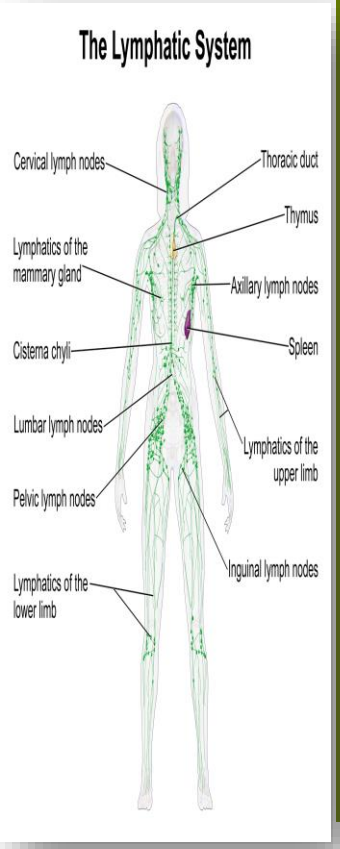
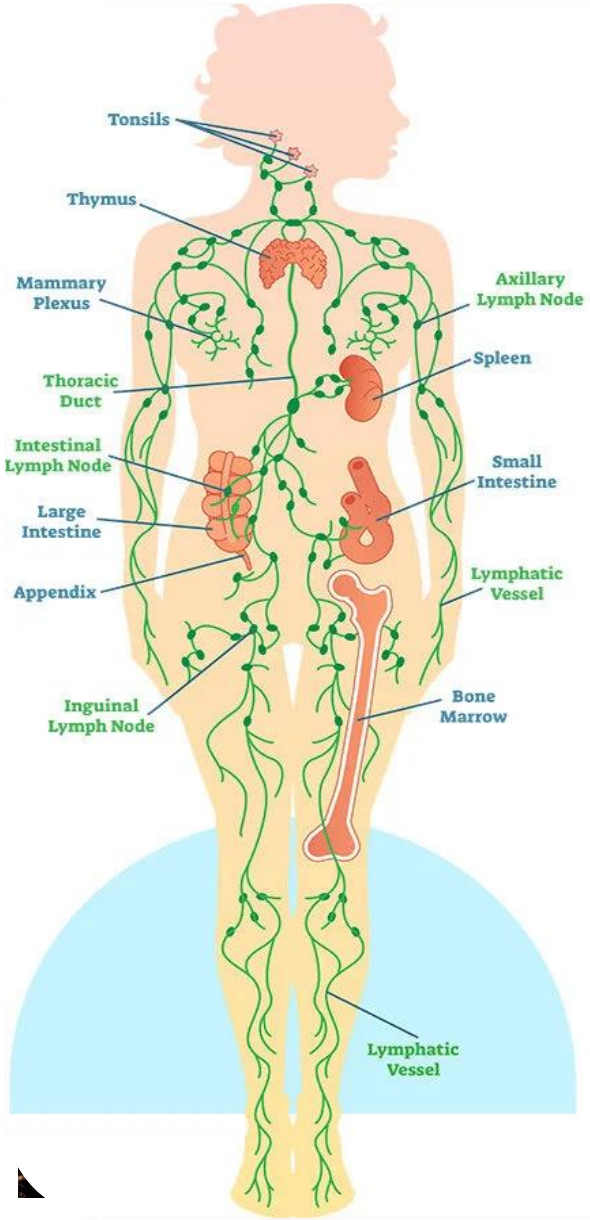
Lymphatic System And Lymphedema

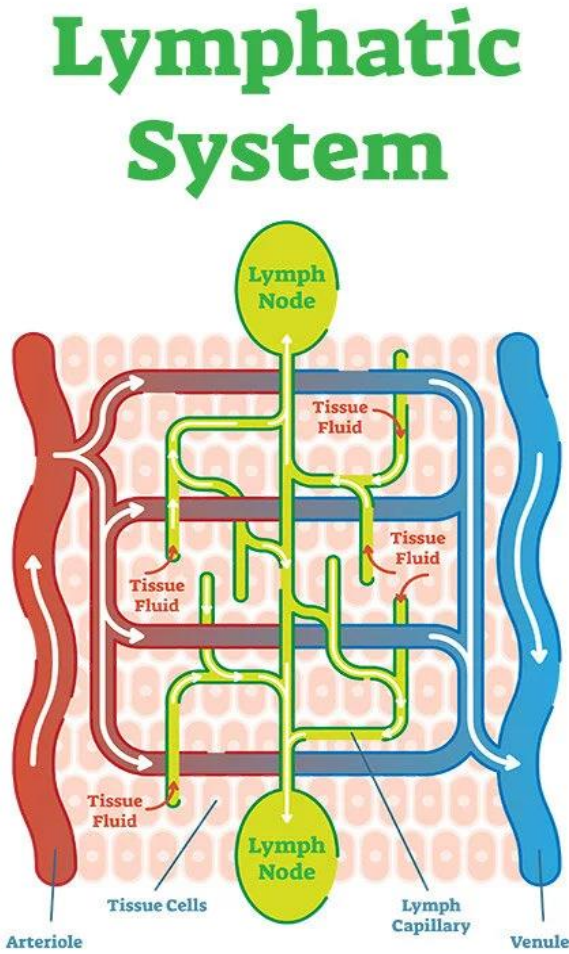


Dr. Saif Almudhaffar M.B.Ch.B F.I.B.M.S C.Th.V.S.

Department of Surgery /Collage of Medicine / Al Mustansiriyah University

Lecture time : 50-60 min





Learning Objectives

Describe the structure and main components of the lymphatic system.

Explain the physiological functions of the lymphatic system

Outline the mechanism of lymph formation and lymph flow.

Define lymphedema and distinguish it from other causes of limb edema.

C**lassify** lymphedema into primary and secondary types with examples.

Explain the basic pathophysiology of lymphedema.

Identify the clinical stages and key clinical features of lymphedema.

Recognize important physical signs such as **Stemmer's sign**.

Outline the principles of diagnosis and initial management of lymphedema.

Difinition

The lymph system is a network of organs, lymph nodes, lymph ducts, and lymph vessels that make and move lymph from tissues to the bloodstream. Lymphatic system is considered as a part of both the circulatory and immune systems

If veins return blood to the heart, why do we need another drainage system in the body

Although veins return blood to the heart, they **cannot remove all the fluid that leaves the arterial capillaries**.

- At the capillary level, blood pressure forces **plasma fluid and proteins** out of capillaries into the interstitial space to deliver oxygen and nutrients. Most of this fluid is reabsorbed at the venous end of capillaries; however, **approximately 10% of the fluid and most plasma proteins remain in the interstitial space**.
- Veins are **unable to reabsorb large proteins**. If these proteins were left in the tissues, they would increase interstitial oncotic pressure, leading to **progressive tissue edema**.

The lymphatic system provides a **separate, low-pressure drainage pathway** that:

- Collects excess interstitial fluid
- Removes leaked plasma proteins
- Returns them to the venous circulation
- Prevents accumulation of fluid in tissues

Therefore, the lymphatic system is essential to maintain **fluid balance and tissue homeostasis**. When this system fails, protein-rich fluid accumulates, resulting in **lymphedema**, a form of edema that does not respond to diuretics.

Mechanism of Lymph Formation

Capillary filtration (Starling forces)

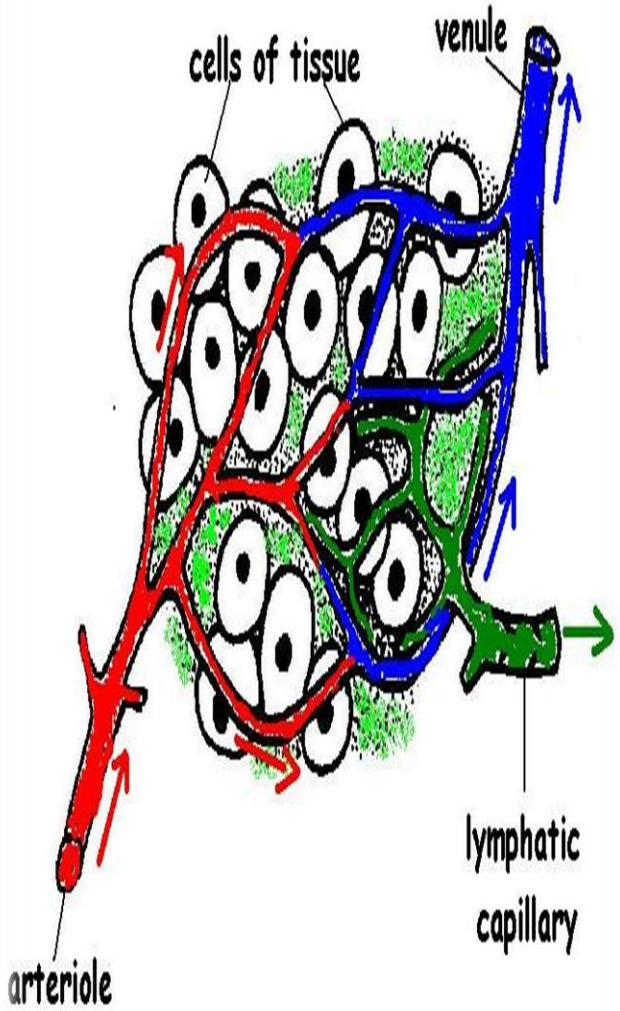
- At the venous end, **plasma oncotic pressure** pulls most fluid back.
- About **10% of filtered fluid is not reabsorbed** → remains as excess interstitial fluid.

Formation of lymph

- Excess interstitial fluid, plasma proteins, lipids, waste products, and immune cells accumulate. This fluid becomes **lymph** once it enters lymphatic vessels.

Entry into lymphatic capillaries

- Lymphatic capillaries are:
  - Blind-ended
  - Highly permeable
  - Have overlapping endothelial cells acting as **one-way micro-valves**
- Increased interstitial pressure opens these valves → fluid enters.
- **Anchoring filaments** prevent collapse during tissue edema.



Mechanism of Lymph Flow

Lymph flow is **low-pressure** and **unidirectional**, driven by several mechanisms:

Intrinsic lymphatic pumping

- Smooth muscle in lymphatic vessel walls contracts rhythmically.

One-way valves

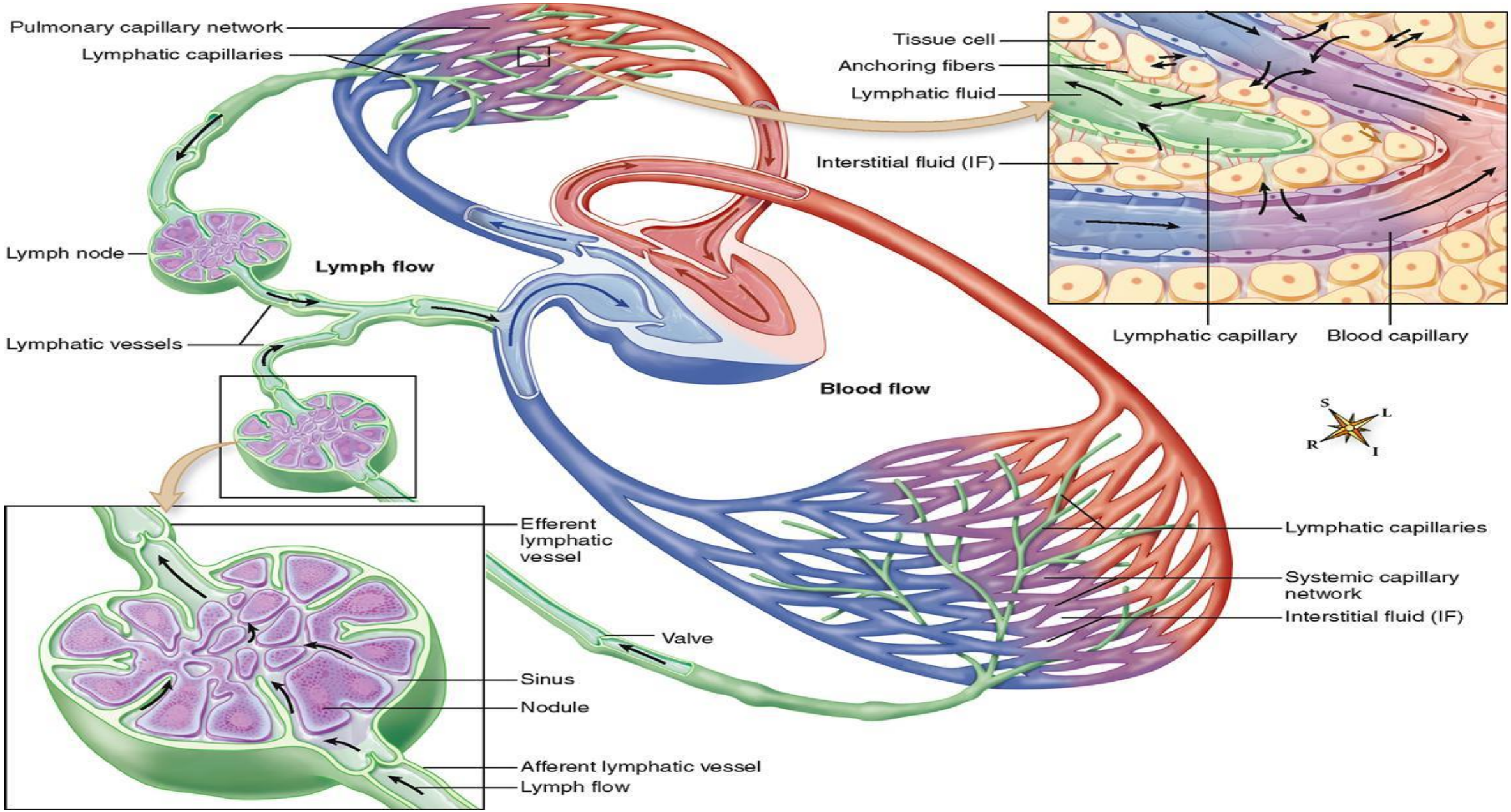
- Prevent backflow.Ensure movement toward the venous system.

Extrinsic forces

- **Skeletal muscle contraction** (most important in limbs)
- **Arterial pulsations**
- **Respiratory movements** (negative intrathoracic pressure during inspiration)
- **Body movements and posture**

Gravity

- Assists lymph flow from head and neck.
- Opposes flow from lower limbs → explains predisposition to leg edema.


Pulmonary capillary network
Lymphatic capillaries
Lymph node
Lymph flow
Lymphatic vessels
Blood flow
Tissue cell
Anchoring fibers
Lymphatic fluid
Interstitial fluid (IF)
Lymphatic capillary
Blood capillary
S
L
R
I
Efferent lymphatic vessel
Valve
Sinus
Nodule
Afferent lymphatic vessel
Lymph flow
Lymphatic capillaries
Systemic capillary network
Interstitial fluid (IF)

Components of the Lymphatic System

A. Lymph

- **Clear, yellowish fluid present in most tissues of the body. It is created as a result of the filtration of the plasma**
- Protein-rich
- Contains lymphocytes
- No red blood cells

B. Lymphatic Capillaries

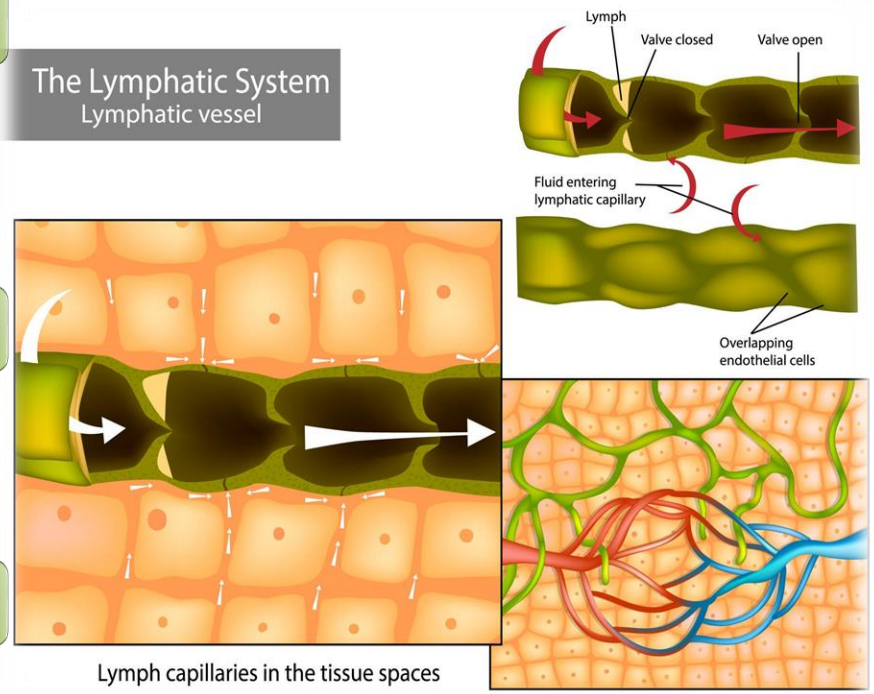
- Blind-ended
- Very permeable
- Located in most tissues
- Collect interstitial fluid

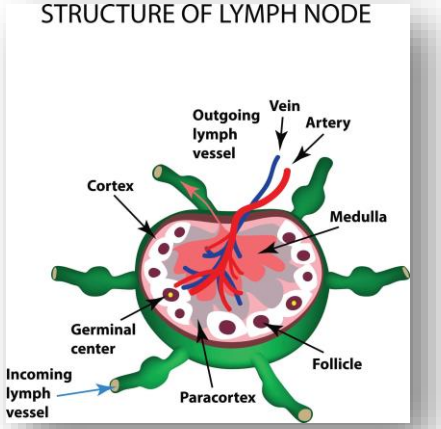
C. Lymphatic Vessels

- Thin walls
- Many valves
- Transport lymph centrally

D. Lymph Nodes

- **Soft, small, round- or bean-shaped structures. They usually cannot be seen or easily felt. They are located in clusters in various parts of the body, such as the neck, armpit, groin, and inside the center of the chest and abdomen Act as filters : Contain immune cells: Common sites:**
  - **Cervical**
  - **Axillary**
  - **Inguinal**

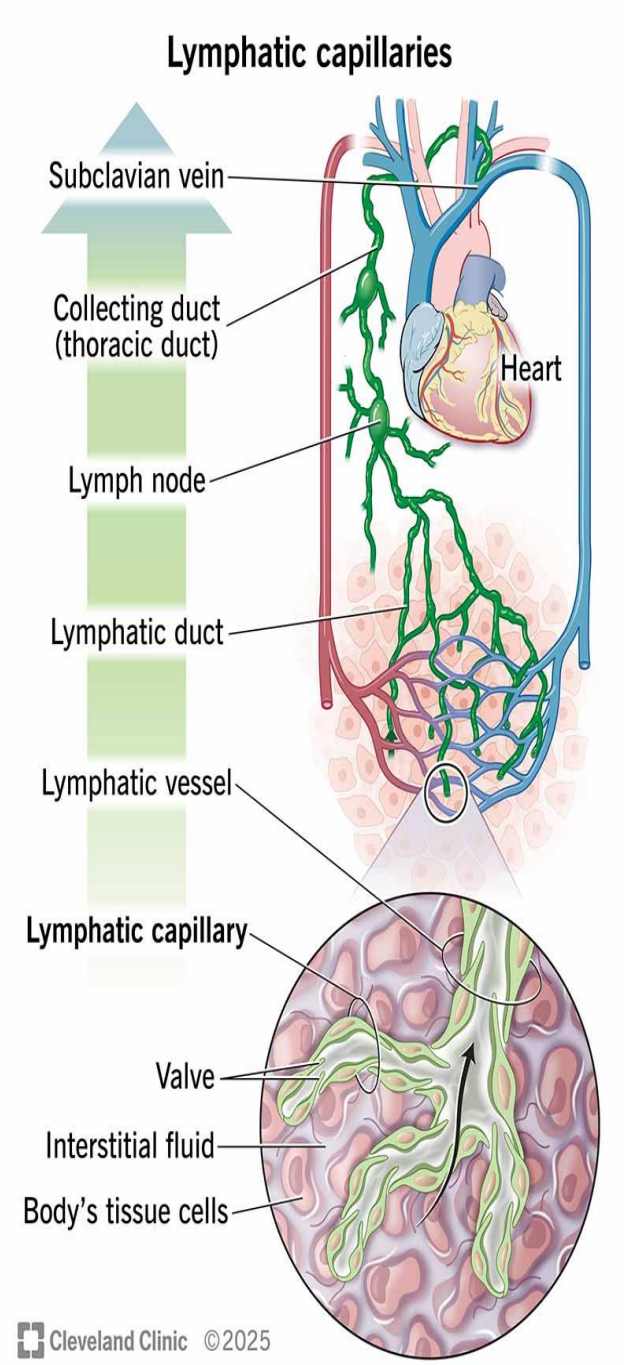




lymphatic vessels

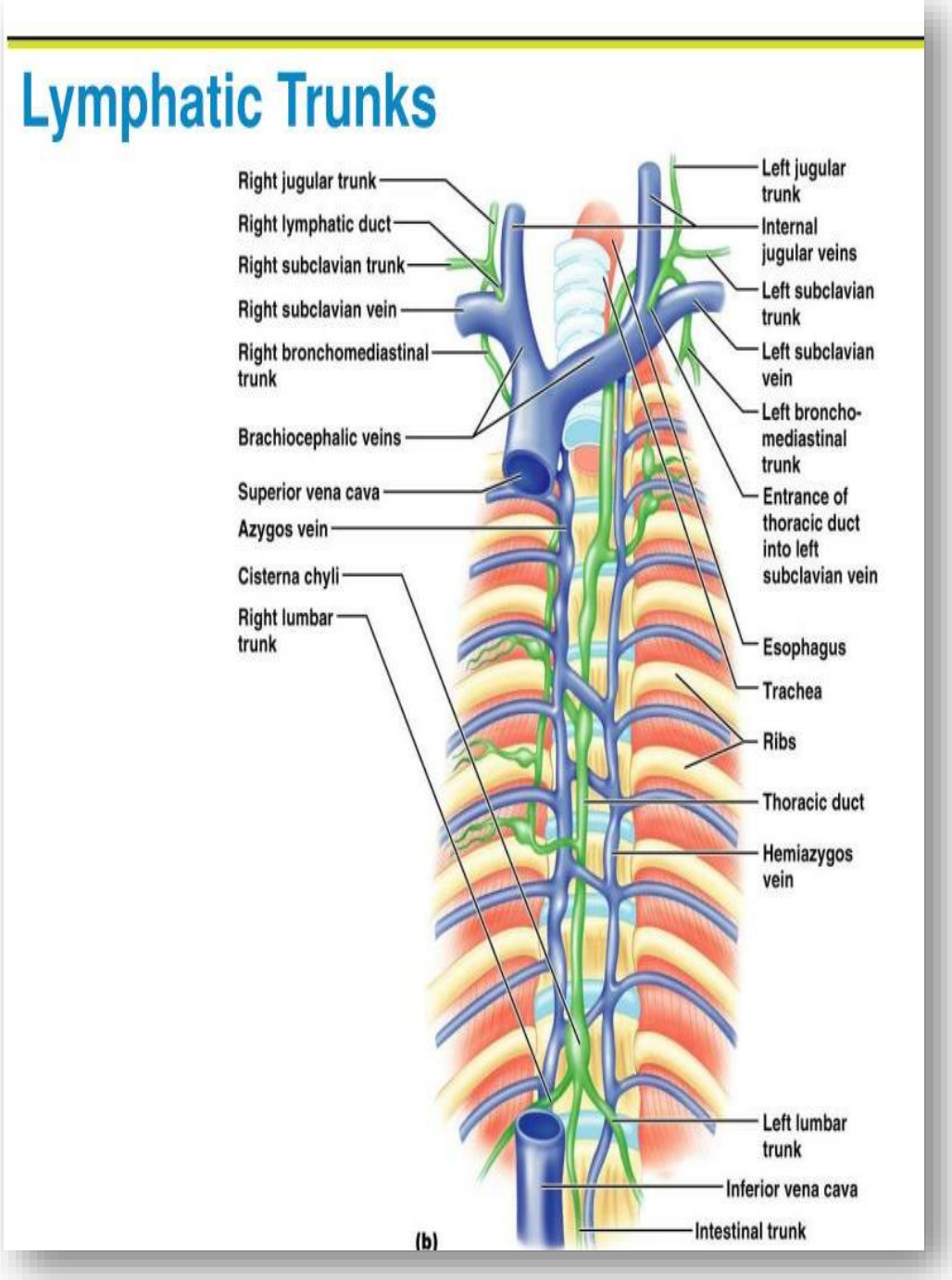
The are divided into two large groups superficial and deep lymphatic vessels.

The superficial vessels are located in the subcutaneous layer of the skin where they collect the lymph from the superficial structures of the body. They tend to follow the drainage of the venous system and in the end, drain into deep lymphatic vessels.	The deep lymphatic vessels carry lymph from internal organs. In contrast to the superficial vessels, the deep vessels are accompanied by the arteries.	Both superficial and deep lymphatic vessels go through lymph nodes that monitor the content of the lymph. Lymphatic vessels that carry lymph towards the lymph node are known as afferent, whereas the vessels that carry lymph away from the lymph node are called efferent lymphatic vessels.	The efferent vessels empty into the lymphatic trunks. The lymphatic trunks are named according to the region of the body that they drain the lymph from.

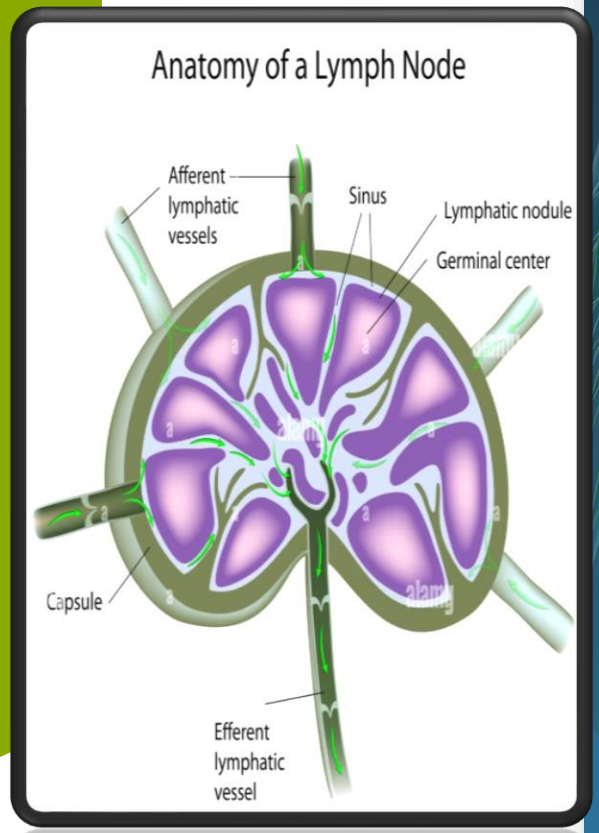


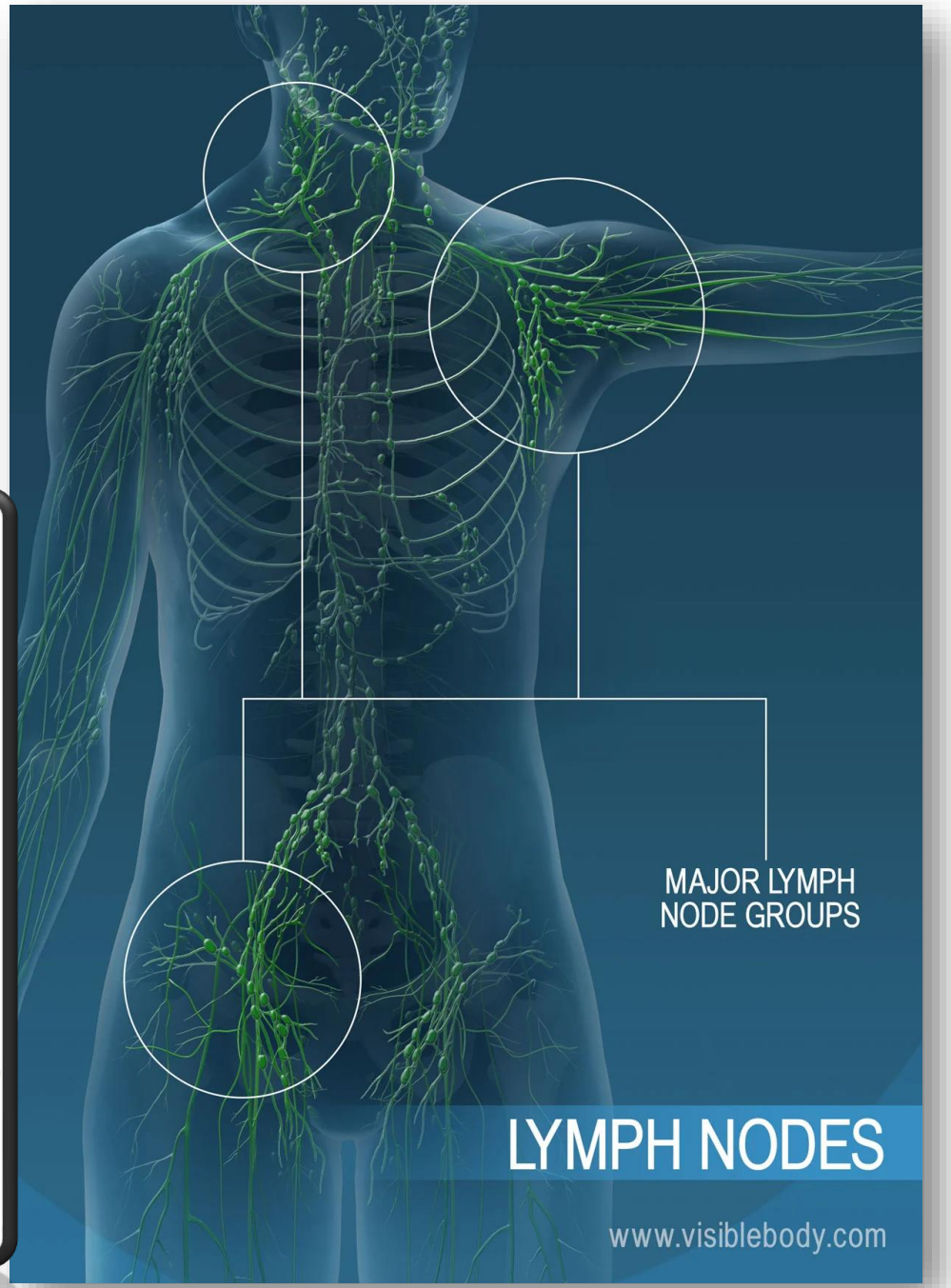
There are four pairs of trunks: lumbar, broncho mediastinal, subclavian and jugular. There is also one unpaired intestinal lymph trunk, that drains lymph from the majority of organs of the gastrointestinal tract. The duct opens in the cisterna chyli which is the dilated origin of the thoracic duct

- The lymphatic trunks then converge into the two lymphatic ducts; the right lymph duct and thoracic duct.
- The right lymphatic duct collects lymph from the right upper limb and the right side of the head and chest.
- The thoracic duct is a larger vessel and collects lymph from the rest of the body.
- The lymphatic ducts take the lymph into the right and left subclavian veins, which flow into the superior vena cava.



There are about total 450-600 lymph nodes in the body. Around 200 in the neck; around 100 in the thorax; around 50-60 in the axilla; around 250 in the abdomen and pelvis; around 50 in the groin area



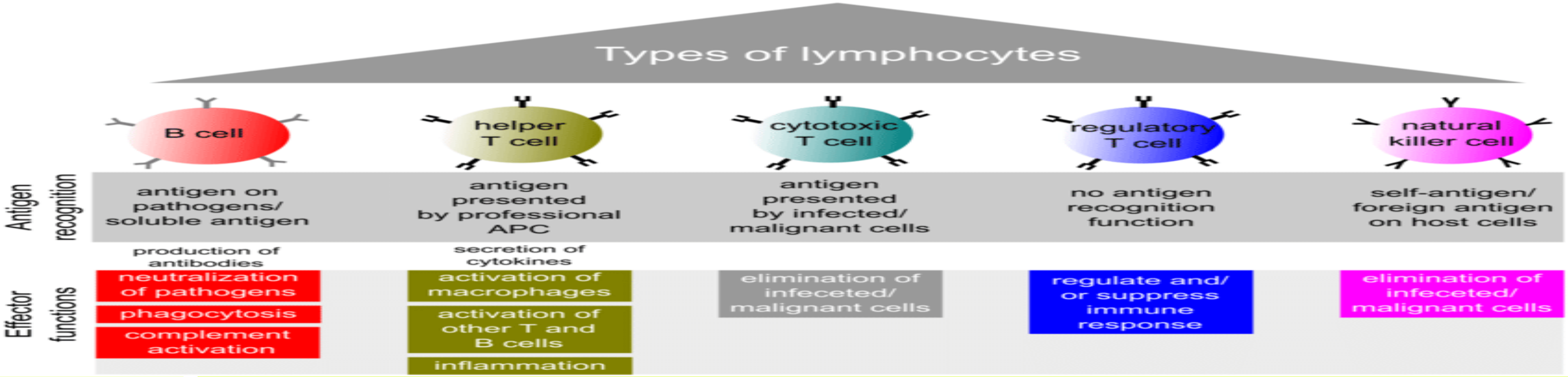


The lymphocytes

are one of the body's main immune cells. They arise from the stem cells in the primary lymphoid organs and belong to the part of the immune system called the acquired immunity.

lymphocytes are divided into three major groups

- B lymphocytes, T lymphocytes and natural killer (NK) cells.
- Their main role is to establish a specific immune response to foreign particles (antigens).
- B lymphocytes destroy the antigens indirectly, by producing antigen-specific antibodies that attach to antigens and mark them for destruction.
- T lymphocytes and NK cells directly kill cells that are infected by viruses or become cancerous



Lymph organ

Definition" Lymphoid organs are specialized organs where **lymphocytes are produced, mature, and activated**, forming the anatomical basis of the immune system.

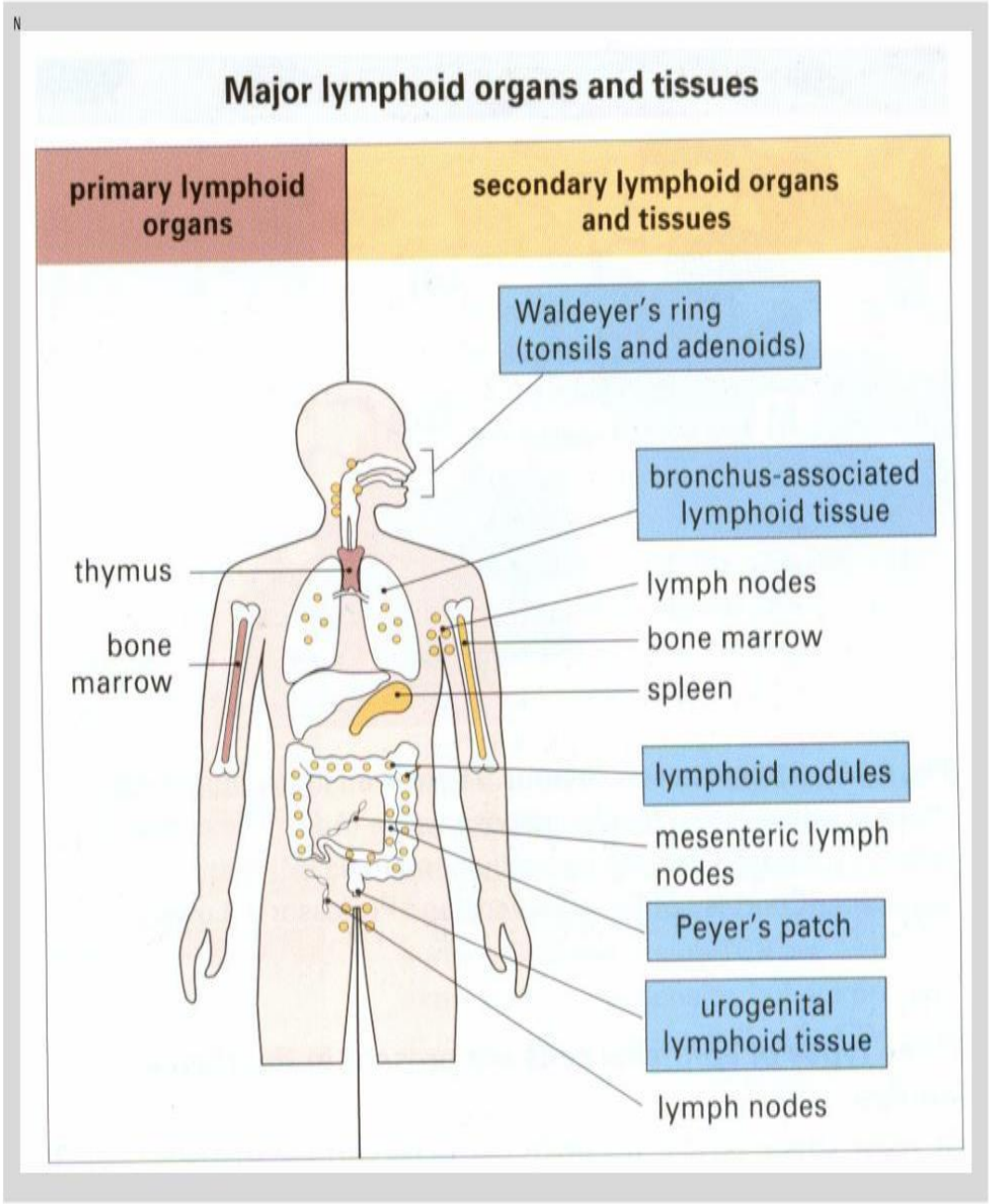
1 Primary Lymphoid Organs

- **A. Bone Marrow**
- **B. Thymus**

2 Secondary Lymphoid Organs

- **Lymph Nodes**
- **Spleen**
- **Mucosa-Associated Lymphoid Tissue (MALT)**ncludes:TonsilsPeyer's patches (ileum) Appendix, Bronchial lymphoid tissue

Primary and Secondary Lymphoid Organs:



Why Is the Lymphatic System Important to Surgeons?

- Major pathway for cancer spread to regional lymph nodes.
- Determines cancer staging and prognosis through lymph node involvement.
- Guides surgical planning (extent of resection and node dissection).
- Basis for lymph node dissection in oncologic surgery.
- Allows sentinel lymph node biopsy to minimize surgical morbidity.
- Postoperative lymphedema may occur after lymphatic damage.
- Risk of thoracic duct injury during neck and thoracic surgery.

Lymphadenopathy

Definition: Lymphadenopathy is abnormal enlargement of lymph nodes due to infection, inflammation, or malignancy. Normal lymph nodes are usually ≤ 1 cm (inguinal up to 1.5 cm can be normal).

Classification

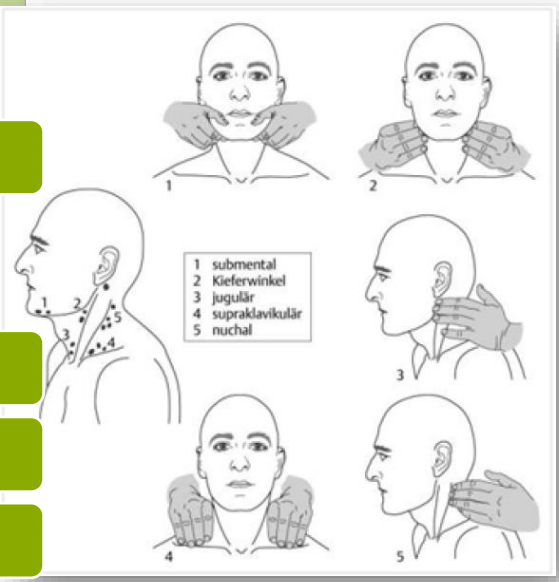
- **By Distribution : Localized:**
  - ***Infective:***
    - **Acute, e.g. a cx lymphadenopathy (tonisillitis)**
    - **Chronic, e.g. tuberculous nodes of neck.**

- ***Neoplastic:* due to secondary spread of tumour**
- **Generalized**
  - **Infective:**
- **Acute, e.g. glandular fever (mononucleosis), septicaemia;**
- ***Chronic*, e.g. human immunodeficiency virus (HIV), secondary syphilis.**
- **The reticuloses: Hodgkin's disease, non- Hodgkin's lymphoma, chronic lymphocytic leukaemia.**
- **Sarcoidosis**
- **Duration : Acute: days–weeks, Chronic: >4–6 weeks**

Causes

- **Infectious: Bacterial (e.g. tonsillitis), Viral (e.g. EBV, HIV), Tuberculosis**
- **Malignancy: Lymphoma, Leukemia, Metastatic cancer**
- **Inflammatory / Autoimmune: Rheumatoid arthritis, SLE, Sarcoidosis**
- **Drugs: Phenytoin, Allopurinol**

Clinical Examination of Lymphadenopathy



Inspection: Look for:

- Visible swelling
- Skin redness or scars
- Sinuses or ulceration
- Asymmetry of neck, axilla, or groin

Palpation (MOST IMPORTANT Part Examine in an Order

A. Cervical Lymph Nodes: Submental, Submandibular, Pre-auricular, Post-auricular, Anterior cervical, Posterior cervical, Supraclavicular

B. Axillary Lymph Nodes: Anterior, Posterior, Lateral, Central, Apical

C. Inguinal Lymph Nodes: Horizontal group, Vertical group

Assess Each Lymph Node For (S–C–T–M–M)

- Size: Normal: ≤1 cm, Inguinal: ≤1.5 cm, Larger → pathological,
- Consistency: Soft → infection, Firm / rubbery → lymphoma, Hard → malignancy
- Tenderness: Tender → acute infection, Non-tender → malignancy or chronic disease
- Mobility: Mobile → benign, Fixed → malignancy,
- Matting: Nodes stuck together → tuberculosis or lymphoma

Temperature of Overlying Skin: Warm → inflammation or infection

Examination of Drainage Area (VERY IMPORTANT)

- Cervical nodes → ENT, oral cavity, scalp
- Axillary nodes → breast, upper limb
- Inguinal nodes → lower limb, genitalia


IV-positive patient with Burkitt lymphoma. Photo is

General Examination

- Look for systemic signs:, fever, Weight loss, Night sweats , Hepatosplenomegaly, Skin rash

Red Flag Findings 

- Hard, fixed nodes
- Non-tender nodes
- Supraclavicular lymphadenopathy
- Generalized lymphadenopathy
- Nodes >2 cm persisting >4 weeks

Investigations for Lymphadenopathy

Basic (Initial) Investigations

- **Complete blood count (CBC):** Anemia, leukocytosis, leukemia
- **ESR / CRP:** Infection or inflammation
- **Peripheral blood smear:** Abnormal cells (leukemia)

Infectious Work-Up

- **Viral serology:** EBV (infectious mononucleosis), HIV
- **Tuberculosis tests:** Mantoux test, Interferon-gamma release assay, **Blood cultures** (if febrile)

Imaging Studies

- **A. Ultrasound:** First-line for superficial nodes:
- **B. Chest X-ray,** Mediastinal lymphadenopathy, Pulmonary tuberculosis, Lymphoma

CT / MRI

- Deep lymph nodes, Staging of malignancy, Extent of disease

Definitive Investigation (MOST IMPORTANT ⭐)

- **Lymph Node Biopsy: Gold standard,** Indications:Persistent lymphadenopathy, Hard, fixed nodes, Supraclavicular nodes, Suspicion of malignancy

Autoimmune markers (ANA, RF)

Bone marrow biopsy (suspected hematological malignancy)

TB lymphadenitis

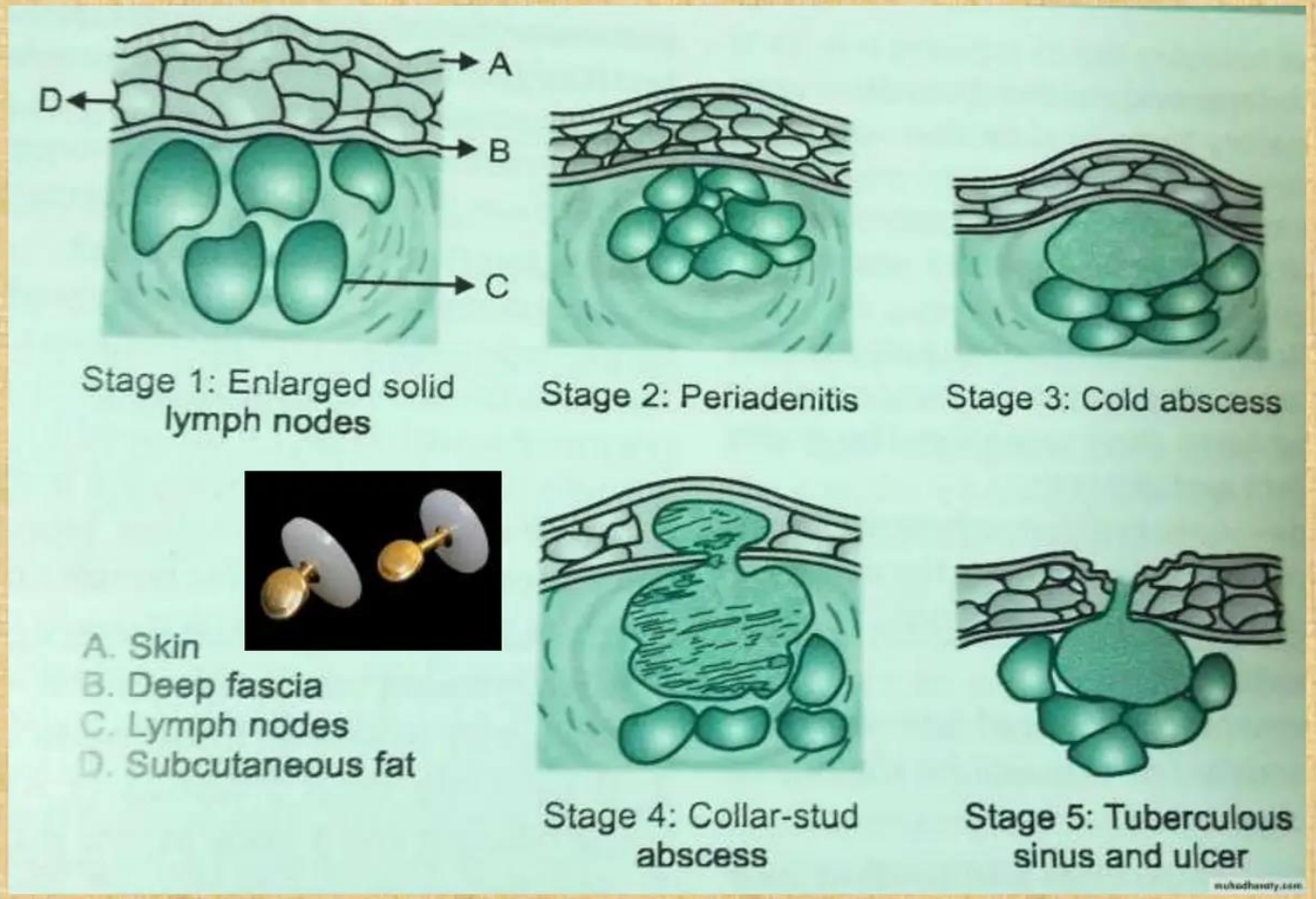
Tuberculous lymphadenitis is a form of **extrapulmonary tuberculosis** caused by *Mycobacterium tuberculosis*, leading to **chronic enlargement of lymph nodes**, most commonly in the **cervical region**.

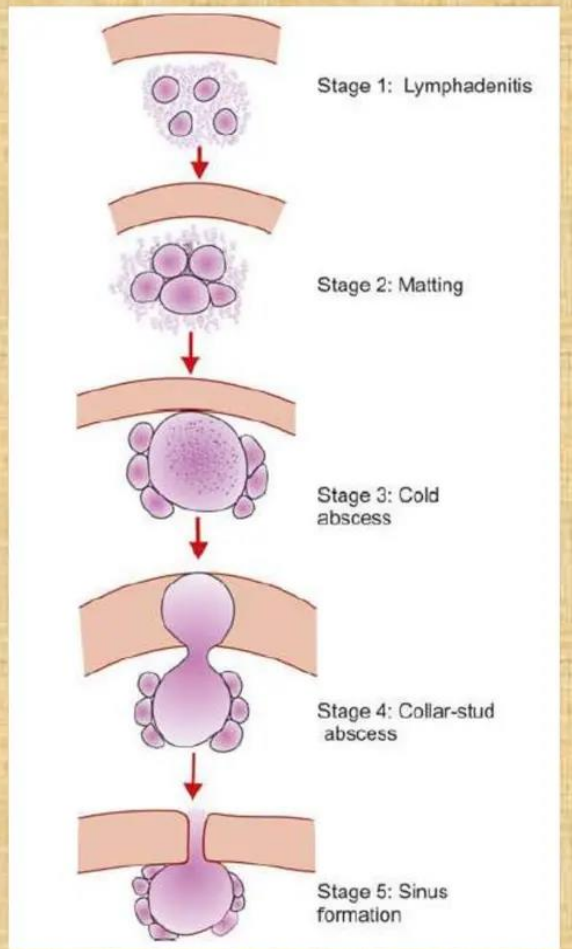
It is the **most common form of extrapulmonary TB**.

Bacteriology: Caused by mycobacterium tuberculosis (human or bovine)

- Stain: Stained by Z.N. stain because it is acid fast bacilli.
- Cultured upon: Dorset egg media.
- Lowenstein Jensen media, which is selective for TB bacilli as it contains Malachite Green.
- **Types:** *Lymph borne* (primary type) and *Blood borne* (secondary type)

Stages of Tuberculous lymphadenitis





Pathology :

Lymph- borne (primary type):

- More common in children and young adult.
- the organism reach the nodes by afferent lymphatics, thus the first reaching the capsule and causing *tuberculous periadenitis*, which causes *matting* of the nodes.
- The cortex will then be affected and finally the medulla.multiple tubercles will form, coalesce and may *caseate* and break down to give a *cold abscess*.
- This may burst through the capsule of the gland into the tissues around it. Ultimately it may rupture thruogh the skin producing a tuberculous sinus or ulcer.
  - Rupture of cold abscess through deep fascia is called collar –studd abscess

Blood –borne type:

- This type is more common in elderly people.
- The organisms reach lymph nodes via blood stream and so affect many groups of noded in the body.
- The organism enter the nodes through the arterial supply in the hilum and so the main affection is central in the medulla and L.Ns show hyperplais and not caseation.
  - There is **No** periadenitis, No matting, No caseation, No cold abscess, No calcification and No sinus formation

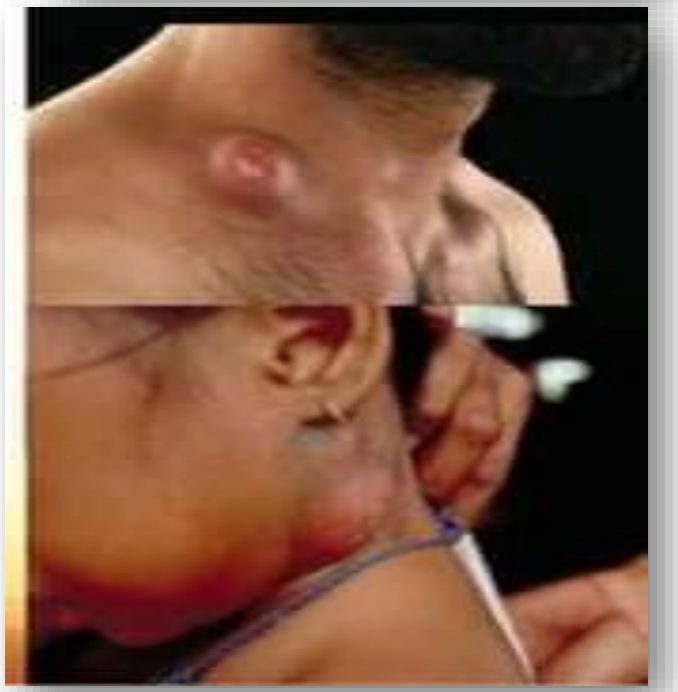
Lymph borne (primary type)	Blood borne (secondary type
• Fibrocaseous type • Localized L.Ns • Affect the cortex of L.Ns • Clinical features: ➢ No Tb toxaemia ➢ Affected nodes are enlarged, not tender nor warm. They are firm, elastic in consistency and matted giving feeling of beaded cord, presence of soft fluctuant swelling connected to the underlying caseasting L.N	• Lymphadenoid type • Generalized L.Ns • Affect the medulla of L.Ns • Clinical features: Manifestations of pul TB toxaemia., Affected LNs → enlarged, not tender, rubbery, not matted & discrete

Investigations:

- Blood picture (anaemia , leucopenia and relative lymphocytosis)
- Tuberculin test
- **GeneXpert / PCR:** Detects *Mycobacterium tuberculosis* DNA

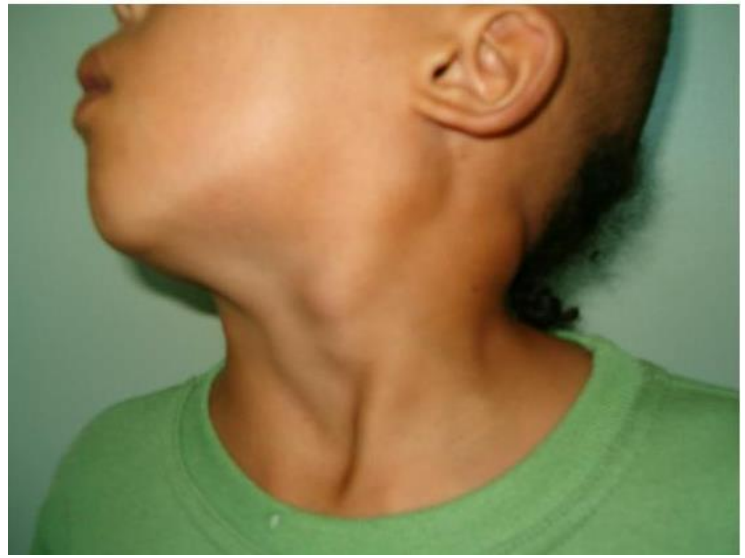
Aspiration of cold abscess for bacteriology: Ziehl-Nelson's stain→demonstrate tubercle biopsy in 72 %

- C/S on Lowenstein media→ For 6 weeks, +ve in 98% of cases
- Chest x-ray
- Lymph node biopsy(caseation in lymph borne, hyperplasia in blood borne)



Treatment:

- Antituberculous drugs
- Treatment of cold abscess: by repeated aspiration with injection of streptomycin, and by incision and drainage if there is secondary infection



Role of Surgery (LIMITED), Surgery is NOT routine

Indications:

- Diagnostic biopsy (if FNAC inconclusive)
- Persistent cold abscess
- Non-healing sinus
- Failure to respond to adequate ATT

Acute lymphangitis

Acute inflammation of lymph vessels secondary to infected wound. Affected Lymphatics appear as tender, hot lines. Toxemia is often severe. Suppuration may occur.**Causative organism:** Streptococcus pyognes or staphylococcus aureus

- **Treatment**
  - Bed rest
  - Rest of affected limb and elevation.
  - Antibiotics (broad-spectrum).
- Failure to improve within 48 hours suggests inappropriate antibiotic therapy, the presence of undrained pus or the presence of an underlying systemic disorder (malignancy, immunodeficiency).
  - If suppuration → incision and drainage
  - Care of primary wound

Lymphoedema

Definition: Abnormal limb swelling caused by the accumulation of increased amounts of high protein interstitial fluid (ISF) secondary to defective lymphatic drainage in the presence of (near) normal net capillary filtration.

Lower extremity edema occurs in clinical settings: edema of fluid overload, venous insufficiency, lymphedema.

- Lymphedema is unilateral or bilateral and is very slow to clear with elevation.

Lymphoedema— incidence/ prevalence

250 million people

- The incidence of lymphedema is estimated to affect up to 250 million people worldwide, with approximately 10 million living with it in the United States alone.

The condition is often secondary to cancer treatments, with studies indicating that 10 to 40% of breast cancer survivors may develop lymphedema due to surgery or radiation.

- Additionally, lymphedema can occur due to other causes, including congenital conditions and trauma.
- Estimates of the incidence of lymphoedema of the arm following treatment for breast cancer range from 3 to 60%. .
- Those who have had varicose vein stripping, ligation, or sclerotherapy may also develop lymphoedema due to damage/ removal of major lymphatic collectors but incidence rates are apparently low.

- **Stemmer's sign:** A thickened skin fold at the base of the second toe or second finger that is a diagnostic sign for lymphedema.
- A positive result occurs when this tissue cannot be lifted but can only be grasped as a lump of tissue. In a negative result, it is possible to lift the tissue normally.

Brunner's grading of lymphoedema

Grade I – Mild (Early Lymphoedema)

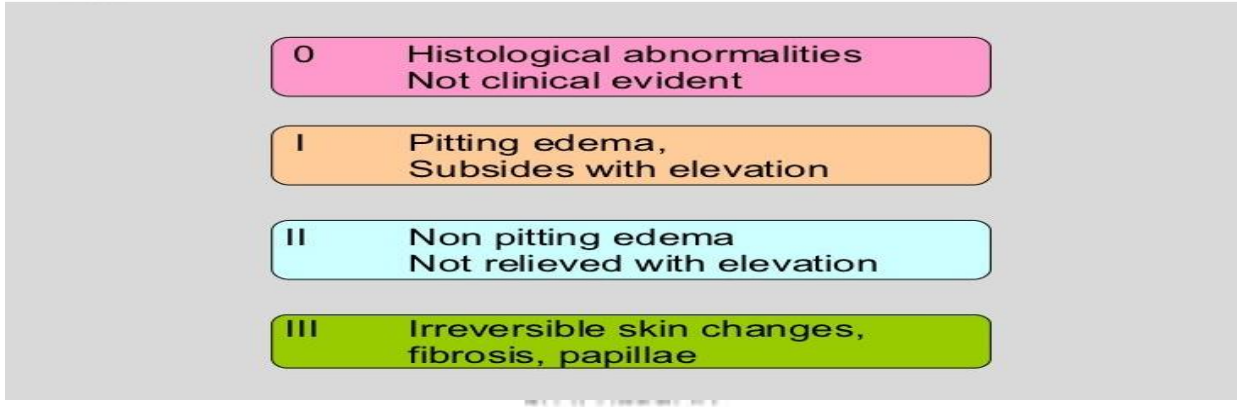
- Soft swelling
- **Pitting edema present**
- Swelling **reduces on limb elevation**
- No skin changes
- Reversible

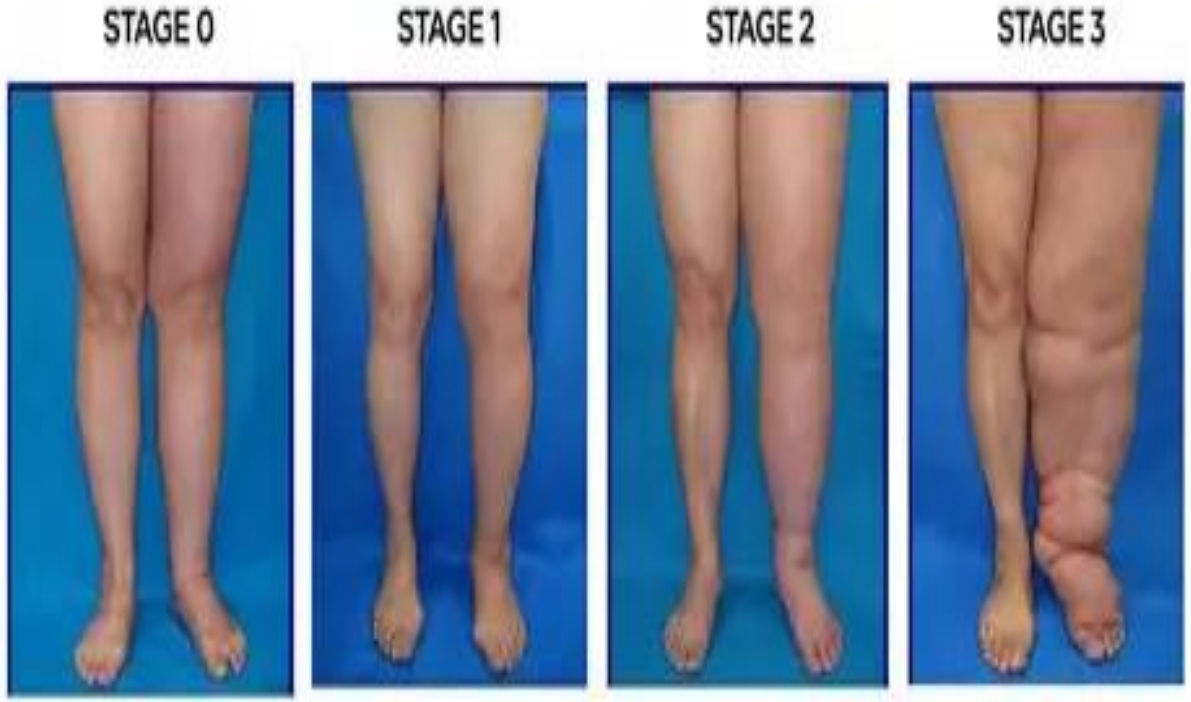
Grade II – Moderate Lymphoedema

- Firm swelling
- **Pitting may be present or absent**
- Swelling **does not disappear on elevation**
- Early skin thickening
- Partially reversible

Grade III – Severe Lymphoedema (Elephantiasis)

- Massive limb enlargement
- **Non-pitting edema**
- Hard, fibrotic tissues
- Skin changes: Thickening, Hyperkeratosis , Papillomatosis, Irreversible, End-stage disease



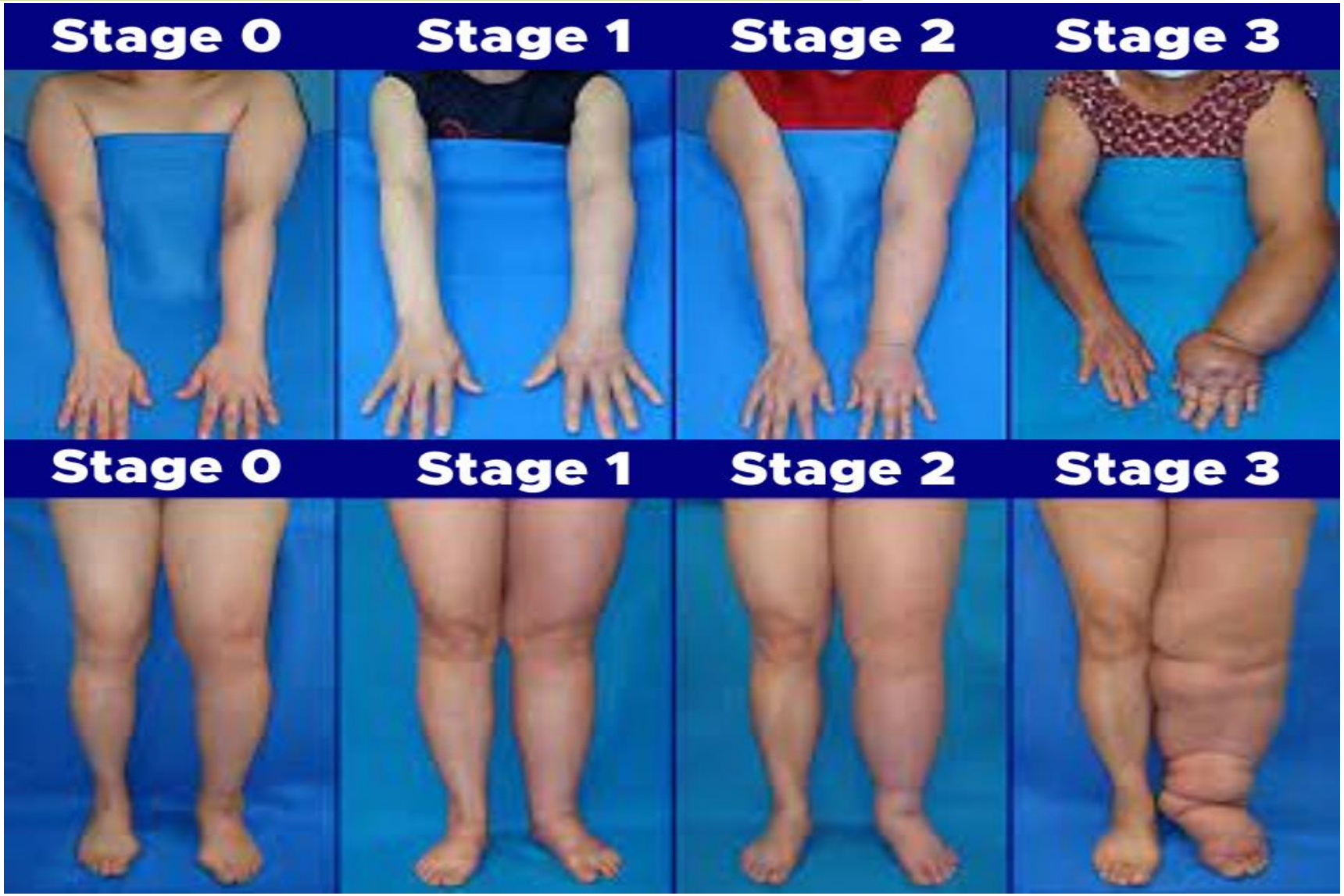


The severity of lymphoedema can be:

Mild lymphoedema < 20% of excess limb volume.

Moderate lymphoedema 20-40%

Severe lymphoedema > 40%.



Classification

1. **The primary lymphedemas** (without any identifiable lymphatic disease). They are classified as follows:

- Congenital: present at birth
- Praecox: onset in childhood
- Tarda: onset in adulthood

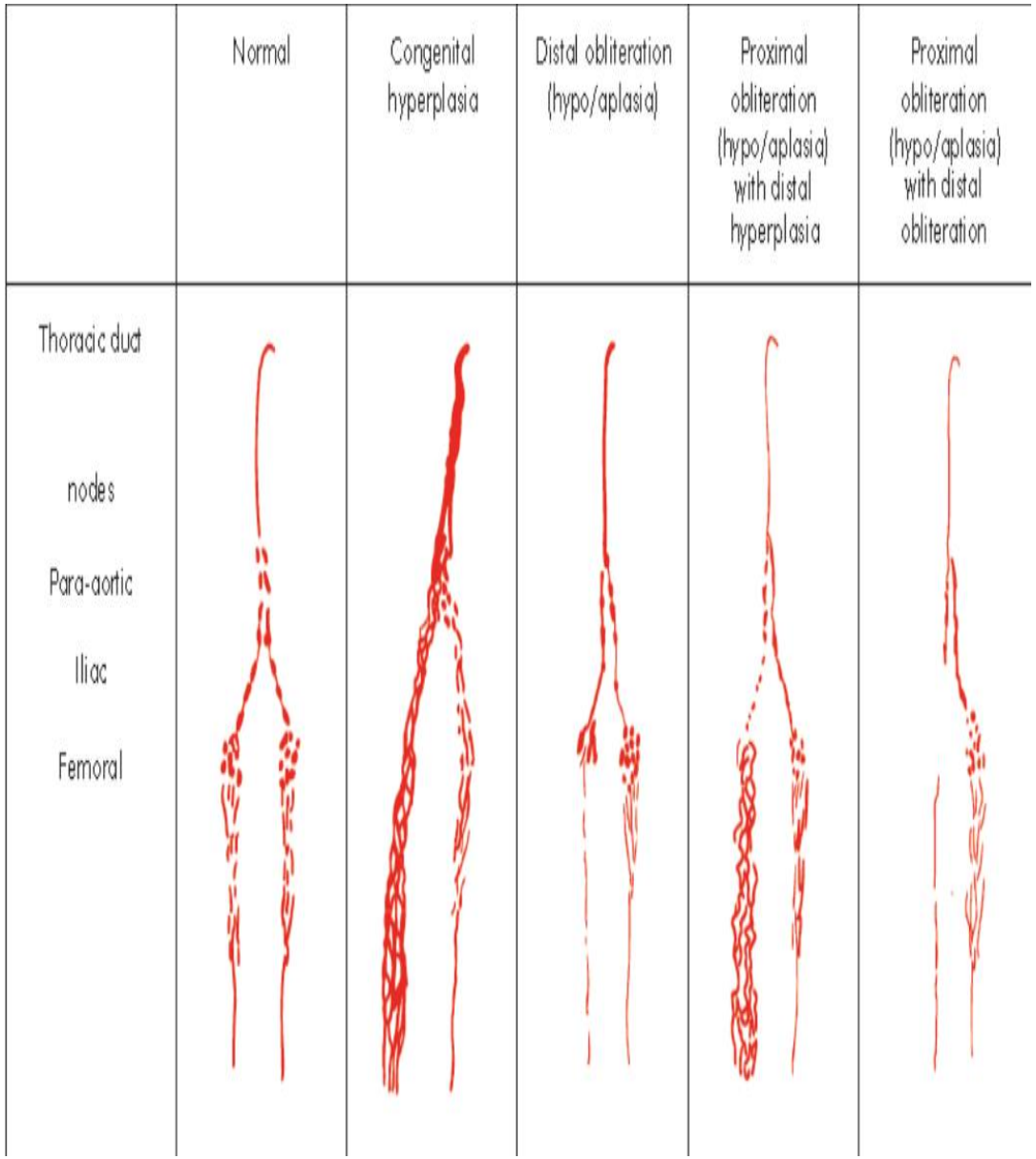
☞ *It can be radiologically (lymphangiography)*:

- Hypoplasia 70%
- Aplasia 15%
- Hyperplasia (varicose lymphatics) 15%

Secondary lymphedema is frequently secondary to lymph node metastases and may occur after radiation, trauma, surgical excision, or parasitic invasion (e.g. filariasis)

Complications:

- Rec. cellulitis and lymphangitis (the most frequent)
- Lymphoedema ulcer from ruptured and infected bleb
- Huge and heavy limb
- Lymphangiosarcoma (very rare)



Differential diagnosis: (causes of swelling limb)

In bilateral cases i.e. Generalized oedema:

- Renal oedema
- Cardiac oedema
- Hepatic oedema
- Allergic oedema
- Cushing syndrome
- Myxedema

In unilateral cases i.e. Localized oedema:

- Venous oedema (low protein content)
- Lymphatic oedema (high protein content)
- Congenital AV fistula (local gigantism)
- Neurofibromatosis elephantiasis

Investigations:

1. The diagnosis of lymphedema frequently is based on clinical grounds.
2. For the cause:

– ESR, peripheral smear.

– Lymphangiography.

– Isotope-lymphoscintigraphy.

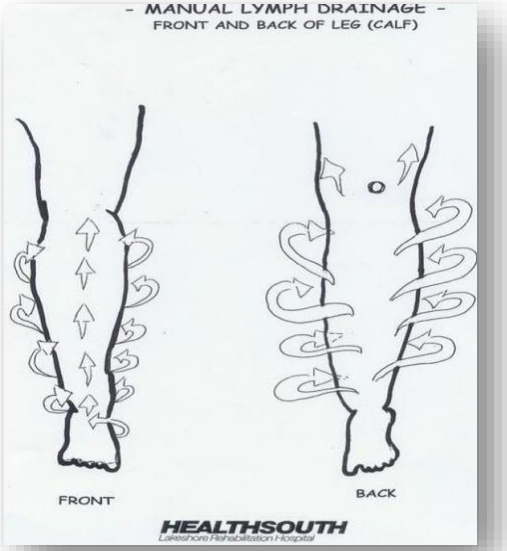
– MRI, CT scan

✪ Treatment

- The three goals of treatment are to relieve pain, reduce swelling and prevent the development of complications
- Conservative (usually indicated for early cases): Management is supportive, with rest and elevation of the limb, compression stockings, care taken to avoid factors that predispose the patient to cellulitis and antifilarial drugs for filariasis.

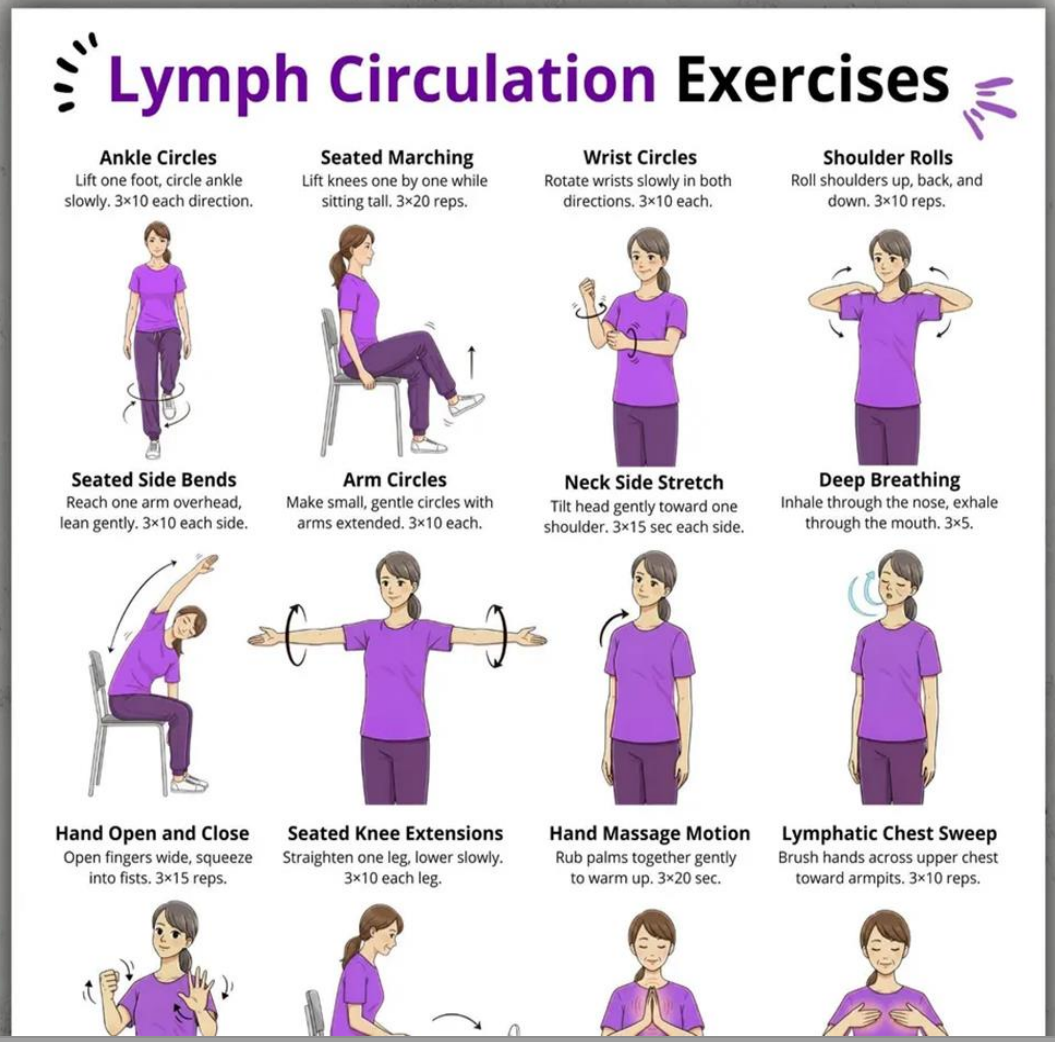
Treatment of Lymphedema

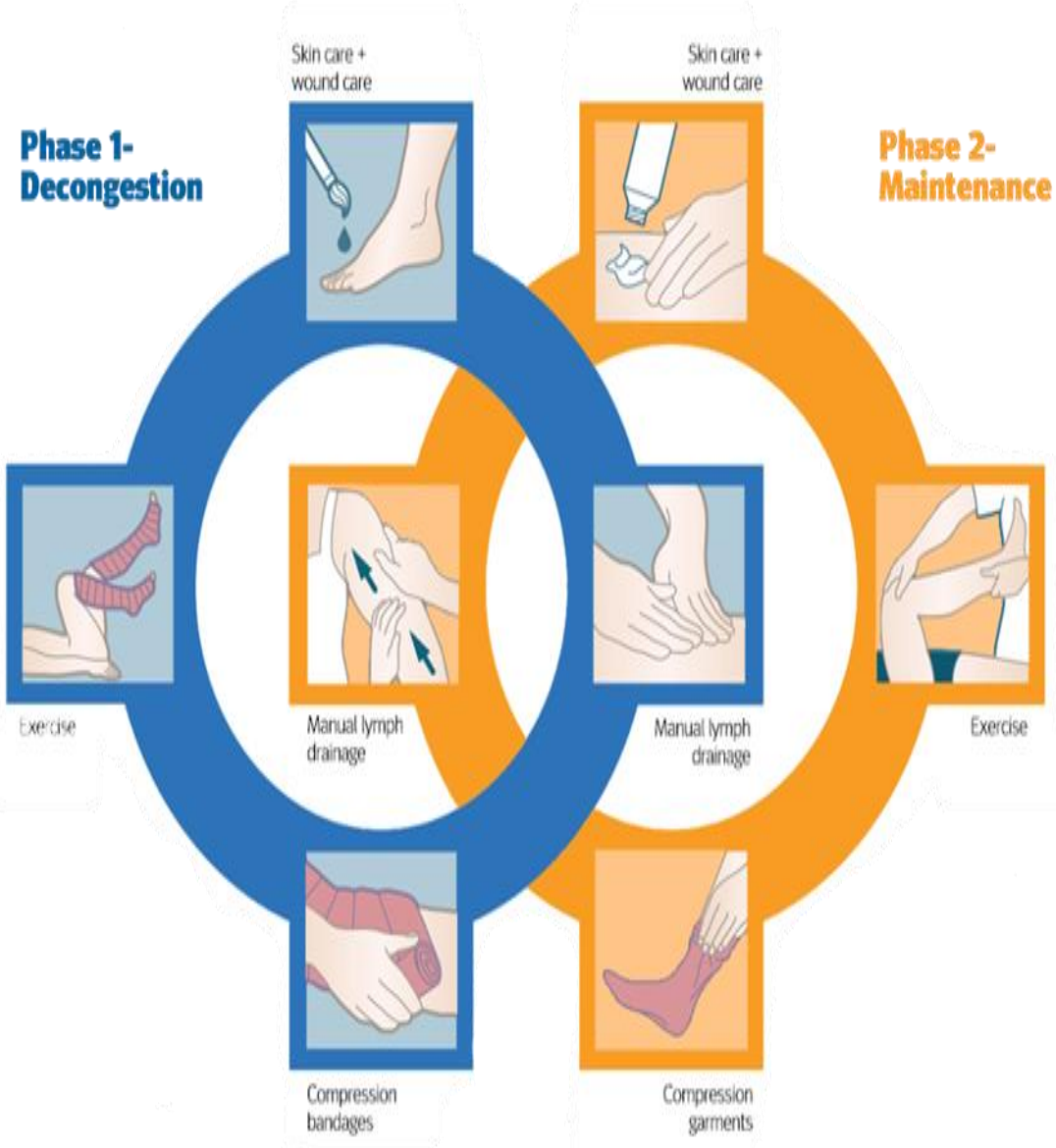
- **Compression therapy** (bandages or stockings)
- **Manual lymphatic drainage** (specialized massage)
- **Exercise and limb elevation**
- **Skin care and hygiene** to prevent infection
- **Complete decongestive therapy (CDT)**
- **Antibiotics** for cellulitis or infection
- **Analgesics** for pain control
- **Avoidance of trauma and injections** in the affected limb
- **Physiological surgical procedures**
  - Lymphovenous bypass
  - Vascularized lymph node transfer
- **Excisional or debulking surgery** (advanced cases)
- **Long-term follow-up and lifestyle modification**



Lymph Circulation Exercises

Instant Digital Download / A4 / US Letter





- Surgical Rx (usually indicated in chronic cases):

➢ Operative treatment is used rarely in patients with lymphoedema and only a small minority of patients with lymphoedema benefit from surgery.

➢ Operations fall into three categories: liposuction, reduction procedures and bypass procedures.

– **Liposuction**: It is usually reserved for patients who have progressed to non-pitting oedema. It results with more than 100 per cent reduction in limb oedema volume

– **Reduction procedures**: The attempts have been directed at removing the subcutaneous tissues of the extremity.

- Charles procedure consisted of wide excision of the lymphedematous tissue followed by skin grafting of the extremity.
- Sistrunk procedure: A wedge of skin and subcutaneous tissue is excised and the wound closed primarily.
- Homan's procedure: skin flaps are elevated, and then subcutaneous tissue is excised from beneath the flaps.

– **Bypass procedures:**

- Direct lympho-venous anastomoses have been undertaken at a few centers but have yet to be proved effective.
- Pedicle transfer of lymphatic bearing tissue

☞ Diuretics are of no value in pure lymphoedema

Indications for Surgery in Lymphedema

- Surgery is considered **only when conservative treatment fails**.
- **Failure of adequate conservative treatment** (CDT and compression)
- **Severe or advanced lymphedema** (Brunner Grade II–III)
- **Recurrent cellulitis or infections**
- **Marked functional disability**
- **Severe cosmetic deformity**
- **Psychological distress due to chronic swelling**


thank you