months of the attack.

### The Physiotherapy Programme in the Hospital Ward

Once the patient is stable the mobilization programme is advised to the patient. This programme consist of set of exercises with increased repetitions day by day.

*Stages of mobilization programme:* The mobilization programme is the patient response of the activity to the rehabilitation programme. A record of this programme is maintained. This programme is divided into stages. They are:

Stage -1

a. The patient is given bed rest
b. Breathing exercise to improve the breathing efficiency
c. Foot and ankle exercises to prevent deep vein thrombosis
d. Patient is given bath and also food if required.

Stage -2

a. The patient sits in the chair for about one hour
b. Patient feeds himself
c. Breathing exercises
d. Foot and ankle exercises.

Stage -3

a. The patient sits in the chair for about 2 hours. One hour in the morning and one month in the evening
b. Breathing exercises
c. Foot and ankle exercises.

Stage -4

a. The patient goes independently to the toilet
b. Bed end exercises are performed. Each exercise should be performed for 5 repetitions. The patient stands facing the end of his bed.

1. Double knee bending
2. Arm abducted to the shoulder level

3. Alternate leg swinging
4. Finger tips on the shoulder and arm circling.

Stage-5: The same above programme should be continued by the patient with six repetitions of each exercises should be done.

Stage-6: The same above programme should be continued by the patient with seven repetitions of each exercises should be done.

Stage-7: The same above programme should be continued by the patient with eight repetitions of each exercises should be done.

Stage-8: The same above programme should be continued by the patient with eight repetitions of each exercises should be done and walking up and down the stairs should be done.

Once the patient is able to perform all the exercises then the exercise regime is given which the patient should follow:

### Physiotherapy Rehabilitation Programme in the Physiotherapy Department

*Aim*

a. To reduce the severity of the myocardial infarction
b. To reduce the frequency of the myocardial infarction
c. To restore the patient confidence to go back to the normal life
d. To increase the exercise tolerance
e. To provide the benefits of the exercise.

*Indications*

a. 65 years of age, above and below
b. Previous history of the myocardial infraction attack
c. No other disease or disability.

*Contraindications*

a. Emotional disturbance
b. Non-co-operative patients.

*Test:* Exercise tolerance test is done before the exercise prescription so to know the functional physical capacity and based on that the exercise programme can be suggested.

The exercise tolerance test can be done on treadmill or bicycle ergometer. The ECG, Blood pressure and resting heart rate can be recorded before and after the test. The heart rate is recorded continuously by finger pulsimeter. The test should be stopped if patient shows the symptoms like high blood pressure, excess heart rate, shortness of breathe of chest pain.

*Exercise regime:* This consist of warm up exercises, circuit exercises, group activity and home programme.

*Warm up exercises:*

a. Arm swinging forward, backward and sideways
b. Trunk side flexion to the right side and left side
c. Alternate leg swinging
d. Trunk rotation with arm swinging
e. Knee bends.

*Circuit exercises:*

a. Shoulder wheel exercise
b. Rowing machine
c. Westminster pulley for arm extension using weights
d. Step–ups on a low stool
e. Sitting, raising, lowering 5lb medicine ball over head
f. Static bicycle.

*Group exercise:*

Volley ball playing with other patients.

*Home programme*

a. Supine lying: Raise both the arms above the head to touch the floor behind the head
b. Supine lying: Alternate straight leg raising
c. Crook lying: Bend up both the knees, feet resting on the floor, raise the pelvis count 10 and lower called pelvic bridging exercises

d. Crook lying: Bend up both the knees, feet resting on the floor, raise the pelvis and turn both the knees to one side then to the other side
e. Prone lying: Elbow push ups.

## CHRONIC OBSTRUCTIVE AIRWAY DISEASE

### COPD

### Definition

The chronic obstructive pulmonary disease is a chronic, slow progressive disorder characterized by airflow obstruction.

Chronic obstructive airway disease comprises of chronic bronchitis, emphysema, asthma, bronchiectasis and cystic fibrosis.

### Aetiology

- Cigarette smoking causes airway inflammation and causing a direct imbalance in oxidant/anti-oxidant capacity and proteinase/Antiproteinase load in the lungs.
- Dusty or polluted environment
- Low birth weight
- Alpha antitrypsin deficiency causes emphysema.

### Pathology

- Retention of secretion
- Broncho spasm
- Pulmonary embolus
- Cardiac failure
- Rib fracture–Intercostal tears
- Pneumothorax
- CNS depression.

### Treatment

- Reduction of bronchial irritation
- Treatment of the respiratory infection
- Bronchodilators

- Oxygen therapy
- Anti-inflammatory therapy.

*Surgical Treatment*

Lung transplantation.

### Complications

- Respiratory failure
- Pneumothorax
- Cor Pulmonale
- Heart failure.

### Prognosis

This is related to the age, patient with atrophy has a better survival, pulmonary hypertension in COPD implies a poor prognosis.

## CHRONIC BRONCHITIS

### Definition

It is a chronic or recurrent increase of mucus secretion on most days during at least three consecutive months of two successive years sufficient to cause expectoration is called chronic expectoration.

### Aetiology

*Age:* Middle to adult life
*Sex:* Men : Women = 5 : 1

### Causes

Atmospheric pollution by cigarette smoking or coal dust.

### Pathology

Excess of mucous is produced by irritative substances which stimulates over activity of the mucous secreting glands and globlet cells in the bronchi and bronchioles. The cells increase in size, ducts become dilated causes chronic inflammatory process results in mucosal Oedema causes decrease in diameter of the airways. Airway obstruction occurs during expiration results in air-trapping in the alveoli. Lung elasticity is decreased as disease progresses.

### Clinical Features

- Cough is intermittent and later becomes continuous cough or years on lying down or in the morning
- Sputum will be mucoid and tenacious
- Wheeze will be worse in the morning
- Dyspnoea
- Deformity like barrel chest
- Cyanosis
- Cor-pulmonale.

### Diagnosis

- *X-ray:* No abnormality is seen
- *Lung function test:* Residual volume and vital capacity is increased, Decrease of FEV 1 and FVC ratio
- *Blood gases:* Partial pressure of carbon dioxide increases and partial pressure of oxygen falls
- *Auscultation:* Breath sounds are vesicular with prolonged expiration.

### Treatment

- Advising the patient to stop smoking, avoid dusty atmosphere if required occupation and housing condition are to be changed can decrease bronchial irritation
- Control the infection by antibiotics and flu injection in each winter
- Control bronchospasm with drugs like salbutamol
- Control or decrease the amount of sputum by inhalations and humidification
- Oxygen therapy: Controlled oxygen is given through ventilatory mask.

## EMPHYSEMA

### Definition

This is a lung condition with permanent dilatation of the airspaces and destruction of the wall of airways distal to the terminal bronchioles.

### Aetiology

1. Family History
2. Smoking
3. Congenital factors: Antitrypsin deficiency
4. Secondary to other COPD conditions
5. Pneumoconiosis

*Sex:* Both

*Age:* 40-60 years

### Types

1. Centrilobular (Centri-acinar): Affects only respiratory bronchioles
2. Panacinar (Pan–lobular): Alveoli and Respiratory Bronchioles.

### Clinical Features

1. Dyspnoea: Initially on exertion later on less activity and rest
2. Respiratory pattern: Inspiration is fish like, Expiration is pursed lips
3. Cough with sputum
4. Poor posture: Thoracic kyphosis causes elevated and protracted shoulder girdle
5. Cor Pulmonale
6. Polycythaemia.

### Diagnosis

1. Breathe sounds decreases
2. Prolonged expiration is seen.

*Radiograph:* Low diaphragm and flat

*Chest shape:* Barrel chest

*Lung function tests:* FEV1/FEV below 70%, Residual volume is increased.

### Complications

1. Pneumothorax
2. Respiratory failure
3. Congestive cardiac failure.

### Treatment

1. Treatment of the chest infection like flu—injection every winter
2. Antibiotics
3. Stop smoking
4. Change of house, Occupation
5. Improve lung function: Steroids, Bronchodilators, Oxygen therapy.

#### *Surgery*

Large bullae are resected to improve lung function.

#### *Prognosis*

Patient becomes disables and death occur from respiratory failure.

## ASTHMA

### Definition

Wheezing and breathlessness due to narrowing of the intrapulmonary airways characterize this condition.

### Aetiology

Common in children. In males occurs in childhood, puberty and later life, in women occurs in middle age.

### Types

1. Extrinsic or Atopic Asthma: This occurs in the younger groups

*Aetiology:* Allergic pollen, House mites, Feathers, Food, Fur, Drugs, Family history.

*Pathology:* Exposure causes mucosal inflammatory allergic changes and asthma will be episodic.

*Onset:* Sudden, Paroxysmal, Night.

### Symptoms

Chest tightness, Dryness or irritation in the upper respiratory track.

*Attack:* Episodic

*Duration:* Few seconds to many months

*Severity:* Mild wheezing to great distress.

### Clinical Features

1. Wheeze and Dyspnoea
2. Cough
3. Posture
4. Pulse: Rapid, Paradoxical
5. Tachycardia
6. Cyanosis
7. Breath sounds–vesicular with prolonged expiration and high pitched bronchi.
8. Percussion: Hyper-Resonant.

### Diagnosis

*Radiograph:* Chest will be over-shaded

*Lung function test:* FEV1 and FEV drop on severe attack.

### INTRINSIC ASTHMA OR NON-ATROPIC ASTHMA

*Age:* Older patient and is a chronic condition

### Aetiology

1. Bronchial infection
2. Chronic bronchitis
3. Strenous exercise
4. Stress or anxiety.

### Pathology

Main pathological changes occurring during an asthmatic attack are:

1. Spasm of the smooth muscle in the walls of the bronchi and bronchioles.
2. Oedema of the mucous membrane of the bronchi and bronchioles.
3. Excessive mucus production.

### Clinical Features

1. Associated with chronic bronchitis
2. Wheeze and dyspnoea are continuous and worse in the morning
3. Cough produces mucoid sputum
4. Respiratory infection occurs.

### Diagnosis

*Radiograph:* This shows emphysematous changes.

#### *Status Asthmaticus*

A severe progressive acute attack of asthma present for 24 hours. This is a life threatening because this condition won't respond to the bronchodilators.

### Treatment

#### *Aim*

1. Prevention of attack
2. Maintenance of general fitness
3. Treatment during an attack.

*Management*

1. Patient has to avoid certain food, home environment must be dusted regularly, avoid domestic animals, Patient should have plenty of fresh air, away from people with infection such as bronchitis and influencing. Patient should be free of stress and anxiety.
2. *Drugs:* Administration by aerosol as the effects will be long lasting, Inhaler, Bronchodilators for wheeze, corticosteroids when bronchodilators are ineffective, Rotahalers and spinhalers deliver the rug in a dry powder form.

## BRONCHIECTASIS

### Definition

It is an abnormal dilatation of the bronchi associated with obstruction and infection.

### Aetiology

*Congenital*

This is rare and occurs in triad. They are frontal sinusitis, visceral transposition and bronchiectasis.

*Acquired*

The causes are bronchial obstruction, Bacterial infection due to tumour or foreign body.

### Clinical Features

1. Whooping cough
2. Measles
3. Pneumonia

*Site:* This is bilateral and effects lower lobes.

## Pathology

Bronchial obstruction will cause absorption of the air from the lung tissue. So airways will shrink and collapse. So more work has to be done by the proximal airways because of this they get distort and dilated. Secretions get accumulated and get infected, pus is formed. The mucosal lining is replaced by granulation tissue. So mucous passage is hindered. Haemoptysis occur as a result of arterial vessels anastomosis with the pulmonary capillaries.

## Clinical Features

*Onset:* Childhood

1. Cough –Persistent
2. Sputum: Purulent sputum, green in colour, Foul smelling
3. Dyspnoea
4. Haemoptysis
5. Recurrent pneumonia
6. Halitosis
7. Chronic sinusitis
8. Pyrexia
9. Night sweats
10. Anorexia
11. Malaise
12. Weight loss
13. Lassitude
14. Clubbing
15. Thoracic mobility decreases.

## Investigations

*Radiograph:* Bronchovasicular markings are seen, Multiple cysts with fluid levels are seen.

*Bronchography:* Accurate localization are affected.

*Sputum culture:* Haemophilus influenzae, *Staphylococcus*.

### Complications

1. Recurrent Haemoptysis
2. Pleurisy and empyema
3. Abscess formation
4. Emphysema
5. Respiratory failure
6. Right ventricular failure
7. Pneumonia.

### Treatment

1. Relieve obstruction
2. Control infection by antibiotics
3. Good diet and fresh air for promoting good health.

### Surgery

1. Segmental resection
2. Lobectomy.

## CYSTIC FIBROSIS OR MUCOVISCIDOSIS

### Definition

This is a disorder of exocrine glands with a high sodium chloride content in sweat and pancreatic insufficiency resulting in malabsorption.

### Aetiology

Heredity

### Pathology

1. Heredity
2. Pulmonary changes:
   - Excessive mucus in bronchi and bronchioles and gets bloke by mucous plugs
   - *Viscid mucus:* The mucus produce will be viscid and sticks to the bronchial walls

- *Infection:* The mucus gets infected by bacterial, secretion becomes purulent cause irritation and inflammation of bronchial wall tissue.
- *Bronchiectasis:* This is because of weakening and dilatation of the bronchial walls.
- *Lack of development of the lung tissue:* The above all results as a barrier or development of lung tissue.

## Clinical Features

| *S.No* | *Children* | *S.No* | *Adolescents and Adults* |
|---|---|---|---|
| 1 | Meconium ileus | 1 | Breathlessness |
| 2 | Foul smelling stools | 2 | Wheezing |
| 3 | Sweating | 3 | Productive cough |
| 4 | Wheeze | 4 | Purulent sputum |
| 5 | Dyspnoea | 5 | Haemoptysis |
| 6 | Under weight | 6 | Finger clubbing |
| 7 | Cough | 7 | Puberty changes |
| | | 8 | Infertility in males |
| | | 9 | Respiratory failure |
| | | 10 | Cyanosis |
| | | 11 | Cor Pulmonale |

## Complications

- Haemoptysis
- Spontaneous Pneumothorax
- Lung abscess
- Bronchiectasis
- Liver disease
- Psychosocial disturbance.

## Treatment

1. Antibiotics
2. Bronchodilators
3. Oxygen therapy
4. A low fat high calorie diet is recommended supplemented with vitamins

5. Pancreatic enzymes are given before each meal to improve absorption.

### Chest Physical Therapy

The chest physical therapy is the group of treatment used for obstructive lung diseases including Chronic obstructive lung diseases like—Chronic bronchitis, Asthma, Bronchiectasis, Cystic fibrosis and Emphysema and other neurological conditions.

*Aims of the chest physical therapy are:*

a. To improve respiratory efficiency
b. To promote expansion of the lungs
c. To strengthen the respiratory muscles
d. To remove secretions from the respiratory system.

*Uses of the chest physical therapy are:*

a. This technique is useful for Newborns, Infants, Children and adults
b. The patient can breathe more freely
c. Patient gets more oxygen into the body.

*Techniques of the chest physical therapy are:*

a. Postural drainage
b. Chest percussion
c. Chest vibration
d. Turning
e. Deep breathing exercises
f. Coughing
g. High frequency chest compression
h. Flutter
i. Positive expiratory pressure (PEP) mask
j. Autogenic drainage
k. Exercise.

*Indication of the chest physical therapy are:*

a. Chronic obstructive lung diseases
b. Guillain-Barré syndrome
c. Myasthenia gravis

d. Cerebral palsy
e. Muscular dystrophy
f. Patient confined to the wheel chair like in Tetraplegia
g. Post-operative pain
h. Bronchitis
i. Pneumonia
j. Bedridden patient like high cervical spinal cord lesion patients.

*Contraindications of the chest physical therapy are:*

a. Recent surgery
b. Spine injury
c. Lung abscess
d. Pulmonary embolism
e. Recent heart attack
f. Tuberculosis
g. Open wounds
h. Fracture of ribs
i. Head injuries, etc.

*Techniques of the chest physical therapy are:*

a. *Postural drainage:* This technique involves the draining the secretions from the lung to central airway and from there secretions can be removed either by coughing or suctioning. The patient is in gravity assited position with head or chest down position kept for 15 minutes. The percussion and vibration are performed with postural drainage.
b. *Chest percussion:* This technique includes treating the patients with massage manipulations like clapping, cupping, etc. This is used to break up thick secretions of the lungs for easy removal. This technique is performed on each lung segment for 1 or 2 minutes at a time.
c. *Chest vibration:* This is the massage manipulation that helps to break up lung secretions. This can be performed mechanically or manually by the physiotherapist. The patient is asked to breathe deeply and physiotherapist places his or her hands against the patient chest and vibrates by quickly contracting and relaxing

arm and shoulder muscles when patient is expiring the air out. This can be done several times each day and nearly for five exhalations.

d. *Turning:* The turning is very important because it permits lung expansion, prevents pressure sores if patient is turned every two hours and helps for postural drainage by raising the head end of the bed if patient can tolerate the position.
e. *Deep breathing exercises:* The patient sits upright in the bed or chair and patient is asked to inhale the air through nose and abdomen will push out and contract and exhale the air through mouth. This can be done several times a day.
f. *Coughing:* This is encouraged several times a day. This helps in breaking the secretions in the lung so that mucus can be suctioned. The technique is patient sits in upright position, ask patient to inhale deeply through the nose and exhale in short puffs or coughs. This technique of coughing can be repeated several times a day.
g. *High frequency chest compression:* This technique uses inflatable vest which is connected to a high frequency pulse generator. This discharges air to the vest, that vibrates the chest. This high frequency airway clears all the lobes of lungs, cleans mucus and does not require help of other persons.
h. *Flutter:* This is a hand–held device like a small, fat pipe. This is helpful to loosen the mucus, aids for easy coughing. The parts are mouth piece, high density stainless steel ball, cone that holds the ball. The technique is patient has to exhale through the flutter, the steel ball moves up causes vibration in the lungs and loosens the mucus. This is most effective in airway clearance for some patients and can be used by patient independently once he or she is perfect with the technique.
i. *Positive expiratory pressure mask (PEP):* The PEP mask helps in airway clearance. This mask consist of rubber mask connected to one way breathing valve, tube adapter that creates resistance. The patient's active participation is very important. The patient has to press the mask against the face and inhales through the

inspiratory port and exhales against the expiratory resistance. This mask keeps the airways open allowing the mucus to be secreted. The valves in the PEP mask allows the airways to keep open for long time causing air to push out the secrections. The patient is given adequate training and different sizes valves of PEP masks are available depending on the requirement they can be selected. The PEP mask can be used by the patient independently.

j. *Autogenic drainage:* This is a gentle procedure. This is used for patients with Haemoptysis. This clears the secretions and further can be drained by coughing or huffing. This technique is similar to PEP mask. This is the combination of breathing technique at different levels to move the secretions up and can be coughed or huffed. The first level is low lung volume breathing that unsticks the mucus, the mid volume breathing collects the secretions and high volume removes the secretions with huff. This patient need to learn this technique perfectly, with discipline and concentration while performing. Patient can be independent and no equipment is required. If done in proper way patient need not cough violently.

k. *Exercise:* The exercise is of two types: (a) Aerobic exercise and (b) Anaerobic exercise.

*Uses of the exercises are:*

a. Loosens the mucus
b. Decreases the shortness of breath
c. Decreases the muscle deterioration
d. Maintains the sense of well being
e. Patient gets independence
f. Increases stamina
g. Gives less congestion.

*Aerobic exercise:* The aerobic exercise is the exercise performed by using the oxygen. Some of them are slow walk, swimming, bicycling and sports like basket ball, tennis and soccer.

*Uses*

a. Clears mucus from the lung moving high volumes of air through partially clogged passages
b. Prevents new passages from becoming clogged
c. Prevents elasticity of the lung walls
d. Promotes the ability to clear mucus in the long term
e. Prevents organism growth by creating an environment that is less conductive
f. Induces deep breathing
g. Extends life period.

*Anaerobic exercise:* The anaerobic exercise includes weight training regimen with one warm up set of 15-20 repetitions and one all –out set of 8-12 repetitions. The repetitions causes creatine phosphate to be used by the muscle and receive adequate nutrition and built lean body mass by stimulating muscle growth.

The exercise regimen programme is as follows:

*Day –1*

*Chest exercises :* Dumbells, incline bench press, dips

*Shoulder exercises:* Side laterals, dips

*Triceps exercises:* Triceps push down, dips.

*Day –3*

*Latissimus dorsi exercises:* Lateral pull down

*Back muscles:* Seated rows

*Lower back exercise:* Hyperextension of the spine

*Biceps muscle exercise:* Biceps curls.

*Day–5*

*Quadriceps exercise:* Leg extension

*Quadriceps, Hamstrings and buttocks exercise:* Leg press

*Hamstrings and buttocks:* Leg curls

*Calf exercise:* Calf raise

*Abdominal exercise:* Sit ups

This programme stimulates major muscle group. The exercise programme is combination of aerobic and anaerobic elements which provides physical and mental well being.

*Surgery:* The surgical options are available:

1. *Lung transplantation:* The transplantation of one or both lungs with heart. The age group should be less than 65 years.
2. *Lung volume reduction surgery (LVRS):* In this severely diseased lung tissue is removed and remaining pats of the lung are joined
3. *Bilateral lung volume reduction (Surgery done on both the lungs):* A cut in the chest area by video assisted thoracoscopy (VATS) involves small cuts. Line of staples are used to reduce lung volume or unilateral lung volume reduction (surgery on one lung)
4. *Bullectomy:* The big air pockets with lung tissues are removed.

### *General Guidelines and Precautions*

1. *Stop smoking:* It is the most important. It slows the progression, decreases symptoms of breathlessness and cough, decreases the risk of heart disease, decreases systematic inflammation.
2. *Diet:* Good nutrition is always important or breathing becomes difficult when patient consumes calories there will be extreme effort to breathe this causes loss of muscle tone, body mass and wasting. The nutritionist identifies appropriate foods and sets the diet plan.

### *Oxygen Therapy*

a. *Supplemental oxygen:* It is also important component because it improves exercise endurance, decreases breathlessness, decreases pulmonary hypertension, improves sleep, improves quality of life and mental outlook thus increases affected, lung's ability to exchange carbon dioxide for oxygen. This decreases heart problem. Long term oxygen therapy given through the nose continuously prolong survival by 30%.

b. *Heliox:* The Heliox is the mixture of oxygen with nitrogen. It is more effective because it increases endurance time and ability to exercise.

c. *Continuous oxygen therapy:* The continuous oxygen therapy is given for more than 15 hours a day for emphysema patient that improves alertness of the patient. The lung oxygen level below 55 mm of Hg while resting is given and lung oxygen level of below 60 mm of Hg is given while resting and with right heart failure or abnormal increase of RBC. The patient should receive enough oxygen level at 65 mm of Hg or oxygen saturation level of at least 90%. Additional oxygen is required during sleep or physical activity. 40% of the patient improve in one month.
d. *Intermittent oxygen:* The intermittent oxygen is useful for less severe COPD conditions. Patient receive oxygen level drops below 55 mm of Hg only while exercising benefit from supplemental oxygen during physical activity.
e. *Supplemental oxygen:* Supplemental oxygen enhance delivery of oxygen to the muscles when working. Patient whose oxygen level drops below 55 mm of Hg during sleep need oxygen at night. Such patients will have poor quality sleep.
f. *Emergency situation oxygen delivery:*
   i. *Intubation:* The tube is inserted down through nose or mouth and oxygen is administered
   ii. *Endotracheal intubation:* This is delivery of high concentration of oxygen
   iii. *Non-invasive positive pressure ventilation (NPPV):* The patient is able to breathe naturally, Oxygen is delivered through a tube using a tight filled oxygen mask to maintain airway pressure during breathing.
   iv. *Mechanical ventilation:* In acute respiratory failure this mechanical ventilator functions the breathing process by restoring a balance of exchange of gases.
g. *Devices of administrating oxygen are:* There are three ways of administrating the oxygen. They are:
   i. *Nasal canula:* The oxygen is delivered through a long standing plastic tube that runs from the oxygen tank to small plastic prongs that fit in the nostrils. The tube can be long when attached to a stationary tank at home for easy walking or short when attached to portable unit.

ii. *Transtracheal oxygen:* This is delivered directly into the trachea through a catheter tube implanted by a surgeon. This works more efficiently. Long term use leads to complication like infection, dislodgement and blockage by mucus and sometimes may be serious.

iii. *Electronic demand devices:* These devices have facility of sensing the beginning of a breath and deliver oxygen. This has the complication of the mechanical failure.

iv. *Continuous positive airflow pressure (CPAP):* This supplies a steady stream of air through a tube that connects to a bedside machine. The patient wears a plastic mask and machine supplies sufficient air pressure to prevent the tissues from collapsing during sleep.

*Pulmonary rehabilitation:* This reduces disability, improves mental and physical quality of life. This includes exercise, nutritional advices, breath training, education and psychological assessment.

*Exercise:* The exercise maintain strength, endurance, patient will be active, maintains quality of life and ability to live independently. When patient no longer responds to medication then surgery is indicated and type is bullectomy, lung volume reduction surgery (LVRS) or lung transplantation. LVRS improves lung function, decreases breathlessness, improves exercise tolerance and quality of life.

*Prevent upper respiratory infection:*

a. *Good hygiene:* The hands should be washed before eating and after coming from outside. Liquid washing soaps are more effective in killing respiratory syncytial virus (RSV) that cause pneumonia.

b. *Vaccines:* The two important vaccines that prevent respiratory infections are:

*Influenza vaccination:* This is very safe and helps to reduce Chronic obstructive pulmonary diseases exacerbation during the flu season so patients are advised to take vaccination 6 weeks before flu season begins.

*Pneumococcal vaccine:* This prevents pneumonia by protecting against 23 types of pneumococcus bacterial. This vaccination is effective for years.

The flu and Pneumococcal vaccination can be taken at same time with mild initial adverse side effects.

### *Breathing Exercise*

a. *Pursed lip breathing technique:* The patient is asked to inhale air through the nose and the abdominals move out, the diaphragm lowers and the lungs fill with air then exhale the air through the mouth with the pursed lips by making a hissing sound. The exhalation should be twice as inhalation. The patient experiences pressure in the chest, trachea and trapped air is forced out.

b. *Breath holding and coughing:* The technique is patient is asked to inhale deeply, slowly and holding breathe for 5-10 seconds then cough on exhalation.

c. *Controlled secretions:*
   i. *Fluids and humidity:* The patients with heavy sputum and congestion benefit from the fluid intake and keeping their homes humidified.

*sDevices for improving the lung function:* Neuromuscular electrical stimulation (NMES): This is a device with electrical pulses to stimulate muscles in the legs. The treatment of the leg muscles initially for 16 minutes during first week and later week for 30 minutes for total of 30 sessions. This is done for 6 weeks the patients endurance capacity increased with less muscle fatigue and shortness of breathe.

*Strengthening muscles of the limbs:* Arms and leg muscles strengthening exercise improve their endurance and decrease breathlessness.

*Yoga and meditation:* This includes deep breathing and meditation techniques.

*Breath Training*

a. *Inspiratory muscle training:* This is the device with different inhaling to strengthen breathing muscle, walking capacity and quality of life.
b. *Intensive spirometer:* This is used for 15 minutes to loosen sputum and done twice a day. This is a small hand held device with breathing gauge.
c. *Peak inspiratory flow:* The device where patient exhales and inhales forcefully through the tube by using the pressure of the inhalation to raise the gauge to the highest level. This measures the patient ability to draw air into the lungs and assess the fitness of the breathing muscle.

*Dietary factors:* The dietary factors are taken into the consideration because chronic bronchitis patients are obese and emphysema patients are under weight. So nutritional status assessment is important. Lack of vitamins like A, C, E and insufficient consumption of the fruits and vegetables can lead to chronic obstructive pulmonary disease. The patient should take omega 3 fatty acids found in the cold water oily fish and omega – 3 supplements that have anti-inflammatory effects which are useful for COPD.

*Psychological support:* The psychological counselling and social support are required for patients suffering from depression and anxiety that limits activities and social interaction. The treatment improves emotional state, stress and helps in maintaining independence and social relationship.

*Minimizing airborne contaminants:* Avoid exposure to airborne irritants including smoke from wood fires, hair sprays, insecticides, etc. Good ventilation, exhaust fans for stores. Avoid exposure to pollen, house dust and pets.

# Physiotherapy Rehabilitation Programme

CHAPTER 5

The physiotherapy rehabilitation programme consist of two major rehabilitation programmes. They are:

1. Cardiac rehabilitation programme
2. Pulmonary rehabilitation programme.

## CARDIAC REHABILITATION

The cardiac rehabilitation is a long term comprehensive rehabilitation programme with graded exercise. This result in improvement of physical, physiological and psychological well being of the patient. It is successful in lowering mortality rate in patients suffering from the cardiac disease.

Cardiac rehabilitation is a multidisciplinary programme for patients with heart disease to achieve physical, psychological and functional status and to improve the quality of life.

### Aims of Cardiac Rehabilitation

a. To prevent sudden death due to cardiac disease
b. To improve functional capacity
c. To encourage exercise training
d. To prevent the reversal of the symptoms
e. To maximize the cardiac function
f. To build fitness and functional capacity

g. To mould the patient life style and habits like smoking cessation
h. To bring changes in the diet by attending the nutritional classes
i. To teach stress management techniques and technique to reduce the anxiety
j. To counsel and educate the patient about the heart condition and its management
k. To encourage and prepare the patient to return to the work and meet the demands of the job both physically and psychologically.

*Team of the cardiac rehabilitation programme:* The cardiac rehabilitation programme is conducted for both the inpatients and out patients. The skilled professional team includes:

a. Cardiologist
b. Cardio-vascular surgeon
c. Dietitician
d. Physiotherapist
e. Occupational therapist
f. Speech therapist
g. Psychiatrist
h. Rehabilitation nurse.

## Indications Cardiac Rehabilitation Programme

a. Myocardial infarction
b. Angina pectoris
c. Coronary artery bypass surgery
d. Valve transplant
e. Heart failure
f. Heart transplant
g. Angioplasty
h. High risk patient
i. Congestive heart failure
j. Congenital heart disease
k. Open heart surgery
l. Myocardial infarction
m.. Angina Pace maker
n. Arrhythmias

o. Balloon angioplasty
p. Rheumatic heart disease.

### Contraindications

a. Hypertension
b. Diabetic
c. Congestive heart failure
d. Acute illness
e. Angina.

*Assessment:* According to the cardiac disability classification

*Class-1:* No symptoms with ordinary physical activity

*Class-2:* Symptoms with ordinary activity. There will be slight limitation of the activity

*Class-3:* Symptoms with less than ordinary activity and limitation of activity is seen

*Class-4:* Symptoms with any physical activity or even at rest.

### Cardiorespiratory Fitness Test

The fitness evaluation is done on the patient both on rest and during exercise. This measures maximum oxygen uptake denoted by $VO_2$.

### Guidelines

a. Age and risk factors should be considered
b. One day before the test is done, the therapist must give pre-test instructions
c. The patient is instructed to read and sign the consent form and physical activity readiness questionnaire (PAR-Q).

### Procedure

a. Check the patient resting heart rate and blood pressure
b. When the test is started monitored the heart rate and blood pressure and ratings of perceived exertion (RPE) at frequent intervals
c. Exercise heart rate measured at the end of one minute

d. Blood pressure and ratings of perceived exertion are monitored at the end of the stage of exercise
e. Monitor the patient physical appearance and symptoms throughout the test
f. Cool down exercise is must because active recovery reduces the risk of hypotension
g. Measure post exercise heart rate, blood pressure, ratings of perceived exertion for at least four minutes, if any abnormal responses are seen, measure for longer period
h. The heart rate and blood pressure during this period should be stable but higher than pre-exercise level
i. If the patient has discomfort use passive cool down by patient in sitting or supine position
j. Heart rate is measured pre-test, exercise and recovery periods.

There are two different exertion grade scales. Any one of the scale can be followed. They are:

**Ratings of perceived exertion scale**

| *No* | *Category scale* | *No* | *Category ration scale* |
|---|---|---|---|
| 6 | No exertion at all | 0 | No exertion |
| 7 | Extremely light exertion | 0.5 | Extremely weak exertion |
| 9 | Very light exertion | 1 | Very weak exertion |
| 11 | Light exertion | 2 | Light exertion |
| 13 | Somewhat hard exertion | 3 | Moderate exertion |
| 15 | Hard exertion | 5 | Strong exertion |
| 17 | Very hard exertion | 7 | Very strong exertion |
| 19 | Extremely hard exertion | 10 | Extremely strong exertion |
| 20 | Maximal exertion | | |

Borg 10 – exertion grade scale

| *Grade* | *Type of exertion* |
|---|---|
| Zero | No exertion |
| 0.5 | Very very weak exertion |
| 1.0 | Very weak exertion |
| 1.5 | Very light exertion |
| 3.0 | Moderate exertion |
| 4.0 | Some what strong exertion |
| 5.0 | Heavy exertion |
| 7.0 | Very heavy exertion |
| 10.0 | Maximum exertion |

### Indications for Termination of the Test

a. Onset of angina
b. Decreased blood pressure
c. Excess increase of blood pressure
d. Fatigue
e. Nausea
f. Light-headedness
g. Confusion.

*Test Termination*

The patient voluntarily terminates or the therapist is aware of the indications of the patient from stopping the test by sins and symptoms.

## EXERCISE TEST PROTOCOL

1. Maximal exercise test (MET)
   a. Treadmill maximum exercise test
   b. Bicycle ergometer maximal exercise test
   c. Bench stepping maximal exercise test.
2. Submaximal exercise test
   a. Treadmill submaximum exercise test
   b. Bicycle ergometer submaximal exercise test
   c. Bench stepping submaximal exercise test.

### Maximal Exercise Test (MET)

The MET is used to assess the aerobic capacity. Select the appropriate exercise mode and test protocol required for the patient according to the age, gender, health and fitness status.

*Guidelines of ExerciseTesting*

a. The treadmill or stationary bicycle ergometer for graded exercise testing (GXT)
b. Begin with 2-3 minutes warm up
c. The intensity of the exercise should be slow

d. There should be gradual increase of exercise intensity
e. For healthy individual the MET value can be 2MET and for the disease individual it can be 0.5 MET
f. Monitor heart rate each minute of graded exercise testing, heart rate should stabilise between two heart rate with in plus or minus 5-6 beats per minute (BPM)
g. Measure blood pressure and ratings of perceive exertion at each stage of graded exercise testing
h. Check signs and symptoms of the patient, if severe ask patient to terminate the test
i. For submaximal graded exercise testing, heart rate range is 70-85% is sufficient and test can be terminated
j. Cool down period for about four minutes or more is called recovery period. During this period check heart rate and Blood pressure. Passive recovery is used if patient experiences signs of discomfort
k. Estimate exercise tolerance in MET for treadmill protocol
l. Testing should be quiet, room temperature of 21 to 23 degree centigrade and humidity is 60% or less than that can be considered.

*The common mode of exercise are:*

a. Treadmill walking
b. Running
c. Stationary cycle
d. For Paraplegics and patients with limited use of upper extremity this arm ergometry can be tested
e. For large group bench stepping can be tested.

*Types of maximal exercise testing are:*

a. *Continuous $VO_2$ maximum test:* This is the test without rest between work
b. *Discontinuous tests:* This test gives 5 to 10 minutes rest intervals between work load.

Once the test is completed ACSM metabolic equation is used for the clinical testing. This is used to estimate the rate of energy expenditure for treadmill walking, running, bicycle ergometer and bench stepping test both maximal and submaximal exercise testing. The total energy expenditure in ml $kg^{-1}$ $mil^{-1}$.

There are three functional components. They are horizontal component, vertical component and resting component for energy expenditure.

## Maximal Exercise Testing

a. Treadmill maximal exercise testing

This exercise testing is done on the motorised treadmill. The parameters required are speed is of about 25 miles per hour (MPH) and inclination – elevation per 100 horizontal units.

## Metabolic calculation

| S. No | $VO_2$ mode (units) | Resting component → | Horizontal component H | Vertical component V |
|---|---|---|---|---|
| 1 | Walking ml. $kg^{-1}.min^{-1}$ | 3.5 ml . $kg^{-1}.min^{-1}$ | Speed (m. $min^{-1}$ × 0.1) | Grade ( decimal ) x m . min -1 x 1.8 |
| 2 | Running ml. $kg^{-1}.min^{-1}$ | 3.5 ml . $kg^{-1}.min^{-1}$ | Speed (m. $min^{-1}$ × 0.2) | Grade ( decimal ) x m . min -1 x 0.9 |
| 3 | Leg ergometer ml .$min^{-1}$ | 3.5 ml . $kg^{-1}.min^{-1}$ × Kg Bw | None | Kgm .$Min^{-1}$ × 2 |
| 4 | Arm ergometer ml .$min^{-1}$ | 3.5 ml . $kg^{-1}.min^{-1}$ × Kg Bw | None | Kgm .$Min^{-1}$ × 3 |
| 5 | Stepping | Included in H and V components | Steps/min × 0.35 | m/step x steps/min × 1.33 × 1.8 1.33 is positive component going up is 1.0 and negative component of going down 0.33 = 1.33 |

## Valid Estimation: ACSM Metabolic Equation to Estimate $VO_2$

1. Body weight in kgs if pound 1kg = 2.2 lb
2. Treadmill speed 1 mph = 26.8 m .$min^{-1}$
3. Treadmill grade from percent to decimal
4. Convert MET to ml.$kg^{-1}$.$min^{-1}$.1 Met = 3.5 ml.$kg^{-1}$.$min^{-1}$
5. Convert Watts to kgm.$min^{-1}$.1 Watt = 6 kgm . $min^{-1}$
6. For arm and leg ergometer it is non-weight bearing. So has to convert ml. $kg^{-1}$.$min^{-1}$ to ml. $min^{-1}$

7. For walking , running and bench stepping it is weight bearing so convert ml $.min^{-1}$ to ml $.kg^{-1}.min^{-1}$
8. Convert the step height in inches to meter 1 inch is equal 0.0254.

*Example*

1. If the body weight of the person is 180 pounds, then body weight in kgs is body weight in pound/2.2 lb so we can get the body weight in kgs as 1 kg = 2.2 pounds, 180/2.2 = 82 kgs
2. Treadmill speed is 1 mph = 26.8 m $.min^{-1}$
   If the patient speed is 6 mph then treadmill speed is 6 mph × 26.8 = 160.8
3. Treadmill grade from percent to decimal is if percent is 14 % then decimal is 14 × 100 = 0.14
4. Convert MET to $ml.kg^{-1}.min^{-1}$.1 Met = 3.5 $ml.kg^{-1}.min^{-1}$
   If the patient MET is 6 then 6 × 3.5 = 21 $ml.kg^{-1}.min^{-1}$
5. Convert Watts to $kgm.min^{-1}$.1 Watt = 6 kgm . $min^{-1}$
   If the watt is 140 then 140 × 6 = 8406 kgm . $min^{-1}$
6. For arm and leg ergometer it is non-weight bearing. So has to convert ml. $kg^{-1}.min^{-1}$ to ml. $min^{-1}$
   30 ml. $kg^{-1}.min^{-1}$ × 70 kg = 2100 ml. $min^{-1}$
7. For walking, running and bench stepping it is weight bearing so convert ml $.min^{-1}$ to ml $.kg^{-1}.min^{-1}$
   2400 ml . $min^{-1}$/60 kg = 40 ml $.kg^{-1}.min^{-1}$
8. Convert the step height in inches to meter 1 inch is equal 0.0254
   If the step height is 8 inches then 8 inch × 0.0254 = 0.2032 m
   Calculate the $VO_2$ for the 80 kg subject who is walking on the treadmill at the speed of 2.5 mph and grade of 20% follow these steps.

## ACSM Walking Equation

$VO_2$ = Resting component + horizontal component + vertical component.

3.5 + speed (m. $min^{-1}$) × 0.1 + grade × (Decimal) × speed (m. $min^{-1}$) × 1.8.

1. Convert the speed in mph to m. $min^{-1}$
   1 mph = 26.8 m. $min^{-1}$
   2.5 mph × 26.8 = 67 m. $min^{-1}$

2. Calculate the horizontal component
   H = speed × 0.1 = 67 m. $min^{-1}$ × 0.1 = 67 ml . $kg^{-1}$ .$min^{-1}$
3. Calculate the vertical component (V) convert % grade into the decimal by dividing by 100
   V = grade (Decimal ) × speed × 1.8
   0.20 × 67 m. $min^{-1}$ × 1.8 = 24.12 ml . $kg^{-1}$ .$min^{-1}$
4. Calculate the total $VO_2$ in ml . $kg^{-1}$ .$min^{-1}$ by adding the H, V, R components
   R = 1 MET = 3.5 ml. $kg^{-1}$ .$min^{-1}$
   $VO_2$ = H + V+R = ( 67+ 24.12 + 3.5 ) ml. $kg^{-1}$ .$min^{-1}$
   = 94.62 ml.$kg^{-1}$ .$min^{-1}$
5. Calculate the rate of energy expenditure (E) in MET by converting $VO_2$ to MET
   E = $VO_2$ /1 MET or 3.5 ml. $kg^{-1}$ . $min^{-1}$
   = 94.62 ml. $kg^{-1}$ .$min^{-1}$/3.5 = 27.0 ml.$kg^{-1}$ .$min^{-1}$.

### Bicycle Ergometer Maximal Exercise Tests

This is the commonly used instrument. There is friction type bicycle ergometer where the resistance is applied against the fly wheel using a belt and weighted pendulums. This bicycle has hand wheel that adjusts the work load either by tightening or loosening the brace belt. The workload can be increased by raising the resistance on the fly wheel.

Power = force × distance/time
P = watts .1 Watt = 6 kgm . $min^{-1}$
Force = kilograms
Distance = number of revolutions per minute
Power = 2 kg × 6 m × 60 rpm = 720 kgm.$min^{-1}$ or 120 watt.

The distance is calculated by measuring the circumference in meters of the resistance track on the fly wheel and multiply the circumference by the number of fly wheel revolutions during on complete revolution (360 degrees) of the pedal.

Some ergometers have speedometer that display the individual pedalling rate. Few use a metronome to establish clients pedalling cadence.

Test protocols:
Pedalling ate: 50 or 60 rpm
Power : 150 to 300 kgm . $min^{-1}$ (25 to 50 watt)

The total energy expenditure in $ml.min^{-1}$ is a function of two components.

*Vertical component:* The energy expenditure to over come the resistance of flywheel per minute

*Resting component:* It is the amount of the oxygen consumed per minute by the client at rest and depends on the body weight

*Resting component:* Resting metabolic equivalent (1 MET or 3.5 ml. $kg^{-1}$ $min^{-1}$)
By the clients body eight (BW) in kilograms.

### Advantages of Ergometer

| *S. no* | *Advantages* | *Disadvantages* |
|---|---|---|
| 1 | Safer than treadmill | Difficult to calibrate |
| 2 | Easy to monitor | Leg fatigue occurs |
| 3 | Easy to quantify the work | Lower $VO_2$ maximum |
| 4 | Easy to obtain the details | |

### ACSM leg ergometer equation

To calculate the energy expenditure of a 60 kg (132 lb) (As 1 kg = 2.2 lb) and women cycling at the work rate of 400 kgm $.min^{-1}$

1. Resting component : (V)
   V = kgm .min -1 × 2 = 400 kgm $.min^{-1}$ × 2 = 800 ml $.min^{-1}$
2. Absolute $VO_2$ = V = + (1 MET × BW = 3.5 $ml.kg^{-1}$ $min^{-1}$ × 60 kg = 210 ml $.min^{-1}$)
   $VO_2$ = 800 $ml.min^{-1}$ + 210 ml $.min^{-1}$ = 1010 ml $.min^{-1}$
   Convert the absolute $VO_2$ to relative $VO_2$ by dividing the body weight
   Relative $VO_2$ = absolute $VO_2$/Body weight
   Relative $VO_2$ = 1010 ml $.min^{-1}$/60 kgs = 16.8 $ml.kg^{-1}$ $.min^{-1}$

Relative energy expenditure in MET is calculated by dividing $3.5\ ml.kg^{-1}.min^{-1}$

$MET = 16.8\ ml.kg^{-1}.min^{-1}/3.5\ ml.kg^{-1}.min^{-1} = 58.8\ MET$

## Bench Stepping Maximal Exercise Tests

The individual in this type of the test performs up-phase or positive work and down phase or negative work

The intensity of the work is increased by gradual increase of the height of the bench or rate of stepping

Work can be calculated by the equation

$W = F \times D$

F = body weight in kilograms

D = bench height ties number of steps per minute

E.g: A 60 kg (132 lb) woman stepping at a rate of 20 steps $.min^{-1}$ on a 25 cm bench.

$W = 60\ kg \times 0.25 \times 20\ steps\ .min^{-1}$

$= 300\ kgm\ .\ min^{-1}$

The negative work is combined with the step height and the rate of stepping in different body weights as less energy consumed in negative work .

The equation to adjust the step height and stepping rate for differences in the body weight to achieve a given work rate.

Step height (cm) = work ( Kg .cm $.min^{-1}$)/body weight (kg) × stepping rate (cm).

Stepping rate (steps $.min^{-1}$ : = work (Kg .cm $.min^{-1}$)/body weight (kg) × step height (cm).

Graded step test protocol:

Patient = 50 kg (110 lb)

Work rate = 200 Kgm $.min^{-1}$

Stepping rate is set at 16 steps $.min^{-1}$

Step height: Work rate/patient weight × stepping rate = 200 Kgm $.min^{-1}/50\ kg \times 16\ steps\ .min^{-1}$

$= 200\ Kgm\ .min^{-1}/800 = 0.25\ m$ or 25 cm

Stepping rate = work rate/patient weight × step height = 400 Kgm $.min^{-1}$ / 50 kg × 0.25 m = 400 Kgm .min-1/12.5 = 32 steps . $min^{-1}$ .

**ACMS Stepping Equation**

To calculate the energy expenditure for the bench stepping using a 14 inch step height at a cadence of 22 steps $.min^{-1}$.

Follow these steps :

$VO_2$ = Horizontal component + vertical component

$VO_2$ in $ml.kg^{-1}.min^{-1}$ = (Steps. $min^{-1}$ × 0.35 ) + (m/step × steps $.min^{-1}$ × 1.33 × 1.8 ).

1. Calculate the horizontal component ( H)
   H = Stepping rate × 0.35 = 22 $steps.min^{-1}$ × 0.35 = 7.7 ml. $kg^{-1}.min^{-1}$
2. To convert the bench height to the meter (1 inch = 2.54 cm or 0.0254 m)
   Height = 14 inch × 0.0254 = 0.3556
3. Calculate the vertical component ( V)
   V= bench height x stepping rate × 1.33 × 1.8
   0.3556 × 22 steps $.min^{-1}$ × 1.33 × 1.8
   = 18.72 $ml.kg^{-1}.min^{-1}$
4. Add the H and V to calculate the relative $VO_2$
   $VO_2$ = 7.7 $ml.kg^{-1}.min^{-1}$ + 18.72 $ml.kg^{-1}.min^{-1}$
   = 26.42 $ml.kg^{-1}.min^{-1}$
5. Convert the $VO_2$ to MET by dividing by 3.5 $ml.kg^{-1}.min^{-1}$
   MET = 26.42 $ml.kg^{-1}.min^{-1}$/3.5 $ml.kg^{-1}.min^{-1}$
   = 7.54 MET.

**SUBMAXIMAL EXERCISE TEST**

This test consist of the following tests:

a. Treadmill submaximal exercise test
b. Bicycle ergometer submaximal exercise test
c. Bench stepping submaximal exercise test
d. Other submaximal exercise test.

### a. Treadmill Submaximal Exercise Test

The test provides an estimate of functional aerobic $VO_2$ maximum

The $VO_2$ maximum has two stage model

1. *Single stage model:* To estimate the $VO_2$ maximum using the single stage model, use one submaximal heart rate and one work load. The submaximal heart rate range from 130 to 150 bpm. Men $VO_2$ maximum = SM $VO_2 \times (HR_{max} - 61) / HR_{Sm} - 61$
   Women $VO_2$ maximum = SM $VO_2 \times (HR_{max} - 72) / HR_{Sm} - 61$

e.g.: $VO_2$ for 40 years old female

Submaximal data stage -3

$VO_2$ = 6.0 MET (SM $VO_2$)

HR = 150 bpm ($HR_{sm}$)

Max MR: 220 –age = $HR_{sm}$

: 220 –age = 175 bpm

$VO_2$ max = SM $VO_2 \times (HR_{max} - 72) / HR_{sm} - 72$

= $6 \times (175 - 72) / (150 - 72)$

= $6 \times 103/78$

= $6 \times 1.3205$

= 7.92 MET

#### *Single Stage Treadmill Walking Test*

The single stage walking treadmill test for estimating the $VO_2$ maximum.

*Indications:* Low risk and healthy adults 20 to 59 years of age.

*Protocol:* Walking speed ranges from 2.0 to 4.5 mph to 53.6 to 120.6 m $.min^{-1}$

This depends on the clients age, gender and the fitness level.

Initially the test should begin with 4 minutes warm up at 0% grade. The heart rate should be 50 to 70% of the age of the patient.

The test consist of brisk walking for 4 minutes at 5% grade record in the heart rate.

$VO_2$ maximum in $ml.kg^{-1}.min^{-1}$

$VO_2$ max = 15.1 + 21.8 (speed mph) – 0.327 (HR bpm)

= -- 0.263 (speed x age years) + 0.00504 (HR × Age)

= + 5.48 (Gender where female = 0, male = 1).

*2. Multistage Model*

The stages 1 and 2 refers to the last 2 stages of the graded exercise test completed by the client. For the calculation the first and the second stage of the test protocol are no considered, but if the client completes 3 stages of the submaximal exercise test protocol. The data used is from the stage 2 and stage 3 to estimate the $VO_2$ maximum.

The estimation of the $VO_2$ max by Heart rate and workload. The data is then taken two or more submaximal stages of the treadmill test. The patient heart rate can be in between 115 to 150 bpm.

Slope (b) = Difference between two submaximal work loads SM/ Changes in the submaximal heart rate.

$B = (SM_2 - SM_1)/HR_1 - HR_2$

Submaximal data stage -2:

$VO_2$ max = 20.5 ml.kg$^{-1}$.min$^{-1}$ ($SM_2$)

HR = 140 bpm ($HR_2$)

Submaximal data sage -1

$VO_2$ max = 14.1 ml.kg$^{-1}$.min$^{-1}$ ($SM_2$)

HR = 120 bpm ($HR_1$)

Maximum HR: 220 –age = 182 bpm

Slope (b) = $(SM_2 - SM_1)/(HR_2 - HR_1)$

B = 20.5 -14.1/140-120

B = 6.4/20 = 0.32

$VO_2$ max = $SM_2 + B\,(HR_{max} - HR_2)$

= 20.5 + 0.32 (182–140)

= 20.5+ (0.32 × 42) = 20.5 + 13.44 = 33.94.

## b. Bicycle Ergometer Submaximal Exercise Test

The protocol uses 3 or 4 consecutive 3 minutes workload on the bicycle ergometer designed to raise the heart rate between 110 and 150 bpm. The pedal rate is 50 rpm and the initial work load is 150 kgm .min$^{-1}$ (25 watt ). Using the heart rate during the last minute of the initial work load to determine the other work loads. If heart rate is less than 80 bpm set the second workload at 750 kgm.min$^{-1}$

The rest are as follows:
First workload 150 kgm. The heart rates are
HR < 80, HR =80 -90, HR = 90-100, HR > 100

| Workload | HR < 80, | HR =80-90 | HR = 90-100 | HR > 100 |
|---|---|---|---|---|
| Second | 750 kgm | 600 kgm | 450 kgm | 300 kgm |
| Third | 900 kgm | 750 kgm | 600 kgm | 450 kgm |
| Fourth | 1050 kgm | 900 kgm | 750 kgm | 600 kgm |

Calculate the energy expenditure ($VO_2$) for the last two work loads using the ACSM metabolic equation.

### c. Bench Stepping Submaximal Exercise Test

The bench stepping submaximal test consist of two protocols. They are:

#### *1. Astraud Ryhming Step Test Protocol*

This protocol gives $VO_2$ maximum from post exercise heart rate and body weight during bench stepping. The patient steps 2.2 steps per 5 minutes. The height of the bench is 33 cm or 13 inches of women and 40 cm or 15.75 inches for men.

Measure the post exercise heart rate by counting the number of beats between 15 and 30 seconds after exercise (convert this 15 seconds count to beats per minute by multiplying by 4). The nomogram can be used for correct $VO_2$ maximum if the patient age is 25 years less or more.

#### *2. Queen College Step Protocol*

The female patient steps 22 per minute and male patient steps 24 per minute for 3 minutes. The height of the bench is 16-25 inchs or 41.3 cm. After exercise the patient will be standing, wait for 5 seconds and take 15 seconds heart rate count. Cover the counts to beats per minute by multiplying by 4. If in group teach patient how to take their own pulse rate. Test $VO_2$ maximum.

### d. Other Submaximal Exercise Test

*Stair Climbing Submaximal Test Protocols*

This estimates the aerobic capacity. Two types of step ergometers are used. They are stair master 4000 PT and 6000 PT.

4000 PT has step pedals that go up and down and 6000 PT has revolving stair case.

*Rowing Ergometer Submaximal Step Protocol*

To know the patient $VO_2$ maximum

The patient will perform rowing exercise and note down the heart rate, distance and duration.

### e. Field Tests

To measure the cardio-vascular fitness of the larger group. This test is practical, inexpensive, less time consuming and easily administered. The test can be used for age group of less than or equal to 40 years in males and women of less than or equal to 50 years. This will assess the cardio-vascular endurance by walking, running, swimming, cycle or bench stepping and measure both the pre-exercise heart rate and post-exercise heart rate.

### f. Distance Run Tests

This is to evaluate the aerobic capacity. The individual should be able to run the given distance in less time or more distance in given time. The distance is of 1.0 or 1.5 miles (1600 -2400).

E.g. : Select 1.0 mile or 1600 meter or duration of 9 minute run and 1.0 or 1.5 mile runs.

### g. Nine or Twelve Minute Run Test

9 or 12 minute run test on a flat track.

### h. One and 1.5 Mile Run/Walk Test

Conduct the 1.5 mile run/walk test on a 400 meter track or flat odometer or measuring wheel to measure the distance. For 1.5 mile patient should fastly cover the distance in the fastest time by running, walking includes covering the shortest distance in the short possible time.

### i. One Mile Jogging Test

The patient should run as fast as possible and give their best effort. So submaximal one mile track jogging test for 18 to 29 years old women and men. The patient should be comfortable moderate jogging pace, post exercise heart rate. The time for 1 mile is 8 minute for males and 9 minute for females and post exercise heart rate not exceed 180 bpm. In 1 mile test 2 or 3 minute warm up jog.

### j. Walking Test

To assess the cardio-vascular fitness for males and females of 20 to 69 years. This is fast walking in the older or sedentary individual of about 1.0 mile at the earliest and check the heart rate. The walking course is flat, 400 meter tract. Stretch for 5 to 10 minutes before the test is taken. Ask the patient to wear the good walking shoes and loose fitting clothes.

### k. Step Test

This test is to check the cardio-vascular fitness. This is done for Large groups, this is inexpensive, useful for aerobic fitness and pulse rate should be checked regularly.

### l. Additional Field Test

The 12 minutes cycling test use bike with 3 speeds is conducted on hard and flat surface and wind velocity is less than 10 mph. The odometer is used to measure distance travelled in 12 minutes.

### m. Twelve Minutes Swimming Test

The patient can use any stroke and can take rest. This test is least preferred because the results of this test depends on the skill of the patent.

### n. Wait Test

This is to assess the cardio-respiratory fitness in young children the treadmill or the bicycle ergometer is used. The age group will be 5-17 years. 1.0 mile or run/walk test for 8 to 17 years and 0.5 mile run / wet test for 5-7 years.

### Graded Exercise Test Protocols

a. The test should start with the warm up for 3 or more minutes
b. The initial exercise intensity should be about 2 or 3 MET
c. Duration of the each work stage is for 3 minutes and also for the steady state of the patient.
d. The total test duration will be of 8 to 12 minutes.

### Aerobic Capacity or Cardiorespiratory Fitness–graded Exercise Testing

a. The graded exercise testing is done and $VO_2$ maximum is measured
b. The maximum exercise testing is done or men greater than 40 years and females greater than 50 years.
c. Before, during and after maximal and submaximal test check the heart rate, blood pressure and resting pulse rate.
d. The common modes of the exercise testing are treadmill, bicycle ergometer and bench stepping
e. Field tests are done for the aerobic capacity and not for the diagnostic purpose
f. For the cardio-vascular fitness of the large groups the distance run test, walking test and step tests are used.
g. The distance run test is at least for 9 minutes for the aerobic functional assessment. The distance is 1 to 3 miles or 1600 to 4800 m or 9 to 12 minutes.

### Advantages of all the Tests

| *S.no* | *Advantages* | *Disadvantages* |
|---|---|---|
| 1 | Natural form of exercise | Risk of accident |
| 2 | Easy to calibrate | Patient will be anxious |
| 3 | High $VO_2$ maximum | Difficult to obtain |
| 4 | | Difficult to obtain quantify weight |
| | | Difficult to calibrate |

## Exercise Prescription

1. Intensity: The stress test must be done before giving the exercise regime
2. The exercises should begin with the low level intensity
3. The duration is about 15 to 60 minutes
4. The frequency is about 3-5 days per week with 2 days of rest between the sessions.

*MET level:* The MET level is used to compare the energy costs of various activities and energy costs at rest.

The following are the MET levels for the selected activities. *They are:*

| *S.No* | *MET level* | *Activity* |
|---|---|---|
| 1 | 1½ to 2 MET | Standing<br>Walking (1 mph)<br>Desk work<br>Sitting<br>Reading<br>Self-feeding<br>Extremities active assisted exercises in supine lying or sitting |
| 2 | 2-3 MET | Walking (2 mph)<br>Bicycling (5 mph)<br>Typing<br>Standing<br>Performing the mat exercises<br>Light weight moving of 2-3 pounds |
| 3 | 3-4 MET | Walking (3 mph)<br>Cycling (6 mph)<br>Slow stair climbing<br>Balance<br>Mild resistance mat exercises |
| 4 | 4-5 MET | Walking (3.5 mph)<br>Cycling (8 mph) |
| 5 | 5-6 MET | Walking (4 mph)<br>Stairs/step aerobics |
| 6 | 6-7 MET | Cycling (11 mph)<br>Walking (5 mph) |

*Contd...*

*Contd...*

| | | |
|---|---|---|
| 7 | 7-10 MET | Jogging<br>Cycling (13 mph)<br>Walking (5.5 mph) |
| 8 | 11-12 MET | Climbing hill<br>Running (5 minutes mile) |
| 9 | 13-14 MET | Running 7 minutes mile |

## CARDIAC REHABILITATION EXERCISE PROGRAMME

The cardiac rehabilitation programme is given to the patient in four phases: They are:

1. Phase –I or inpatient cardiac rehabilitation
2. Phase –II or convalescent stage and recovery stage
3. Phase – III or maintenance stage
4. Phase –IV or commitment phase.

### 1. Phase –I or Inpatient Cardiac Rehabilitation

The cardiac rehabilitation programme is given to the patient when the patient is still in the hospital.

*Aims of Phase –I*

a. To make the patient to return back to early physical activity
b. To perform the activities of daily living
c. To prevent deep vein thrombosis
d. To prevent the effects of the bed rest
e. To relieve from anxiety and depression
f. To educate both patient and family
g. To reduce the risk factors.

*Plans of Phase –I*

a. Regularly monitor the patients heart rate, blood pressure
b. Initially passive range of motion exercises, then active exercises and finally resisted exercises
c. Ankle and foot exercises

d. Breathing exercises
e. Walking 50 to 75 feet
f. Low level exercise test
g. Activities of daily living training and toilet training
h. Progression from 1.0 to 4.0 MET
i. Nutritional management with a diet plan
j. Ruling out the risk factors
k. Life style modifications
l. Habits like cessation of the smoking
m. Recreational interest
n. Vocational information like type of work, number of hours of work per week, type of job and work related pressure.
o. Exercise programme started from the distal to intermediate to the proximal parts of the body and extremities
p. Initially extremities then trunk
q. Exercises in supine lying, side lying, sitting and standing
r. Increased ambulation
s. Stair climbing both ascending and descending
t. Exercise prescription initially for 5 to 10 minutes for 2 to 4 repetitions and later 20 to 30 minutes for 1 to 2 repetitions.
u. Exercise sessions include warm up, endurance aerobic activity and cool down session.

### *Steps or Levels of Activity*

#### *Step-1*

a. Active and passive range of motion exercises to the extremities
b. Ankle and toe exercises done regularly every one hour
c. The patient sits in the chair for 15 minutes, 1-2 times per day
d. Self care is taught
e. Education about intensive care unit, emergencies and services.

#### *Step-2*

a. Active range of motion exercises to the extremity
b. The patient will be sitting on the side of the bed
c. The patient sits in the chair for 15 -30 minutes for 2-3 times a day

d. Complete self care is taught
e. Education about role of physiotherapy and cessation of the smoking.

*Step-3*

a. The patient is shifted to the ward
b. Ward exercises are taught like warm up exercises
c. Exercise done at 2 MET
d. Stretching is taught
e. Walking at a slow pace of about 50 feet front and back
f. Sitting in a chair
g. The patient attends the ward classes in the wheel chair
h. The patient walks in the room
i. The education is about atherosclerosis, myocardial infarction and 1-2 MET activity.

*Step-4*

a. Range of motion exercises are taught
b. Exercise done at 2.5 MET
c. The patient walks 75 feet
d. The patient is taught the pulse checking and monitoring
e. The patient walks to the toilet
f. The patient is educated about the risk factors and control.

*Step-5*

a. The range of motion exercises are taught
b. The exercise of 3.5 MET is taught
c. The patient is taught the pulse checking and monitoring
d. The patient walks outside the ward till the corridor
e. The patient is educated about the diet, energy conservation during work.

*Step-6*

a. All the above
b. Patient ascends and descends the stairs

c. The patient walks 500 feet
d. Home programme is given
e. Occupational therapy is taught like activities of daily living
f. The patient is educated about the drug to be taken and kept with the patient always in emergency of the second attack with emphasis upon exercises, surgery and role of the family for the patient.

*Step-7*

a. All the above
b. The patient climb the stairs
c. The patient walks about 500 feet
d. Home exercises is taught
e. Continue with the previous ward activities
f. Education about the discharge, medication, diet, exercise regime, back to work, fixing an appointment and review.

### Phase –II or Convalescent Stage and Recovery Stage

This is the period from discharge to 12 weeks or 3 months. The patient will be discharged.

*Aims of this Phase–II*

a. To improve the aerobic endurance
b. To encourage the patient for positive life style changes
c. To promote early return to the normal activity
d. To improve the functional capacity
e. To educate the patient.

The exercise programme is designed based on the Braded exercise test and the level of risk factors.

*The Risk Factors Affect is as Follows*

a. *Low risk:* The patient is uncomplicated
b. *Moderate risk or intermediate risk:* The patient has new angina pectoris
c. *High risk:* The patient had attack of recurrent ischaemic pain.

In the phase – II, the exercise programme has intensity of exercise, duration, frequency, mode of exercise, age, sex and musculoskeletal system. When the patient is given the exercise regime 5 points are checked regularly. They are Heart rate, blood pressure, ECG, Heart sounds and their signs and symptoms. Before prescribing the low to moderate MET the exercise regimen is given and this programme should not produce cardio-vascular complications or interfere with healing process.

*Recovery period:* This is the termination of the phase II. The duration is 6-8 weeks. The exercise test is performed. The exercise level is increased.

### Phase–III or Maintenance Stage or Maintenance Programme

*Aim*

a. To maintain the function
b. To educate on risk factors or risk factors modification
c. To become perfect with the exercise programme.

*Exercise Regimen*

a. The duration of the exercise is for 45 to 60 minutes
b. The frequency of the exercise is everyday to the three times a day
c. Community exercise programme
d. The patient should have the ability to self-regulate exercises
e. The functional capacity is about 6 MET.

### Phase –IV or Commitment Phase or Ongoing for the Life Phase

The phase is commitment towards the cardiac care like exercises, diet and behavioural modification.

### The Cardiac Response to the Exercise

a. *Normal response:* Cardiac output, heart rate increases with increase of work load, oxygen consumption. The maximum heart rate will decrease, in the blood pressure there is systolic pressure rises and diastolic pressure will slightly rise.

b. *Abnormal response:* The ST segment elevate or depress indicate heart injury, the blood pressure, the systolic pressure the normal level or high after exercise and diastolic pressure increases 20 mm of Hg or decrease.
c. Angina symptoms
d. *Bradycardia or tachycardia*–abnormal exercise rate.

## Risk Factors

The risk factors commonly seen with the patient suffering from the cardio-vascular problem are:

a. Smoking
b. Hypertension
c. Elevated cholesterol level
d. Age
e. Diabetes
f. Sedentary life style
g. Family history
h. Male gender.

## Guidelines for the Management of the Risk Factors

a. Lipid management
b. Hypertension management
c. Diabetic management
d. Smoking cessation
e. Weight management
f. Psychological management

| *S. No* | *Management* | *Evaluate* | *Aim* | *Plan* |
|---|---|---|---|---|
| 1 | Lipid | Check the total cholesterol, HDL, LDL and triglycerides | 1.LDL< 100 mg/dl or if more<br>2.HDL > 40 mg/dl or more | 1. Nutritional counselling<br>1. Weight management<br>2. Exercise<br>2. Smoking cessation |

*Contd..*

*Contd..*

| | | | | |
|---|---|---|---|---|
| 2 | Hypertension | Check blood pressure | 1.If BP <140/90 mm of Hg<br>Systolic BP > 130 mmHg<br>Diastolic BP > 85 mmHg<br>2. If BP is 130/85 mmHg<br>Systolic BP > 140 mm of Hg<br>Diastolic Bp is > 90 mm of Hg | 1. Exercise<br>weight management, sodium restriction alcohol and smoking cessation<br>2. All the above and lifestyle modification |
| 3 | Diabetes | Fasting blood glucose and in diabetics HbAIC | Fasting blood glucose < 110 mg/dl<br>HbAIC < 7<br>Hypoglycaemic therapy | Weight reduction<br>Exercise<br>Oral hypoglycaemic agents or insulin<br>Before and after exercise monitor the blood glucose level. Train the patient to check the post exercise hypoglycaemia. If blood glucose is > 300 ml/dl discourage the exercise |
| 4 | Smoking | Enquire about the smoking habits, amount and duration of smoking | Complete cessation is encouraged | Education<br>Counselling<br>Drug therapy |
| 5 | Weight | BMI–Weight, height and waist circumference | BMI should be in between 21–25 $kg/m^2$ | Total calorie intake should be reduced and the energy expenditure should be increase by regular diet and exercise |
| 6 | Psychological | Anger, Anxiety, Depression and Distress | Stress management | Counselling, Education, treatment by the mental health professional |

## PULMONARY REHABILITATION

The pulmonary rehabilitation is a multi-disciplinary programme of patient with acute and chronic respiratory disease that are designed to increase in over all quality of life of the patient.

*Indications*

a. Chronic respiratory failure
b. Reduced capacity to perform activities of daily living
c. Dyspnea
d. Surgical intervention.

*Contraindications*

a. Pulmonary hypertension
b. Ischaemic heart disease
c. Liver dysfunction
d. Cancer
e. Renal failure.

## Goals

1. To decrease disability
2. To reduce symptoms
3. To increase physical activity
4. To improve quality of life.

The goals are achieved through the following four phases:

1. Patient and his/her family education
2. Exercise training about respiratory care
3. Behavioural and psychosocial intervention
4. Outcome assessment.

## Components of Pulmonary Rehabilitation: This includes Respiratory Care

| *S.no* | *Aims* | *Plans* |
|---|---|---|
| 1 | To loosen the secretions | Massage manipulations, Breathing exercises, Postural drainage and inhalation therapy |
| 2 | To aid in removal of secretions | Coughing, huffing, Forced expiratory technique and suction |
| 3 | To induced relaxation | Relaxation technique is demonstrated |
| 4 | To teach breathing control | Breathing control techniques are taught |
| 5 | To prevent postural deformity | Teach postural awareness |
| 6 | To maintain the mobility of the upper extremity, lower extremity and trunk | Mobility exercises of the upper limb, lower limb and trunk |
| 7 | To give home advice | Home care management for preventing of recurrence of the symptoms |

## Assessment for Pulmonary Rehabilitation

a. Patient history
b. Physical examination
c. Previous history
d. Exercise capacity and endurance
e. Minimental state examination (MMSE) and neuro-behavioural cognitive status examination (NCSE), Age, Hypoxaemia
f. Emotional disturbance, Depression and anxiousness
g. Nutritional assessment
h. Body weight and composition using body mass index chart.

## Out Come Assessment

A. *Impairment:* The impairment is loss of function resulting from disease

Diagnosis of impairment can be done by two tests:

1. *Force expiratory volume:* This is the volume of the air expired forcibly after maximum inspiration in a second is Forced expiratory volume (FEV)

   FEV1: This is the volume of the air expired forcibly after maximum inspiration in one second is Forced expiratory volume 1.

   *Forced vital capacity:* This is the maximum volume of air expired forcibly after maximum inspiration

   In a healthy person: FEV1/FVC = 80%

   *Vital capacity:* It is the maximum volume of the air expired after maximum inspiration

   VC = 4000 ml or 4 litres

   The values of VC, FEV1 and its percentage are measured by vitalograph spirometer. Some of them are:

| *S.No* | *Condition* | *VC* | *FEV1* | *FVC/ VC* | *Example* |
|---|---|---|---|---|---|
| 1 | Normal person | 4 litres | 3.2 litres | 80% | ------- |
| 2 | Obstructive airway disease | 3.2 | 1.3 | 41% | Chronic bronchitis<br>Asthma<br>Emphysema |
| 3 | Restrictive airway disease | 2 | 1.6 | 80% | Pneumonia<br>Ankylosing spondylitis |

2. Pulmonary function tests.

## Pulmonary Function Tests

The Pulmonary function tests measure the lung function that can distinguish restrictive from the obstructive disorders.

### Indications

1. A narrowed airway shows reversiblity to medication.
2. Asthma attack in a symptom less patient

   The air in the lung is classified into two divisions

   1. *Lung volumes:* The volumes of the lung are breathed by the subjects. They are:
      a. *Tidal volume:* The volume of the air breathed in and out in a single normal quit respiration is called tidal volume. It is about 500 ml.
      b. *Inspiratory reserve volume:* The additional amount of the air inspired forcefully after the end of the normal inspiration is called inspiratory reserved volume. It is about 3300 ml or 3.3 liters
      c. *Expiratory reserve volume:* The additional amount of the air that can be expired out forcefully after normal expiration is called expiratory reserve volume. The normal value is 1000 ml or 1 litre.
      d. *Residual volume:* The amount of the air remaining in the lung even after the forced expiration is called residual volume. The normal value is 1200 ml or 1.2 litre.

### Importance

1. Residual volume maintains the contour of the lung
2. Residual volume helps top aerate the blood in between breathing and during expiration.
3. *Lung capacities:* The lung capacities include two or more primary volumes.

**They are:**

1. *Inspiratory capacity:* This is the maximum volume of air that and be inspired starting from end expiratory position. Its value is 3800 ml (IC=TV + IRV = 500 + 3300 = 3800).

2. *Vital capacity:* This is the maximum amount of the air that can be expelled out forcefully after a maximal deep inpiration. Its value is 4800 ml (VC = IRV + TV + ERV = 3300 + 500 + 1000 = 4800 ml).
3. *Functional residual capacity:* This is the volume of the air remaining in the lungs after normal expiration. Its value is 2200 ml. (FRC + ERV + RV = 1000 + 1200 = 2200 ml.
4. *Total lung capacity:* This is the amount of the air present in the lungs after a deep inspiration. It includes all the volumes. Its value is TLC = IRV + TV + ERV + RV = 3300 + 500 + 1000 + 1200 = 6000 ml.

*Forced expiratory flow rate:* A Peak flow meter provides a quick and simple indication of airway obstruction. The test is performed thrice and the best of three is taken with rest in between.

### Suggestions to the Patient

1. The patient is asked to avoid tight clothes
2. No to have heavy meal
3. Do not smoke
4. Giving the explanation and technique of the test.
5. If the first reading is taken in one position other two should be taken in the same position.
6. The Physiotherapist should demonstrate the technique with mouth piece
7. The patient should hold the mouth piece tightly.
8. The patient should take a deep breath until the lungs are completely full then blow short and sharp and as hard as possible.

### Aim

1. This is very important with patients with unstable asthma because lung function can decline to 50 or 60 % of normal before symptoms are noticeable.
2. This is useful in the chronic asthma to determine the right drug.
3. To evaluate ventilation by assessing the factors affecting the movement of gas in and out of the lungs.
4. To guide for the diagnosis, treatment plan and prognosis

5. To help therapist to plan for therapeutic goals, appropriate intervention to the pulmonary problems, identify the permanent respiratory impairment.

### Guidelines

1. The pulmonary function tests evaluate airway responsivity, ventilatory regulation and ventilatory mechanics.
2. The pulmonary function tests allows the effect of hypoxia, hypercapnia.
3. The pulmonary function tests helps in assessment of ventilatory mechanics which is measurement of lung volumes occur in restrictive diseases like Pneumonia, intestitial lung disease, Pleural effusion, Pleurisy, Pneumonia, and forced flow rates decreases in obstructive disease like chronic bronchitis, emphysema, asthma, bronchiectasis and cystic fibrosis.
4. The assessment of the ventilatory mechanics also permits evaluation of the effectiveness of therapy.
5. The pulmonary function tests helps to find out the general progress of the disease process.
6. The pulmonary function tests helps in the determination of the pulmonary impairment.

### Tests Performed by the Physiotherapist

A rough estimation of the airway obstruction can be made by asking the patient to blow out a lighted match held 6 inches from the mouth, failure to do suggest an FEV1 of less than one litre.

## MEASUREMENT OF THE PULMONARY FUNCTION

1. Spirometer
2. Gas transfer tests
3. Exercise testing
4. Quantitative perfusion /Ventilation scanning
5. Six minutes walk
6. Stair climbing.

## Spirometer

The method by which the lung volumes and capacities are measured is called spirometry. The simple instrument used for this purpose is called spirometer. The modified spirometer is known as respirometer.

*Spirometer*: The spirometer can be used only for a single breath. The repeated cycles of respiration cannot be recorded by using the spirometer because the carbon dioxide accumulated in the spirometer cannot be removed and oxygen or fresh air cannot be provided to the subject.

*Respirometer:* This is the modified spirometer. This has the facility of removing the carbon dioxide and supply of the oxygen. The carbon dioxide is removed by placing soda lime inside the instrument. The oxygen is supplied to the instrument from the oxygen cylinder by a suitable valve system.

*Spirogram:* The record of the lung-volumes and capacities using spirometer or respirometer is called Spirogram. The downward deflection of the Spirogram indicates expiration and the upward curve denotes inspiration.

*Computerized spirometer:* This is a solid state electronic equipment. The subject has to respire into a sophisticated transducer, which is connected to the instrument by means of a cable.

The residual volume, functional residual capacity and the total lung capacity are measured by the Nitrogen wash out technique and helium dilution technique, not with the spirometry.

## Helium Dilution Technique

### *1. Functional Residual Capacity*

The respirometer is filled with the air containing a known quantity of helium. Initially the subject breaths normally, then after the end of the expiration, the subject breathes from the respirometer. The Helium from the respirometer enters the lungs and starts mixing with the air in lungs. After few minutes of breathing, the concentration of Helium in the respirometer becomes equal to the concentration of helium in the lungs of the subject. This is called the equilibrium of helium. After this between respirometer and lung, the concentration of helium in respirometer is determined.

FRC = V (C1-C2)/C2

C1: Initial concentration of helium in the respirometer

C2: Final concentration of the Helium in the respirometer

V: Initial volume of air in the respirometer.

Example: V = 5000 ml, C1 = 15 %, C2 = 10%

FRC = 5000 (15/100–10/100) ml divided by 10/1000 = 2500 ml =FRC

*Residual Volume*

The subject should start breathing from the respirometer after forced expiration.

### Nitrogen Wash Out Method

The concentration of nitrogen in the air is 80%. So the total quantity of nitrogen in the lungs is measured, so that the amount of air in the lungs can be calculated.

*Functional Residual Capacity*

The subject is asked to breathe normally. After the end of the normal expiration, the subject inspires pure oxygen through a valve and expires into a Douglas bag. This procedure is repeated for 6-7 minutes till the nitrogen in lungs is displaced by oxygen. The nitrogen comes to the Douglas bag.

The FRC is calculated as:

1. Volume of air collected in Douglas bag
2. Concentration of nitrogen in the Douglas bag

FRC = C1 multiply V/C2

V = Volume of air collected = 40,000 ml

C1= Concentration of nitrogen in the collected air = 50%

C2 = Normal concentration of nitrogen in the air = 80%

FRC = 2500 ml.

*Residual volume:* The subject starts inhaling pure oxygen after the end of the forceful expiration.

### 2. Gas Transfer Tests

Arterial blood gases may be used to evaluate gas transfer and ventilation. The partial pressure of carbon dioxide provides the useful information of the alveolar ventilation. If there is minimum alteration indicates severe dysfunction of gas exchange.

### Exercise Testing

Measurement of exercise capacity evaluates the combined performance of cardiac and respiratory system. The maximum uptake is pre-operative outcome and used to identify surgical requirement for the patients.

### Quantitative Perfusion /Ventilation Scanning

Radio nuclide lung perfusion/ventilation scanning estimates the contribution of each lung, regions and lung function. It is used to predict pulmonary function after resection, pneumonectomy and lobectomy.

### Six-minute Walk

This is an in expensive, easily performed test. It is for the chronic obstructive lung disease, pre-operative evaluation of the thoracic surgery patient. The test procedure is the patient is instructed to walk on a pre-determined course as far and fast as they can. The distance will be over 1000 feet. This is for uncomplicated post-operative recovery.

### Stair Climbing

This is an exercise tolerance test done by climbing upstairs.

### Clinical Application

1. For pre-operative evaluation.
2. For the diagnosis of the functional pulmonary disorders.
3. Obstructive ventilatory disorders like chronic bronchitis, emphysema, asthma cystic fibrosis bronchiectasis.
4. Restrictive ventilatory disorders like fibrosing alveolitis, interstitial pneumonitis, and sarcoidosis and chest wall deformities.

## Disability

This is the inability to perform an activity due to the lung disease

The diagnosis of the disability is done based on:

1. *Field test:* This test is for the larger groups.

*Uses*

a. This test is practical
b. The test is inexpensive
c. The test consumes less time
d. The test can use to classify cardio-respiratory fitness of healthy men below or equal to 40 years and women less than or equal to 50 years.

2. *Contraindications of the test:*

a. Coronary heart disease because can't monitor ECG, Blood pressure during the performance

*Indications:*

a. This test can assess cardio-respiratory endurance like walking, running, swimming and cycling, etc.

*Technique:* This test measures post exercise heart rate.

## Handicap

The inability to perform activity because of impairment and disability

*Diagnosis:* Tred walk test: This is developed by rockport walking institute in 1986.

## Aim

a. To assess cardio-vascular fitness of both the sexes of ages between 20 to 69 years.

## Uses

a. Can assess older age group
b. Useful for sedentary individuals

*Guidelines:* The individual should wear good walking shoes and clothing should be loose

*Method:* Fast walking of about 1.0 mile. This gives submaximal $VO_2$

*Technique:* The individual should walk 1.0 mile as quickly as possible and at the end of the test the heart rate is checked by continuing the pulse for 15 seconds.

The walking tract should be flat with no interruptions in its way and of length 400 meters. The individual can do stretching for 5 to 10 minutes locate the walking time and check post exercise heart rate (beats per minute) on the appropriate chart for the client age and gender.

The chart is based on the body weight

*Women:* 125 pounds or 56.8 kilograms

*Men :* 170 pound or 77.3 kilograms

If the individual weight is more than this then the over estimation of cardio-vascular fitness occurs.

### Pulmonary Rehabilitation Programme–Respiratory Care

1. To aid in loosening of the secretions: The following techniques are used to loosen the secretions. They are:
   a. Massage manipulations
   b. Breathing exercises
   c. Postural drainage
   d. Inhalation therapy
   e. Humidification
   f. Intermittent positive pressure breathing
2. To remove the secretions
   a. Effective coughing
   b. Huffing
   c. Forced expiration technique
   d. Suction
3. To induce relaxation
4. To enhance breathing control
5. To bring awareness of posture
6. To mobilize upper extremity, lower extremity and trunk
7. To teach home management
   a. *Massage manipulations:* Massage is the scientific manipulation of the soft tissues of body done with the palmar aspect of hands or fingers.

### The Type of Manipulations Used are

1. Clapping
2. Vibration
3. Shaking

*Clapping (Fig. 5.1)*

The clapping technique is slightly done with cupped hands that strike the chest wall one after the other

*Position of the patient:* Prone lying with blanket over chest

*Position of the therapist:* The therapist is in stride standing position. Arms are kept at 30 degree abduction, elbow flexed to 90 degrees, hands are cupped and finger and thumb are adducted, metatarsophalangeal joint of index and middle and ring fingers are slightly flexed.

*Technique:* There is rapid control of the flexion and extension at the wrist

*Indication:* Chronic respiratory disorders

**Figure 5.1: Clapping**

*Vibration*

The vibration manipulation of the distal part of upper limb is used to transmit the mechanical energy to the body. Vibrations is produced in hands and fingers.

**Types**

a. Vibration
b. Shaking

In vibration the movement of the hand is in upward and downward direction, forearm is kept in full pronation so hand will be in contact with patient skin and wrist in 70 to 90 degrees dorsiflexion (Fig. 5.2).

Shaking forearm in midprone position the wrist in 0-10 angle of dorsiflexion. The hand moves in medio-lateral directly.

*Technique:* The therapist in walk standing postion. The elbow extended shoulder little flexed. One hand is placed over the other which remains in contact with the chest wall of the patient.

Transfer the body weight of the therapist to patient chest through extended upper extremity and tenses up arm, shoulder muscle. This causes oscillatory movement of hand in upward and downward direction and transmits mechanical energy to patient chest.

Vibration is performed during expiratory phase of the respiration. The patient is asked to inhale deeply and then blow out all air through mouth.

Vibration is initiated just before the expiratory phase and extended to the beginning of inspiratory phase. Manual vibration gives frequency of 20 HZ. CO-contraction of upper limb muscle vibration can also produce in finger tips or single palm.

### Physiological Uses

a. Dislodge thick sputum from bronchial wall
b. Mobilizes secretions.

Figure 5.2: Vibration

*Shaking (Fig. 5.3)*

The shaking transmits oscillatory mechanical energy to the chest wall. The direction of the oscillation is side-ways produces radial and ulnar deviation of the wrist.

*Technique:* The therapist adopts walk standing. Both the hands are over the chest wall over the affected lobe. The Shoulder adducted, elbow slightly flexed.

## Position of the Patient

*Position 1:* The patient is in supine lying. The therapist places both the hands on each side of the anterior chest wall.

The other position of the hands are one hand on the anterior aspect and the other hands on the posterior aspect of the chest wall on the same side.

**Figure 5.3: Shaking**

*Position 2:* The patient is in side-lying. Place both hands on upper lateral chest wall and other is place one hand on anterior and other on the posterior chest wall of the same side on the upper side.

Shaking is done only during the expiration phase. The therapist transfers the body weight to the patient chest and produce upward and downward movement of upper extremity. This gives vigorous shaking to the chest wall.

### Uses

a. Dislodge secretions from the bronchial tree
b. The sputum is shifted from smaller to the larger bronchioles
c. The shaking over the sternum during the respiration stimulates the cough reflex.

### Contraindications

a. Haemoptysis
b. Pleuritic pain
c. Pulmonary tuberculosis
d. Rib fractures
e. Osteoporosis.

## BREATHING EXERCISES

The breathing exercises are useful to loosen the secretions.

### Aims

1. To strengthen the muscles of respiration
2. To improve ventilation
3. To improve oxygenation
4. To improve gas exchange
5. To lessen the work of the breathing
6. To teach active range of motion exercises to the shoulder and trunk that help to expand the chest
7. To facilitate deep breathing
8. To stimulate the cough reflex
9. To improve pulmonary status
10. To improve patients overall endurance
11. To improve the function of activities of daily living
12. To promote relaxation
13. To prevent pulmonary impairment
14. To improve patients overall functional capacity
15. To deal with shortness of breath attack
16. To improve strength and co-ordination of respiratory muscles.

The breathing exercises are often combined with the postural drainage, exercises, respiratory therapy devices and medications.

### Indications

a. Pre and post-operative cardiac surgery conditions
b. Acute lung diseases
c. Chronic lung conditions
d. Spinal cord injury
e. Muscular dystrophy
f. Kyphosis
g. Scoliosis
h. Stress management
i. Relaxation.

### Principles

a. The instruction to the patient regarding the therapy should be given clearly and in simpler manner
b. The treatment area should be quiet
c. Explain the patient the importance of the breathing exercise
d. Patient should be comfortable and relaxed
e. Patient should wear loose clothing and avoid restrictive clothing
f. Position of the patient is crook lying in bed with head and trunk elevated 45 degrees
g. Abdominal muscles are relaxed when head and trunk are well supported, flexing the hips and knees and legs are supported with a pillow
h. As the patient is perfect in this position, progression is taught in other position like supine lying, sitting and standing positions
i. The patient is taught relaxation techniques
j. Patient should practice on his own and should be perfect with the correct technique.

### Precautions

a. The expiration should be relaxed and passive
b. Never encourage the patient to expire forcibly as this causes increased airway resistance and bronchospasm
c. The patient should not prolong expire as this mixed with the next inspiration there by breathing pattern becomes irregular and inefficient.

d. The patient should not use accessory muscles and upper chest to initiate inspiration
e. To avoid hyperventilation the patient should practice deep breathing for 3-4 times inspiration and expiration.

## CLASSIFICATION

The breathing exercises are classified into:

1. Diaphragmatic breathing
2. Segmental breathing
   a. Apical breathing
   b. Lateral costal breathing
   c. Posterior basal breathing
   d. Lingular breathing
3. Ventilatory muscle training
   i. Diaphragmatic training using weights
   ii. Inspiratory resistance training
   iii. Incentive respiratory spirometry
4. Glossopharangeal breathing
5. Pursed lip breathing.

### 1. Diaphragmatic Breathing

*Aims*

a. To improve gas exchange
b. To improve oxygenation
c. To improve ventilation
d. To improve ascent or descent of the diaphragm
e. To mobilize lung secretion during postural drainage
f. To decrease work of the breathing.

*Procedure*

*Position of the patient:* Half lying supported by the pillows.

*Position of the therapist:* The physiotherapist stands besides the patient.

*Technique (Figs 5.4 and 5.5):* The hands should be placed on the rectus abdominis below the anterior costal margin. Initially the therapist places the hands on the patient abdomen and ask the patient to inspire so that the abdomen bulges out and contracts and when patient expires the abdomen falls back to normal position. Ask the patient to breathe in through the nose and breathe out through the mouth. Practice the same 3 or 4 times then rest for brief period of time. Initially the physiotherapist demonstrates the technique then train the patient to practice the same on his own by keeping hands on the abdomen and during expiration feels the contraction of the abdominals.

**Figure 5.4: Diaphragmatic breathing**

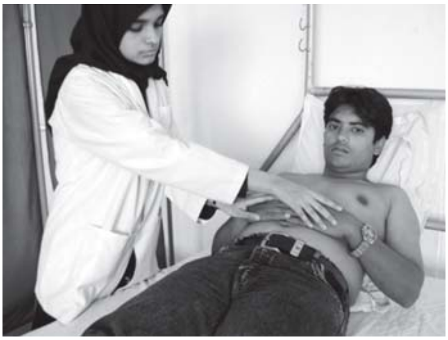


**Figure 5.5: Training the patient to perform the diaphragmatic breathing**

### 2. Segmental breathing

*Indication:* Hypoventilation so the patient is taught to expand only the localized area of the lungs, other areas are quiet.

*Apical Breathing*

*Indications:* Lobectomy

*Position of the patient:* Sitting

*Position of the physiotherapist:* The therapist stands in front of the patient and applies the pressure below the clavicle with the finger tips.

*Unilateral Apical Breathing (Figs 5.6 to 5.8)*

*During inspiration:* The physiotherapist applies the stretch downwards and inwards to the chest and muscle moves in the direction of outward and upward. This stretches the external intercostal muscle on the side of the pressure, i.e. right side or left side.

*During expiration:* The physiotherapist with palms give firm downward pressure and the ribcage is moved downwards and inwards on the side of the pressure, i.e. right side or left side.

**Figure 5.6: Left unilateral apical breathing**

**Figure 5.7: Right unilateral apical breathing**

**Figure 5.8: Self apical breathing**

*Bilateral Apical Breathing (Fig. 5.9)*

*During inspiration:* The physiotherapist applies the stretch downwards and inwards to the chest and muscle moves in the direction of outward and upward. This stretches the external intercostal muscle on the side of the pressure bilaterally.

*During expiration:* The physiotherapist with palms give firm downward pressure and the ribcage is moved downwards and inwards on the side of the pressure bilaterally.

**Figure 5.9: Bilateral apical**

### Lateral Costal Breathing

This is also called lateral basal expansion.

#### *Types*

i. *Unilateral breathing:* Right or left side
   *Position of the patient:* Crook lying
   *Position of the therapist:* The physiotherapist should stand behind the patient and hand is placed on the right side if right lateral costal breathing or on left side if left lateral costal breathing.
   *Technique:* The chest moves upwards and outwards during inspiration and downwards and inwards during expiration.

#### *Unilateral Costal Breathing (Fig. 5.10)*

*During inspiration:* The physiotherapist applies the stretch downwards and inwards to the chest and muscle moves in the direction of outward and upward. This stretches the external intercostal muscle on the side of the pressure, i.e. right side or left side.

*During expiration:* The physiotherapist with palms give firm downward pressure and the ribcage is moved downwards and inwards on the side of the pressure, i.e. right side or left side.

**Figure 5.10: Unilateral costal breathing**

*Bilatera costal breathing (Figs 5.11and 5.12):* The physiotherapist places both the hands on the bilateral lateral aspect of the chest wall and the firm pressure is given for inspiration and expiration in the following direction.

**Figure 5.11: Bilateral lateral costal breathing in supine position**

*During inspiration:* The physiotherapist applies the stretch downwards and inwards to the chest and muscle moves in the direction of outward and upward. This stretches the external intercostal muscle on the side of the pressure bilaterally.

*During expiration:* The physiotherapist with palms give firm downward pressure and the ribcage is moved downwards and inwards on the side of the pressure bilaterally.

*Self costal breathing (Figs 5.13 to 5.15):* The patient is trained to perform the costal breathing unilaterally with hands and bilaterally by using the belt to perform independently at home, etc.

### *Posterior Basal Breathing*

*Position of the patient:* Sitting position and leaning forward on a pillow.

Figure 5.12: Bilateral lateral costal breathing in sitting position

Figure 5.13: Self bilateral lateral costal expansion

Figure 5.14: Belt exercises for lateral costal breathing, applying resistance during inspiration

Figure 5.15: Belt exercises for lateral costal breathing, applying assistance with pressure during expiration along the rib cage

*Position of the physiotherapist:* The physiotherapist stands behind the patient and the therapist hands are on the posterior aspect of the lower ribs.

## Procedure

*Unilateral Posterior Basal Breathing (Fig. 5.16)*

*During inspiration:* The physiotherapist applies the stretch downwards and inwards to the chest and muscle moves in the direction of outward and upward. This stretches the external intercostal muscle on the side of the pressure, i.e. right side or left side.

*During expiration:* The physiotherapist with palms give firm downward pressure and the ribcage is moved downwards and inwards on the side of the pressure, i.e. right side or left side.

**Figure 5.16: Unilateral posterior basal breathing**

*Bilateral posterior basal breathing (Fig. 5.17):* The physiotherapist places both the hands on the bilateral posterior aspect of the lower ribs of the chest wall and the firm pressure is given for inspiration and expiration in the following direction.

**Figure 5.17: Bilateral posterior basal breathing**

*During inspiration:* The physiotherapist applies the stretch downwards and inwards to the chest and muscle moves in the direction of outward and upward. This stretches the external intercostal muscle on the side of the pressure bilaterally.

*During expiration:* The physiotherapist with palms give firm downward pressure and the ribcage is moved downwards and inwards on the side of the pressure bilaterally.

### *Lingular Breathing (Fig. 5.18)*

This is also called as right middle lobe expansion as left lung has only two lobes.

*Position of the patient:* The patient is in sitting position

*Position of the physiotherapist:* The therapist stands behind the patient and hand is placed on the right side of the patient chest below the axilla.

### *Procedure*

*During inspiration:* The physiotherapist applies the stretch downwards and inwards to the chest and muscle moves in the direction of outward and upward. This stretches the external intercostal muscle on the side of the pressure, i.e. right side.

*During expiration:* The physiotherapist with palms give firm downward pressure and the ribcage is moved downwards and inwards on the side of the pressure, i.e. right side.

**Figure 5.18: Lingular breathing**

## 3. Ventilatory Muscle Training

This technique is for improving the strength of the breathing muscle especially muscles of inspiration.

### *Indications*

a. Acute pulmonary disease
b. Chronic pulmonary disease
c. Weakness
d. Atrophy
e. Inefficiency of the muscles of the inspiration like diaphragm and external intercostal.

*Types*

a. *Diaphragmatic training using weights:*
*Position of the patient:* Supine lying
*Procedure:* Put small weight of about 3 to 5 pounds over the epigastric region of the patient abdomen. Ask patient to breathe in against the resistance of the weight. Increase the number of times of the resistance breathing. The weight can be increased gradually and also the time duration can be increased for about 15 minutes. This strengthens the diaphragm. This is useful for the patient with weakness.

b. *Inspiratory resistance training:* This method increases the strength and endurance of the inspiratory muscle and decreases inspiratory muscle fatigue. This is through the breathing device called resistor. The resistor is put in the patient mouth and the patient inhales through the device, that gives resistance to the inspiratory muscles. The more narrow is the diameter of the airway, the more is the resistance. There should be gradual increase of time to 20 to 30 minutes. Once strength and endurance is increased, the diameter of the tube is decreased.

c. *Incentive respiratory spirometry:* This is also called sustained maximal inspiratory maneuver.

*Indication*

a. Post-operative conditions
b. Neuromuscular disorders

*Position of the patient:* Supine lying
*Procedure:* The patient is asked to inspire the air 3-4 times slowly and exhales with the 4th breathe. Then put the spirometer into the mouth and ask the patient to inhale the air and hold for few seconds. This can be repeated 5 to 10 times a day.

### 4. Glossopharangeal Breathing

*Indication*
a. Severe weakness of the inspiratory muscles
b. Spinal cord injuries
c. Post polio patients with inspiratory muscle weakness.

*Aim*

a. To increase patient inspiratory capacity
b. To prepare the patient for coughing
c. To advise the patients with difficult deep breathe.

*Technique:* The patient is asked to take gulps of air. The mouth is closed and the tongue moves the air to pharynx, the glottis gets opened and the air goes to the lungs. This way inspiration is increased and also the vital capacity of the lung.

### 5. Pursed Lip Breathing (Fig. 5.19)

*Indication:* Chronic obstructive pulmonary diseases like chronic bronchitis, Asthma, Bronchiectasis, cystic fibrosis and bronchitis.

*Position of the patient:* Patient in the comfortable and relaxed position

*Technique:* The physiotherapist places the hand on the abdominal muscle and patient is asked to take a deep inspiration and with the lips pursed patient is asked to expire the air. The procedure is repeated many times with frequent relaxation periods in between.

**Figure 5.19: Pursed lip breathing**

*Self pursed lip breathing:* The patient should practice the technique so that he can perform the technique independently. The technique is as follows.

The patient should place the hands on the abdomen and takes a deep inspiration and with the lips pursed expires the air. The procedure is repeated many times with frequent relaxation periods in between.

## POSTURAL DRAINAGE

### Definition

The postural drainage is the technique of loosening of secretions from the specific areas of the lobes of the lungs.

### Anatomy

There are a pair of lungs and the right lung has three lobes (Upper lobe, middle lobe and lower lobe) and left lung has two lobes (upper lobe and lower lobe).

*Right Lung Lobes*

The upper lobe has three broncho pulmonary segments
The middle lobe has two broncho pulmonary segments
The lower lobe has five broncho pulmonary segments

| *Lobes* | *Segments* |
|---|---|
| Upper lobe | Apical |
| | Posterior |
| | Anterior |
| Middle lobe | Lateral |
| | Medial |
| Lower lobe | Apical |
| | Medial basal |
| | Anterior basal |
| | Lateral basal |
| | Posterior basal |

*Left Lung Lobes*

The upper lobe has three broncho pulmonary segments.
The lower lobe has two broncho pulmonary segments.

| Lobes | Segments |
|---|---|
| Upper lobe | Apical |
| | Posterior |

*Contd...*

*Contd...*

| | |
|---|---|
| Lower lobe | Anterior<br>Superior<br>Inferior<br>Apical<br>Anterior basal<br>Lateral basal<br>Posterior basal |

*Diagnosis:* The diagnosis for the requirement of the postural drainage is done by using the radiograph or bronchogram that shows the quantity of the secretions in the lobes.

## Indications

### *Contraindications*

a. Postural drainage should not be done immediately after the meal as it may lead to nausea and vomiting
b. Postural drainage should not be performed on the bare skin.

### *Effects and Uses*

a. The postural drainage uses gravity as the patient is in gravity assisted position to move the mucus from the lungs to the throat.

### *Guidelines*

a. The patient should be comfortable
b. The patient should remove the tight clothing, jewellery, buttons around the neck, chest and waist
c. The patient should participate actively in the postural drainage
d. The patient should worn light and soft clothing
e. The towel is used to decrease the effect of the percussion
f. The treatment is carried out for the period of about 15 to 20 minutes
g. The length of treatment time for each lobe depends upon the amount of secretions present
h. The lobe which has more secretions should be treated first
i. The best recommended time for the postural drainage is either early morning or bed time session

j. The preparation of the therapist includes removal of jewellery like rings, watches, bracelets and maintain the flat and short nails.

### Technique

The postural drainage will be more effective if combined with manipulations like percussion, vibration, deep breathing and coughing. Out of the total duration the time for each manipulation is of about 3-5 minutes of percussion manipulations like clapping followed by vibration for 15 seconds or for five exhalations then coughing or huffing vigorously to get rid of the mucus, thus lungs are cleared.

The patient is positioned on a tilt table and the techniques are started in a sequence at a particular point according to the lobes.

### Manipulations

1. *Clapping:* The clapping is given on the chest wall over the lung segment to drain the secretions into proximal airway. The clapping is rhythmic and one only over the ribs. Clapping is contraindicated over the spine, stomach and lower ribs, breast bone to prevent injury to the spleen on the left side, liver on the right side and kidneys on the lower back.
2. *Vibrations:* The vibration manipulation is done with the flat hand or by placing hand firmly on the chest wall over the required segment and the therapist tenses his or her muscles of arm and shoulder to create shaking motion followed by this the therapist applies light pressure over the area that is vibration manipulation is done. Other way of vibration is therapist puts one hand over the other hand and presses the top and bottom hands on each other to vibrate.
3. *Deep breathing:* The patient is suggested to perform the diaphragmatic breathing that helps to loosen the mucus and stimulate coughing.
4. *Coughing:* The patient is asked to take deep inspiration followed by expiration with cough. This is important in clearing the

airways. The mucus is coughed out. The coughing strain can be reduced to the patient by assisting the supporting the sides of the lower chest with the hands or elbows. This also increases the cough effectiveness.

5. *Huffing:* After each position is drained ask patient to take deep breathe and expire it quickly in a huff. The huff forces the air and the mucus. The huff makes the cough effective.

*Duration of the treatment :* 20 to 40 minutes.

*Position of the patient:* The patient lies on the tilting table. The patient head should be down, well supported, patient should be in comfortable position so can bend his hips and knees and same is useful for the stronger cough.

*Position of the therapist:* The physiotherapist should stand straight, i.e. not in flexed position for longer duration of time or it may lead to low back ache.

*Equipment required:*

a. Drainage tubes
b. Electrical and non-electrical palm percussions
c. Vibrator.

*Procedure:* The Postural drainage is done in the gravity assisted position. The manipulations like percussion, vibration are done on the front, back and side of the patient chest followed by the deep breathing and coughing.

## The following lobes are drained in the following positions

1. Upper lobe: Apical segment
2. Upper lobe: Posterior segment
3. Upper lobe: Anterior segment
4. Lingula: This is the part of upper lobe of the left lung and has superior and inferior segments
5. Middle lobes of the right lung: Medial and lateral segments
6. Lower lobes: Anterior basal
7. Lower lobes: Posterior basal
8. Lower lobes: Lateral basal

9. Lower lobes: Anterior basal
10. Lower lobes: Posterior basal

### Upper Lobe: Apical Segment (Fig. 5.20)

*Position of the patient:* The patient is sitting on the chair with the pillow supporting the back and leaning backward on a pillow at an angle of 30 degrees and should keep both the patient hands on his or her thighs.

*Position of the patient :* The physiotherapist should stand behind the patient.

*Technique:* The placement of the hand is in between the collar bone and top of the shoulder on both the left and right side of the chest and percussion and vibration are done.

**Figure 5.20: Apical segment**

### Upper Lobe: Posterior Segment (Fig. 5.21)

*Position of the patient:* The patient sits on a flat table and leans forward on a folded pillow at a 30 degrees.

*Position of the therapist:* The therapist stands behind the patient.

*Technique:* The placement of the hand is on the upper back on the left side and right side and the percussion and vibrations are given.

Figure 5.21: Posterior segment

### Upper Lobe: Anterior Segment (Fig. 5.22)

*Position of the patient :* The patient is in supine lying on the treatment table with two pillows one under the head and other below the hips and knees.

*Position of the therapist:* The physiotherapist stands in front of the patient.

*Technique:* The placement of hands is between the collar bone and the nipple on the both right side and left side of the chest. The percussion and vibrations are done.

Figure 5.22: Anterior segment

### Lingula

This is the part of upper lobe of the left lung and has superior and inferior segments.

*Position of the patient (Fig. 5.23):* The patient is in side-lying with one pillow under the head. The foot end of the table is elevated by 14 inches or 15 degrees. The patient lies on the right side and rotates ¼ turn backward. A pillow is placed behind the patient from shoulder to the hip and the patient flexes his or her knees.

*Position of the therapist:* The physiotherapist will be standing behind the patient.

*Technique:* The placement of hands is outside the left nipple area for the male and for the female the postural drainage is given the heel of the hand under the arm pit and the fingers are extended below the breast (Fig. 5.24). The percussion and vibration manipulations are done.

**Figure 5.23: Lingula – position of the patient**

**Figure 5.24: Placement of the hand**

### Middle Lobes of the Right Lung (Fig. 5.25)

The middle lobe of the right lung consist of medial and lateral segments.

*Position of the patient:* The tilting table is elevated by 14 inches or 15 degrees. The patient is in side-lying with two pillows one below the head and other behind the back from shoulder to hip. The patient is asked to flex the knees. The patient lies on the right side and rotates ¼ turn backwards.

*Position of the therapist:* The physiotherapist stands in front of the patient.

*Technique:* The placement of the hand is outside the right nipple area and for female patients if the area of the breast is tender, the manipulations are given with the heel of the hand under the arm pit and the fingers are extended forward beneath the breast.

**Figure 5.25: Middle lobe**

### Lower Lobes: Left Lung Lower Lobe Anterior Basal Segment

*Position of the patient:* The treatment table should be elevated by 18 inches or 30 degrees. The patient is in side lying on the right side with one pillow under the head and other behind the back.

*Position of the physiotherapist:* The physiotherapist stands behind the patient.

*Technique:* Placement of the hands is on the left side of the lower ribs and percussion and vibration manipulations are given.

### Lower Lobes: Posterior Basal: For the Right Lung (Fig. 5.26)

*Position of the patient:* The table is elevated 30 degrees or foot end is raised by 18 inches. The patient is in prone lying with two pillows, one below the head and other below the hips. The patient lies on the abdomen.

*Position of the physiotherapist:* The physiotherapist stands beside the patient on the right side.

*Technique:* The placement of the hands on the right side of the patient spine and the percussion and vibration manipulations are done. Care must be taken not to manipulate spine and lower ribs.

**Figure 5.26: Posterior basal segment**

### Lower Lobes: Right Lateral Basal Segment (Fig. 5.27)

*Position of the patient:* The treatment table is elevated by 18 inches or about 30 degrees. The patient is in the side-lying position on the left side with two pillows one under the head and other in between the flexed knees. The patient lies on the left side, 1/4th turn forward towards the table.

*Position of the physiotherapist :* The physiotherapist is standing behind the patient.

*Technique :* The placement of the hands is on the upper most portion of the lower ribs. The percussion and vibration manipulations are given over the upper most portion of the lower right ribs.

Figure 5.27: Right lateral basal segment

### Lower Lobes: Right Lung Lower Lobe Anterior Basal Segment

*Position of the patient :* The treatment table should be elevated by 18 inches or 30 degrees. The patient is in side lying on the left side with one pillow under the head and other behind the back.

*Position of the physiotherapist:* The physiotherapist stands behind the patient.

*Technique:* Placement of the hands is on the right side of the lower ribs and percussion and vibration manipulations are given.

### Lower Lobes: Posterior Basal Segment for the Left Lung

*Position of the patient:* The table is elevated 30 degrees or foot end is raised by 18 inches. The patient is in prone lying with two pillows, one below the head and other below the hips. The patient lies on the abdomen.

*Position of the physiotherapist:* The physiotherapist stands beside the patient on the left side.

*Technique:* The placement of the hands on the left side of the patient spine and the percussion and vibration manipulations are done. Care must be taken not to manipulate spine and lower ribs.

### Lower Lobes: Left Lateral Basal Segment (Fig. 5.28)

*Position of the patient:* The treatment table is elevated by 18 inches or about 30 degrees. The patient is in the side-lying position on the right side with two pillows one under the head and other in between the flexed knees. The patient lies on the left side, 1/4th turn forward towards the table.

*Position of the physiotherapist:* The physiotherapist is standing behind the patient.

*Technique:* The placement of the hands is on the upper most portion of the lower ribs. The percussion and vibration manipulations are given over the upper most portion of the lower left ribs.

**Figure 5.28: Left lateral basal segment**

### Lower Lobes: Right Apical Segment

*Position of the patient:* The patient is in the prone lying on the abdomen on the flat table with two pillows under the hips.

*Position of the physiotherapist:* On the right side beside the patient.

*Technique:* The placement of the hands is over the middle part of the back at the bottom of the shoulder blade on the right side. Care to be taken that manipulations are not done on the spine.

### Lower Lobes: Left Apical Segment

*Position of the patient:* The patient is in the prone lying on the abdomen on the flat table with two pillows under the hips.

*Position of the physiotherapist:* On the left side beside the patient.

*Technique:* The placement of the hands is over the middle part of the back at the bottom of the shoulder blade on the left side. Care to be taken that manipulations are not done on the spine.

## THORACIC EXPANSION EXERCISE

### Aim

a. To mobilize secretions
b. To improve ventilation
c. To prevent atelectasis
d. To re-expand collapsed alveoli.

Figure 5.29: Half lying-thoracic expansion exercise

*Technique (Fig. 5.29):* The patient is in comfortable position. The patient is asked to breathe in slowly and deeply through the nose and breathe out through the mouth. The patient is asked to inspire the maximum air, ask patient to inspire for the second time. The physiotherapist places the hands over the chest wall where expansion is required and quick stretch to the inspiratory muscles is given, i.e. quickly squeezing the patient chest wall between the therapist hands at the beginning of the inspiration and release the pressure and ask the patient to inspire to the maximum volume possible.

This is explained to the patient and physiotherapist should give maximum resistance to the maximum volume. The resistance initially should be stronger and later should decrease.

This inspired air improves ventilation to the peripheral areas by mobilizing the mucus plugs and secretions.

The thoracic expansion exercises are combined with postural drainage, chest shaking and vibrations or with the active cycle of breathing technique. This can be done unilaterally or bilaterally. This combination is very effective for the patient.

## INHALATION THERAPY

The inhalation therapy is used to break up the mucus and to induce the relaxation in bronchial smooth muscle by using the bronchodilators.

This is done by:

a. Aerosol
b. Nebulizer

These both can be given during intermittent positive pressure breathing or steam inhalation.

*Aerosol:* This is the hand held device and commonly used. The patient should be trained the correct method of use of the inhalers to prevent the loss of the drug to the atmosphere. The correct technique of use of aerosol ensures the patient the maximum amount of the drug ethers the lung.

The effectiveness of the drug can be ensured by correct release. Usually only 10% of the drug reaches the bronchi and 90% of the drug is swallowed. So drug should be released at the beginning of the inspiration to ensure maximum amount of the drug reaches the bronchi instruct the patient to hold the breathe for about 10 seconds and expire quietly through the nose. The patient should take a gap of one minute before starting with the next inspiration. Few patients will be on both bronchodilators and steroid therapy using aerosols. Then the bronchodilators should be administered first so that airways get dilated. Give a gap of 15-20 minutes then steroid therapy can be started depending upon the type of the drug used.

*Rotahaler:* The patient should be well trained how to handle the Rotahaler properly. Initially the capsule should be inserted. The coloured end of the capsule is inserted first and twist the Rotahaler so that the capsule will be broken and inhale deeply to get the powder into the major airways. The patient is asked to breathe several times to inhale the drug completely.

### Other Types of Inhaling Devices

a. *Spinhalers:* This is the device advised for the children and the use is similar to the rotahaler.

b. *Spacer:* For patients who can′t inspire because of actuator in the aerosol. So the patient puts the mouth piece and depresses the actuator and inhales the drug.
c. *Nebuhaler:* This is a aerosol the mouth piece is kept when ever the drug is required this depresses the actuator and drug is released.

## Nebulizer

This is the other device for inhalation therapy where the drug is broken into the fine particles to enhance the inhalation. It is administered by compressed oxygen or air. The patient position should be relaxed and comfortable with well supported by the pillows. The patient has a choice of using either face mask for the young patients or disabled breathless patients and mouth piece for the patients who can hold the mouth piece with the lips to deliver the drug. The drug inhalation takes 10-15 minutes during this period the patient is asked to relax breathing followed by 1 or 2 deep breaths. This causes drug penetration into the airways.

The broncho dilator should be diluted. The solution of 4 ml saline is used to make the drug mild form. If still diluted solution is required then 1 ml salbutamol, 3 ml saline or 2 ml saline and 2 ml ipratropium bromide is used.

## Types of Nebulizer

a. In one type of Nebulizer the steam of gas is passed through a hole that creates a low pressure. This is passed through the tube where other end is immersed in bronchodilator solution. The liquid passes through the tube and get split into the small pieces and Nebulizer is ready for use.
b. *Nebulizer with piezo electric effect:* The liquid is moved by a vibrating crystal. This type of Nebulizer is used for home purpose. This delivers high humidity for patients with thick sputum to aid expectoration.

## HUMIDIFICATION

*Principle:* The air is moistened because it is passed through the water vapour. The patient is asked to inspire the air by face mask or by the mouth piece. Normally the air passing through the nose and pharynx is continuously moistening the respiratory mucous. If this is inefficient the cilial action is impaired and secretions are viscid so the need of humidification to loosen the viscid and thick secretions.

Humidification is the moistening of the air and gases, this is the normal function of the upper respiratory tract if this is inefficient then artificial humidification is required.

### Indications

1. When the patient is breathing through the tracheostomy tubes or endotracheal tubes. These patient feel the dry air which has temperature less than the body temperature. The secretions in the bronchial tree takes the moisture and form crusts. The crusts block the trachea, small airways, ciliary action is lost and humidification is lost.
2. When the patient is using the oxygen mask. The oxygen masks consist of the dry air so lead to lack of humidification. So artificial humidification is required.
3. When the thick secretions are present so artificial humidification will facilitate the removal of the secretions.

### Choice of Humidifiers

a. The patient with dry gases used ultrasonic type of humidifier
b. The patients with respiratory failure with chronic bronchitis, asthma, emphysema need disposal humidifier can deliver less than 28% of oxygen wit warm humidity.

### Methods

a. The humidification is given by the wide boring tube.
b. A short period of humidification is given before the chest clearance is done for the patient who is not intubated but breathe

freely. This is Nebulizer method with a face mask and mouth piece.

c. For the patient with tracheostomy tube or endotracheal tube a Brompton tube (a tracheostomy humidifying tube T tube) is used. This is a plastic tube and can fit into humidification wide boring tube. Other one is disposable tracheostomy mask made of plastic which is flexible.

d. A patient with intermittent positive pressure ventilation also need humidification. For these patient humidifiers are fitted with the ventilators. So heated humidifiers of about 34 degree centigrade + or –2 degree centigrade is used and kept at the endotracheal tube or tracheostomy.

## Types

There are two types of the humidifiers. They are:

a. *Supplies:* These are subdivided into:
   i. Ambient temperature vapour suppliers
   ii. Heated vapour suppliers
   iii. Ambient aerosol suppliers
   iv. Heated aerosol suppliers

b. Installation

   *Supplies:* These are subdivided into

   i. *Ambient temperature vapour suppliers:* In this type the humidification is obtained through the water with tiny gas bubbles at room temperature.
   ii. *Heated vapour suppliers:* In this type the hot water is taken with gas and patient tube is heated in Fischer –Paykell device to prevent temperature loss. A thermometer is attached so it gives feed back about the delivering the gas at over 39 degrees. The thermometer has cuff off mechanism if temperature is more than this as it will not be tolerated by the patient.
   iii. *Ambient aerosol suppliers:* This works on the Bernouilli principle. The subtypes of the aerosols are Bird, ohio, bard inspiron. The mist of the liquid water is produced by three ways.
      a. High pressure gas jet on an anvil

b. High speed spinning disc
c. Ultrasonic vibratory crystal
The recent Ambient aerosol suppliers work on the Babington principle. The air is forced through a fine film of water that produces dense mist.

iv. *Heated aerosol suppliers:* In this type the heated water is used along with nebulizing drug. This also work on Bernouilli principle and care of thermal safety is taken.

*Installation:* The water is added to the airway by the syringe, drip set or pump called installation.

## INTERMITTENT POSITIVE PRESSURE BREATHING

This is also called intermittent positive pressure ventilation. This is the assisted inspiration. The air under pressure by pressure cycled ventilators like bird and benett enters the bronchial tree and mobilizes the secretions and increases the aeration of the alveoli. The patient with bronchospasm can use the broncho dilator drugs. This reduces the energy expenditure and useful for the patient with labored breathing. The ventilators are set in such a way the assisted inspiration with intermittent positive pressure ventilation occurs along with patient normal breathing pattern.

## TO REMOVE THE SECRETIONS

### Effective Coughing

*Definition:* The coughing is the forced expiration technique against a closed glottis.

*Aim :* To clear the secretions from the trachea and bronchi.

*Technique:* The patient is asked to take deep breathe then tighten the abdominal muscle and cough. The air is breathed is high lung volume and deep breathe.

*Effects and uses:* The coughing clears the secretions from the central airways.

## Huffing

*Definition:* This is the forced expiration with the glottis open.

*Aim:* To move the secretions from the lobar and segmental bronchi.

*Technique:* The patient is asked to breathe in and tighten the abdominal muscle and huff through the mouth. The air is breathed in mid lung volume to breathe is medium sized.

*Effect and uses:* The secretions are moved from the peripheral airway.

## Forced Expiratory Technique (Fig. 5.30)

### *Aim*

a. To mobilize the secretions form the peripheral airways to the proximal airways.
b. To decrease broncho spasm.

### *Technique*

The patient is asked to perform 1 or 2 huffs, relaxed breathing and once or twice coughing.

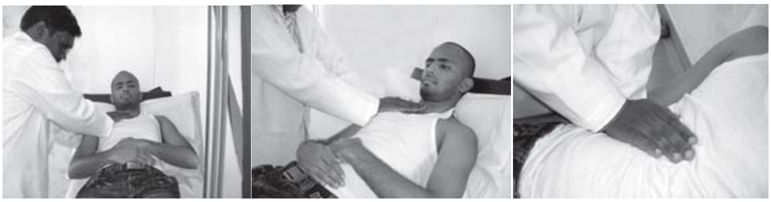
The huffing is done from the mid lung volume to the low lung volume so that the secretions are moved from the peripheral airway.

The coughing is performed at the high lung volume and clears the secretions for the central airway.

The relaxed breathing is to decrease or prevent the bronchospasm.

The patient is asked to take medium size of air breathe in followed by a forced expiration through the mouth open. Then patient is asked to huff once or twice and then breathing control.

The technique must be repeated till the secretions are reached the proximal airways then followed by a cough of high intensity to remove secretions. This technique can also be combined with the active cycle of breathing technique to be most effective.



**Front view** **Side view** **Back view**

**Figure 5.30: Forced expiratory technique**

## Active Cycle Breathing Technique

*Aim:* To clear bronchial secretions

*Position of the patient:*

*Less secretions:* Sitting

*More secretions:* Alternate side lying combined with postural drainage.

*Total treatment time:* 15 to 30 minutes.

*Technique:* The active cycle breathing technique is combined with the thoracic expansion exercise, breathing control, forced expiratory technique with huffing or coughing.

The patient is asked to perform the controlled breathing then three or four thoracic expansion exercises then forced expiratory technique. The techniques are performed initially with mid to low lung volume and once the secretions have reached the proximal airway then coughing or huffing with high lung volume is done to remove the bronchial secretions.

*Self treatment regime (Fig. 5.31):* The patient is trained and encouraged to perform the technique on his own, so that the patient can practice in the time of emergency and as a home programme too.

**Figure 5.31: Side lying-patient is practicing the self treatment regime**

## Suction

*Aim:* To suck the accumulated secretions from the main bronchi, trachea or pharynx.

*Technique:* A catheter is passed through the pharynx or nasopharynx or can be done through endotracheal tube or tracheostomy tube.

This catheter on the other end is attached to the suction pump and the secretions are sucked out.

## TO INDUCE RELAXATION

### Relaxation Definition

The ability to relax is called relaxation.

Relaxation is spending quiet times, spent listening to music or reading a book, and be away from the other distraction of her life.

Relaxing the body and mind during creates a sense of well being. It allow physical recovery and helps to prevent the tension.

A relaxed body is closely linked to a related mind. Stress and worry can manifest as headache or backache while physical pain or exhaustion increase worry and stress. Every one should try to find a little time everyday to relax themselves. By doing this, everyone will feel more energetic towards their work. Try to get plenty of sleep.

### Practicing Relaxation

*Relaxation is very simple:* The art of Relaxation lies in taking time for practicing. Relaxation can be practiced for a period of 15 to 20 minutes in the morning, or after return from work or, after bath, or before going to the bed. Relaxation time is never go waste as relation frees the individual of stress and to cope in all areas of daily living.

### Relaxation Techniques

These are some of the ways, which can be practiced any where any time in sitting, lying positions. They are:

1. Raise your shoulders up towards your ears count five and go back to initial position.
2. Bring shoulders to front and then back to normal and take them each five times.
3. Try to bring both the eyebrows near to each other as if you are frowning, press your lips and tighten your eyes, hold them and count five and release them.
4. Relax all the features of face one by one.

**Figure 5.32: Whole body relaxation**

Breathing techniques and general relaxation are very much useful for the individual. The breathing techniques can be used as an instant free of stress followed by general relaxation. Take time in a day and try to spend minimum of 10 minutes or more on focused relaxation. Find a quiet spot and lie comfortably with a small pillow under head lie down in an calm area, lose your idea and try to imagine each part of your body and relax them part by part.

## Procedure

The individual in supine lying or half lying, the mind is concentrated on normal breathing (Fig. 5.32). All the major and minor parts are mentally viewed, their shapes are recalled and visualized, i.e. and let loose one after another continuously in the following sequence.

### *Upper Limb*

Thumb – fore finger – middle finger – ring finger - little finger - back of the palm - the palm - wrist - forearm - upper arm - shoulder (both sides).

### *Lower Limb*

Big toe– second toe– third toe–fourth toe – little toe - the upper part of the foot–sole–heel–ankle- calf - knee–thigh-thigh joint (both sides).

*Back*

From the bottom of the backbone to the neck-the right side of the back-the back of the right shoulder-the left side of the back-the back of the left shoulder- the back of the neck.

*Abdomen Chest and Throat*

Navel-the left side of the navel (including urinary organs)-the right side of the navel-the upper side of the navel-the central part of the chest –right breast –left breast-the pit below in the throat-throat.

*Head*

Chin –lower lip –tongue-right nostril-right cheek-righ tear-right eye-left eye-left ear-left cheek-left nostril-tip of the nose-the center of the eyebrows-forehead –right side of the head-back of the head-left side of the head-top of the head.

Each part should be concetrated for 10-20 seconds. The shape should be visualized by the mind with closed eyes. While looking so, the concentration spot should be freely let loose. The entire process may be completed in about 15-30 minutes, this is called one round.

### Advantages

1. It helps in relieving stress and tension
2. It helps in getting peaceful sound sleep
3. Mind and body gets complete rest. They are totally relaxed
4. Quality of sleep improves, sleep duration is reduced time is saved
5. Tireness of the body is relieved
6. All the part of the body are relaxed to their maximum and they are re-charged with energy
7. Tension, anxiety, depression, stress, strain, negative thoughts, high blood pressure are controlled
8. The individual feels physically stable and mentally peaceful.
9. Memory, will power, inner energies and knowledge is developed
10. Regular practices play a big role in the higher practices of concentration, meditation and self-realization.

To enhance breathing control

## BREATHING CONTROL

The breathing control is taught to the patients the breathlessness and with decreased work of breathing.

### Aims

a. To reduce broncho spasm
b. To improve the reduced work of breathing
c. To encourage the slow respiratory rate
d. To encourage increased tidal volume.

### Indications

a. Wheeze
b. Severe breathlessness.

### Various Positions to Practice Breathing Control

a. Relaxed half lying
b. Supported forward leaning
c. High side lying
d. Relaxed sitting
e. Forward lean standing
f. Back lean standing
g. Side lean standing.

1. *Relaxed half lying (Fig. 5.33):* The patient is in half lying position and relaxed. The physiotherapist places one hand on the patients upper abdomen just below the xiphisternum to check the rise and fall of the patient breathing pattern and the patient is taught the technique of the breathing pattern.

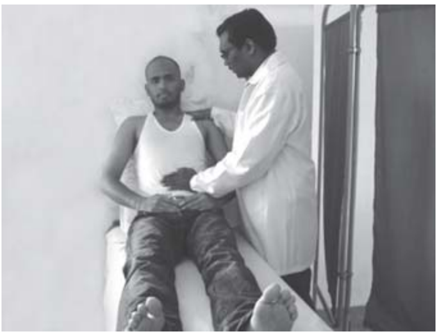


**Figure 5.33: Relaxed half lying position**

2. *Supported forward leaning (Fig. 5.34):* The patient sits in a chair and forward lean on the table with four pillows. The three pillows are placed on the table, then patient is asked to keep both the upper extremities on top of three pillows and the fourth is placed on the top of upper extremities and patient is asked to lie on the fourth pillow.

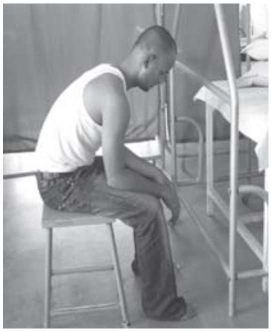
**Figure 5.34: Supported forward leaning position**

3. *High side lying (Fig. 5.35):* The patient is in side-lying position, e.g. if the patient is lying on the right side lying the left upper extremity is placed as follows : Shoulder adducted, internally rotated, elbow slightly flexed, forearm pronated, wrist and fingers are slightly flexed and placed on the anterior aspect of the chest. Three pillows are required two are placed under head and the third on the couch below the right upper extremity. The placement of the right upper extremity is as follows: Shoulder abducted to 90 degrees, externally rotated, elbow flexed, forearm supinated and wrist and fingers extended.

**Figure 5.35: High side lying position**

4. *Relaxed sitting (Fig. 5.36):* The patient sits on the stool and slightly bends the spine forward. The patient is relaxed. The head is bend forward, both the upper limbs are relaxed on the thighs, shoulder flexed, elbows are slightly flexed, forearm are pronated, wrist and fingers are flexed.

Front view



Side view

**Figure 5.36: Relaxed sitting**

5. *Forward lean standing (Fig. 5.37):* The patient is in the walk standing position in front of the couch, trunk, shoulders and elbows are flexed, forearm are supinated, wrist and fingers are slightly flexed. The forearm, wrist and fingers are relaxed on the couch and the wrists of the both hands are crossed.

**Figure 5.37: Forward lean standing position**

6. *Back lean standing (Fig. 5.38):* The patient is in standing position with legs placed wide. The patient back touches the wall from behind and trunk is slightly flexed. The upper extremity is

shoulders adducted, internally rotated, elbows slightly flexed, forearm in mid prone position, wrist extended, the fingers are flexed and placed on the thighs.

Figure 5.38: Back lean standing

7. *Side lean standing (Fig. 5.39):* The patient leans to the wall on one side either right or left, e.g. patient leaned to right side patient head is flexed, right upper extremity is extended, left upper extremity is slightly flexed, right lower extremity, the knee is flexed and left lower extremity the knee is extended.

Figure 5.39: Side lean standing

### To Bring Awareness of Posture *(Fig. 5.40)*

*Indications*

a. Rounded shoulders
b. Kyphosis

c. Flexed posture
d. Decreased thoracic spine mobility
e. Decreased chest expansion.

*Technique*

a. Head should be erect
b. Relax the shoulder girdle
c. Straighten the spine.

The above should be followed by the patient is all positions like sitting, resting, walking, working, reading and watching television and during exercising, etc.

Tensed posture

Relaxed posture

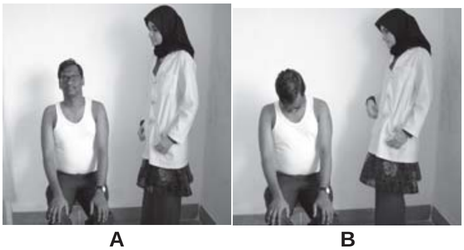
**Figure 5.40: To bring awareness of posture**

To mobilize Neck, upper extremity, trunk, pelvic girdle and lower extremity and trunk.

### Neck Exercises

*Sitting:* The patient will be sitting on the stool.

a. *Neck flexion (Figs 5.41A and B):* Neck should be in neutral position breathe out bend the neck forward so that chin touches the chest and breathe in and bring the neck to the starting position.

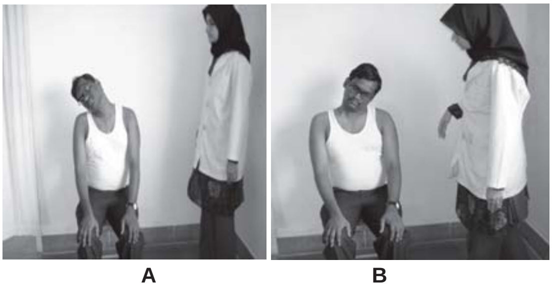



Figures 5.41 A and B: A. Neck in neutral position; B. Neck flexion

b. *Neck extension (Fig. 5.42):* Neck is in neutral position breath out, extend the neck and breathe in and bring the neck into the starting position.

Figure 5.42: Neck extension

c. *Neck lateral flexion or side bending (Figs 5.43A and B):* Neck is in neutral position breath out bend the neck to the right side and breathe in and bring the neck into the starting position. Repeat the same on the other side.




Figures 5.43 A and B: A. Right side lateral flexion; B. Left side lateral bending

d. *Neck rotation (Figs 5.44A and B):* The neck is in neutral position, rotate to the right side bring the neck to the neutral position and then to the left side. Apart from this rotation in clock wise and anti clock direction. Each direction rotation is performed for three times.

A B

Figures 5.44 A and B: A. Rotation to the left; B. Rotation to the right

## Shoulder Girdle Exercises

*Sitting:* The patient should be relaxed, straighten the spine, head should be straight and both the hands on the thighs. The following exercises are to be practiced.

a. *Elevation of the shoulder girdles (Figs 5.45A and B):* Raise the both the shoulder girdles.

A B

Figures 5.45 A and B: A. Neutral position; B. Elevation

b. *Depression of the shoulder girdles (Fig. 5.46):* Lower the both the shoulder girdles.

Figure 5.46: Depression

c. *Protraction of the shoulder girdles (Fig. 5.47):* Bring both the shoulder girdles in front.

**Figure 5.47: Protraction**

d. *Retraction of the shoulder girdles (Figs 5.48A and B):* Bring the shoulder girdles back.

**A B**

**Figures 5.48 A and B: A. Back view; B. Side view**

*Standing:* The patient should be standing with feet separated and practice the following exercises.

a. *Elevation of the shoulder girdles:* Raise the both the shoulder girdles
b. *Depression of the shoulder girdles:* Lower the both the shoulder girdles
c. *Protraction of the shoulder girdles:* Bring both the shoulder girdles in front
d. *Retraction of the shoulder girdles:* Bring the shoulder girdles back.

## Shoulder Exercises

*Supine lying:* The shoulder and elbow should be straight or elbow should be extended and whole upper extremity should move as a single unit.

### Long Lever Exercises

a. *Flexion of the shoulder (Fig. 5.49):* Shoulder is moved forward and raised.

**Figure 5.49: Shoulder flexion**

b. *Abduction of the shoulder (Fig. 5.50):* Shoulder is taken away from the body.

**Figure 5.50: Abduction of the shoulder**

c. *Adduction of the shoulder (Fig. 5.51):* Shoulder is moved towards the body.

**Figure 5.51: Adduction of the shoulder**

### Side-lying: The Top Shoulder Should be Moved

a. *Flexion of the shoulder (Fig. 5.52):* Shoulder moved in front

Figure 5.52: Flexion of the shoulder

b. *Extension of the shoulder (Fig. 5.53):* Shoulder is moved back.

Figure 5.53: Extension of the shoulder

c. *Abduction of the shoulder (Fig. 5.54):* Shoulder is moved away from the body.

Figure 5.54: Abduction of the shoulder

d. *Adduction of the shoulder (Fig. 5.55):* Shoulder should be moved towards the body.

Figure 5.55: Adduction of the shoulder

## Short Lever Exercises

*Sitting:* The patient will be sitting on the stool. The patient elbow is flexed and fingers should touch the shoulder.

a. *Flexion of the shoulder (Fig. 5.56):* Raise both the upper extremities.

Figure 5.56: Shoulder flexion

b. *Extension of the shoulder (Fig. 5.57):* Take the upper extremities backwards.

Figure 5.57: Shoulder extension

c. *Abduction of the shoulder (Fig. 5.58):* Move the upper extremities away from the body.

Figure 5.58: Shoulder abduction

d. *Adduction of the shoulder (Fig. 5.59):* Move the upper extremities towards the body.

Figure 5.59: Shoulder adduction

e. *Rotation of the shoulder:* Circle the upper extremities in clock wise direction.
f. *Rotation of the shoulder (Fig. 5.60):* Circle the upper extremities in Anti-clock wise direction.

Figure 5.60: Rotation

## Standing

a. *Flexion of the shoulder (Fig. 5.61):* Raise both the upper extremities.

**Figure 5.61: Shoulder flexion**

b. *Extension of the shoulder (Fig. 5.62):* Take the upper extremities backwards.

**Figure 5.62: Shoulder extension**

c. *Abduction of the shoulder (Fig. 5.63):* Move the upper extremities away from the body.

**Figure 5.63: Shoulder abduction**

d. *Adduction of the shoulder (Fig. 5.64):* Move the upper extremities towards the body.

Figure 5.64: Shoulder adduction

e. *Rotation of the shoulder:* Circle the upper extremities in clock wise direction.
f. *Rotation of the shoulder:* Circle the upper extremities in Anti-clock wise direction.

## Trunk Exercises

*Standing (Fig. 5.65):* The patient should be standing with wide base and hands are place on the waist.

Figure 5.65: Patient standing with wide base of support

1. *Trunk flexion (Fig. 5.66):* Breathe out and bend forward, breathe in and come to the starting position.

**Figure 5.66: Trunk flexion**

2. *Trunk extension (Fig. 5.67):* Breathe out and bend backward, breathe in and come to the starting position.

**Figure 5.67: Trunk extension**

3. *Trunk lateral bending to right side (Fig. 5.68):* Breathe out and bend to the right side, breathe in and come to the starting position.

**Figure 5.68: Right side lateral bending**

4. *Trunk lateral bending to the left side (Fig. 5.69):* Breathe out and bend to the left side, breathe in and come to the starting position.

**Figure 5.69: Left side lateral bending**

*Sitting (Fig. 5.70):* The patient is sitting on the stool with feet wide apart.

**Figure 5.70: Starting position of the patient**

1. *Trunk flexion (Fig. 5.71):* Breathe out and bend forward, breathe in and come to the starting position.

**Figure 5.71: Trunk flexion**

2. *Trunk extension (Fig. 5.72):* Breathe out and bend backward, breathe in and come to the starting position.

**Figure 5.72: Trunk extension**

3. *Trunk lateral bending to right side (Fig. 5.73):* Breathe out and bend to he right side, breathe in and come to the starting position.

**Figure 5.73: Right lateral bending**

4. *Trunk lateral bending to the left side (Fig. 5.74):* Breathe out and bend to the left side, breathe in and come to the starting position.

**Figure 5.74: Left lateral bending**

5. Sitting with fists on the side of the chest wall and trunk bending sideways .

## Pelvic Girdle

The patient is in crook lying (supine lying with hips and knees flexed) (Fig. 5.75). Whenever the movement is performed raise the pelvis up from the couch.

Figure 5.75: Crook lying

a. Move the pelvis forward (Fig. 5.76).

Figure 5.76: Forward movement of the pelvis

b. Move the pelvis backward (Fig. 5.77).

Figure 5.77: Backward movement of the pelvis

c. Move the pelvis right side (Fig. 5.78).

Figure 5.78: Right side movement of the pelvis

d. Move the pelvis left side (Fig. 5.79).

Figure 5.79: Left side pelvis movement

### Pelvic Bridging Exercise (Fig. 5.80)

The patient is in crook lying. The physiotherapist should stabilize the knee and feet. The patient is asked to raise the pelvis above the couch and count ten. Repeat the same for 3 to 4 repetitions, relax and perform 3- 4 sets.

Figure 5.80: Pelvic bridging

*Standing:* The patient will be standing with wide base with both the hands on the pelvis and perform pelvic rotation, both clock wise and anti-clockwise direction (Figs 5.81A and B).

A B

**Figures 5.81 A and B: A. Clock wise movement; B. Anti-clock wise movement**

## Lower Limb

*Supine lying:* The patient is in supine lying with both the lower extremities straight or extended.

a. *Hip flexion (Fig. 5.82):* Raise the lower extremity to the extent possible.

**Figure 5.82: Hip flexion**

b. *Hip abduction (Fig. 5.83):* Take the lower extremity away from the midline.

**Figure 5.83: Hip abduction**

c. *Hip adduction (Fig. 5.84):* Bring the lower extremity towards the midline.

**Figure 5.84: Hip adduction**

*Side-lying:* The patient is in side-lying with the both lower extremities extended or straight. The lower extremity on the top should be exercised.

a. *Hip flexion (Fig. 5.85):* Move the lower extremity forward.

**Figure 5.85: Hip flexion**

b. *Hip extension (Fig. 5.86):* Move the lower extremity backwards.

**Figure 5.86: Hip extension**

c. *Hip abduction (Fig. 5.87):* Raise the lower extremity away from the midline.

**Figure 5.87: Hip abduction**

d. *Hip adduction (Fig. 5.88):* Raise the lower extremity towards the midline.

**Figure 5.88: Hip adduction**

## Knee Exercises

*Supine lying:* The patient is in supine lying with both the lower extremities straight or extended.

a. *Knee rolling side to side (Figs 5.89A and B)*

**A** **B**

**Figures 5.89 A and B: A. Right knee rolling; B. Left knee rolling**

b. *Flexion of the knee (Fig. 5.90):* Bend the knee.

**Figure 5.90: Knee flexion**

c. *Extension of the knee (Fig. 5.91):* Straighten the knee.

**Figure 5.91: Knee extension**

Perform the same on both the side separately

*Sitting:* The patient will be in high sitting position

a. *Flexion of the knee:* Bend the knee

b. *Extenson of the knee:* Straighten the knee.

## Ankle and Foot

### Supine lying

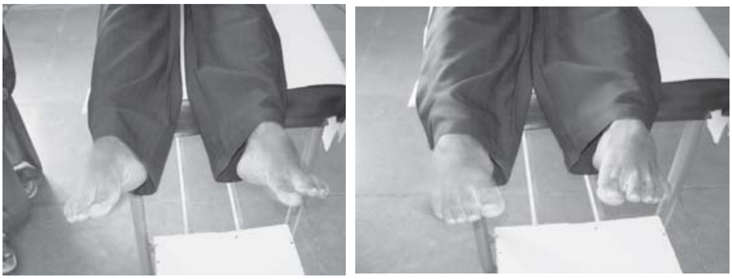
a. *Dorsiflexion (Fig. 5.92):* Bend the foot forwards.

**Figure 5.92: Dorsiflexion**

b. *Plantar flexion (Fig. 5.93):* Bend the foot backwards.

Figure 5.93: Plantar flexion

c. Foot circling in forward and backward direction (Figs 5.94A and B).



A B

Figures 5.94 A and B: A. Clock wise rotation; B. Anti-clockwise rotation

**All the exercises should be performed for about 5 repetitions each and about 3-5 sets with frequent relaxation periods.**

## To Teach Home Management

The patient should be given home programme so that he or she can perform the technique at home. This maintains the control of signs and symptoms, prevent exertions. The techniques of the patient can practice at home are:

*Postural Drainage*

The patient can practice lying on a bundle of news papers and the attendant can perform the percussion manipulation and patient can perform coughing and huffing.

*Breathing Exercise*

The patient can perform all types of breathing exercises and resistance can be offered by using the webbing belt.

*Loosening of the secretion:* The patient can perform thoracic expansion exercises.

*Sputum disposal:* This is done by techniques like coughing, huffing and forced expiratory technique.

Regular exercise regime as mentioned above.

Postural awareness in all activities of the daily living.

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# *Glossary*

*Acute*: Sudden or severe illness of short duration.

*Acute bronchitis*: A respiratory tract infection that causes inflammation of the trachea and the bronchi.

*Aneurysm :* A bulge or swelling in an artery that has been weakened by disease or injury.

*Angina pectoris*: A dull pressure or pain in the centre of the chest that may radiate down the left arm.

*Angiocardiography:* An X-ray examination of the heart and its blood vessel by injecting a substance.

*Angiography* : An X-ray examination of blood vessel.

*Angioplast:* The surgical technique for repairing of damaged blood vessel.

*Aorta* : The main artery of the body that extends from the left ventricle of the heart and distributes blood throughout the body.

*Arrhythmia:* An irregular hear beat.

*Arteriosclerosis:* The condition in which walls of the arteries are thickened that makes them to unable to supply adequate blood.

*Artery:* The vessel that deliver blood from the heart to through out the body.

*Atherosclerosis*: A condition of the arteries in which blood flow is blocked by fatty deposit.

*Auscultation:* Listening to sounds of heart and lungs with the aid of the stethoscope.

*Blood:* A fluid that runs throughout the body by way of the arteries, veins and capillaries.

*Blood vessels*: The arteries, veins and capillaries that carry blood.

*Bronchitis*: The inflammation of the bronchi or air passages of the lung.

*Bypass* :Grafting a section taken from another part of the body for passage of blood around a clogged section of the artery.

*Capillary*: The extremely tiny blood vessel that connect the arteries and veins.

*Cardiology:* The study of heart and circulating system especially diagnosis and treatment of disorder.

*Cardio-pulmonary resuscitation* : The use of artificial ventilation to revive from the cardiac arrest.

*Cardio-vascular system:* The system that circulates blood to all cells.

*Chest:* The chest is formed by 12 pairs of ribs attached anteriorly to the sternum and posteriorly to the vertebrae.

*Chest cavity:* The chest cavity is occupied by heart and lungs.

*Circulating system:* The circulating system carries blood from organs to all parts of the body.

*Congenital*: Existing from birth .

*Cystic fibrosis*: A disease develops during childhood that affects respiratory system and sweat glands by abnormal production of mucus.

*Decortication:* The removal of outer layer of an organ.

*Defibrillation technique:* This technique is to correct abnormal heart beat.

*Diaphragm:* The muscular partition that separates chest cavity and abdominal cavity.

*Embolism:* The blockage of the blood vessel by an obstruction called an embolus.

*Emphysema*: A lung condition in which the air spaces in the lungs are enlarged.

*Extrasystole:* An abnormal contraction of the heart.

*Heart:* Heart is a muscular organ helps in the circulation of the blood throughout the body.

*Heart attack:* A sudden diminishing of the hearts ability to function.

*Heart murmur*: An abnormal heart sound that can be detected by stethoscope.

*Hypertension:* High blood pressure.

*Hypotension* : Low blood pressure.

*Ischemia:* The tissue death because of loss of blood supply.

*Myocarditis*: The inflammation of the myocardium.

*Pacemaker:* An artificial device that stimulates heart action and regularizes the heart beat by the periodic discharge of electrical impulses.

*Respiration*: Inhalation and exhalation is called respiration.

*Respiratory arrest*: A cessation of breathing.

*Respiratory system:* The system that has nose, throat, larynx, trachea, bronchi and lungs that helps in exchange of gases.

*Shock:* The failure of the cardiovascular system.

*Sneeze*: An involuntary action that causes sudden force of air through nose and mouth for expelling irritants.

*Sphygmomanometer*: A device for measuring blood pressure.

*Tachycardia:* Abnormal rapid heart beat.

*Thoracotomy:* A surgical opening of the chest or thorax for corrective surgery.

*Thrombosis* : Coagulation of the blood.

*Thrombus:* A blood clot in heart or blood vessel.

*Trachea:* The tube extend from larynx to the bronchi in the respiratory tract.

*Vein :* The vessel that carry blood back to the heart.

*Wheeze*: Difficulty in breathing that is accompanied by a Whistling sound.

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