

LYMPHATIC SYSTEM (*SYSTEMA LYMPHATICUM*)

The lymph system is a one-way system, transporting interstitial fluid back to blood. It involves lymphatic vessels, lymphatic cells, tissues and organs that work in the defense system of the body: lymphatic follicles, lymph nodes, tonsils, the spleen and thymus.

LYMPHATIC VESSELS (*VASA LYMPHATICA*)

Lymphatics convey the lymph from tissues into veins. They start as **lymphatic capillaries** (*Vasa lymphocapillaria*) that have closed ends and form plexuses throughout nearly the whole body excluding the epidermis and its derivatives, epithelium of mucous membrane of internal organs, the sclera, cornea, lens and vitreous body of the eye, the central nervous system, bone marrow, hepatic lobules, and placenta. Lymphatic vessels return to the circulation about 10% of tissue fluid (3L) a day. The lymphatic system thus provides for the drainage of surplus tissue fluid including plasma proteins, bacteria, cellular debris, and even whole cells (lymphocytes, tumor cells). If this material were to accumulate in the extracellular spaces, it would result in lymphedema. The lumen of lymphatic capillaries is irregular, but larger than that of blood capillaries. Tumor cells may be disseminated via lymphatic vessels to sites distant from the primary tumor (metastasis).

Collecting lymphatics (*Vasa lymphatica*) are thin-walled vessels that receive lymph from lymphatic capillaries. The wall of the lymph vessel is composed of the same layers as that of a vein. They contain abundant flap valves that cause bulging of the vessel in this site and thus vessels filled with contrast dye have beaded appearance at the X-ray picture. Valves permit lymph to flow towards the lymph nodes.

Vas afferens – a lymph vessels conveying lymph towards a node (each node receives several afferent vessels).

Vas efferens – a vessel that leaves the hilum of the node.

Efferent vessels join to form larger and larger vessels and finally form the greatest vessels called **lymph trunks** (*Trunci lymphatici*) – receive lymph from larger parts of the body.

Trunci lymphatici

Thoracic duct (*Ductus thoracicus*)

- originates anterior to the T12–L2 vertebra by confluence of the lumbar and intestinal lymph trunks (may be enlarged in the *cisterna chyli*) – *Pars abdominalis*
- passes through the aortic hiatus of the diaphragm
- *Pars thoracica* ascends in the posterior mediastinum between the thoracic aorta and azygos vein and behind the esophagus to the thoracic inlet
- at the level of C7 arches laterally anterior to the scalenus anterior and descends anterior to the left subclavian artery – *Pars cervicalis, Arcus ductus thoracici*
- ends by opening into the left venous angle (may open into either of the great veins)
- has about 20 valves

Tributaries:

Truncus lumbalis dexter et sinister – formed by efferents of the lumbar lymph nodes that carry lymph from the lower limbs, pelvic, perineal, and infraumbilical abdominal walls, pelvic viscera, testes or ovaries, kidneys and suprarenals.

Truncus intestinalis – receives efferents from the coeliac nodes (terminal ventral aortic group), which drain the stomach, intestine, pancreas, spleen, and greater part of the liver.

Truncus jugularis sinister – receives efferents from the deep cervical lymph nodes, may open independently into the left internal jugular vein.

Truncus subclavius sinister – receives efferents from the apical axillary lymph nodes, may open independently into the left subclavian vein.

Truncus bronchomediastinalis sinister – receives efferents from tracheobronchial, parasternal, and brachiocephalic nodes, usually has an independent venous opening.

Right lymphatic duct (*Ductus lymphaticus dexter*)

- 1 cm long
- drains lymph from the body's right upper quadrant
- inclines across the medial border of the right scalenus anterior
- opens into the right venous angle
- often incomplete (its tributaries open into veins independently)
- has a bicuspid semilunar valve at its orifice

Tributaries (have the same drainage regions as those of the left side):

Truncus jugularis dexter

Truncus subclavius dexter

Truncus bronchomediastinalis dexter

LYMPH (*LYMPHA*)

It is watery, clear or slightly yellow fluid that is formed from the tissue fluid. The content of salts in the lymph corresponds to that of blood. The amount of proteins is lower than in blood. Lymph contains lymphocytes that circulate in the lymphatic system and react with antigens. Lymph in the intestine contains also nutrients and fats in small globules – **chyle (*Chylus*)**. Tissue fluid of extracellular spaces is produced by the metabolism of cells and part of it is filtrated from the blood capillaries. Tissue fluid enters the capillary by means of **capillary lymph pump** (opening of gaps between adjacent endothelial cells after increase of pressure in the interstitial space). The flow of lymph in lymphatics is promoted by the pump, contraction of smooth muscles in their walls, pulsation of neighbouring arteries, contraction of striated muscles of limbs, changes of intraabdominal pressure, and respiratory movements of the thorax.

LYMPH NODE (*NODUS LYMPHOIDEUS; LYMPHATICUS*)

General Description of the Lymph Node

- a bean-shaped organ
- 1–30 mm in length
- smooth surface
- whitish or grey-pink
- located in the connective tissue as a single organ or in groups
- a **tributary region** is part of the body or organ from which a node or group of nodes receives lymph
- **regional nodes** are the nodes that receive lymph from the certain tributary region
- the **sentinel lymph node** is the first lymph node or group of nodes reached by metastasizing cancer cells from a primary tumor

Structure of the lymph node

- the surface of a node is covered by a connective tissue **capsule**
- the capsule sends **trabeculae** into the node to divide the node into incompletely separated follicles
- tiny fibers of connective tissue interlace the whole node – **reticulum**
- **sinuses** – empty canals in the reticulum
- **lymphatic follicles** – the reticulum occupied by lymphocytes

- **cortex** – lymphatic follicles at the periphery of the node
- **medulla** – terminal sinuses uniting to form *vas efferens*
- **hilum** – contains blood vessels, nerves, and lymphatic *vas efferens*

Lymph nodes of the head and neck (*Nodi lymphoidei capitis et colli*)

Lymph from the scalp and face drains into the pericervical ring of lymph nodes located at the junction of the head and neck.

Nodi occipitales

- superficial to the upper attachment of the trapezius
- drain occipital scalp
- efferents reach the superficial and deep cervical nodes

Nodi retroauriculares

- superficial to the mastoid attachment of the sternocleidomastoid
- drain the auricle, external meatus, lower parotid region
- efferents reach the superficial and deep cervical nodes

Nodi parotidei superficiales et profundi

- anterior to the tragus on the parotid fascia and in the parenchyma of the parotid gland
- drain the forehead, temporal region, lateral auricular aspect, lateral halves of eyelids, zygomatic region, parotid gland, external acoustic meatus
- efferents reach the superficial and deep cervical nodes

Nodi submandibulares

- in the submandibular triangle
- drain the external nose, cheeks, upper lip, lateral parts of the lower lip, teeth of the upper jaw and posterior teeth of the lower jaw, anterior 2/3 of the tongue, submandibular gland
- efferents reach the deep cervical nodes

Nodi submentales

- on the mylohyoid between anterior bellies of digastric muscles
- drain the central part of the lip, buccal floor, lingual apex, anterior part of the mouth floor
- efferents pass to the submandibular and deep cervical nodes of both sides

Nodi cervicales anteriores superficiales et profundi

- near the anterior jugular veins in the suprasternal space and around the cervical organs
- drain the anterior cervical skin below the hyoid bone, cervical viscera (*Nodi infrahyoidei, prelaryngei, thyroidei, pretracheales, paratracheales*)
- efferents reach the deep lateral cervical nodes

Nodi retropharyngeales

- between the pharyngeal and prevertebral fasciae
- receive afferents from the nasopharynx, pharyngotympanic tube, and craniovertebral joints
- drain to the upper deep cervical nodes

Nodi cervicales laterales superficiales et profundi

- on the sternocleidomastoid (superficial) and alongside the carotid sheath (deep)

Superior deep cervical nodes

- adjoin the upper internal jugular vein
- drain the occipital, retroauricular and parotid nodes, and the root of the tongue (*Nodus jugulodigastricus of Küttner*)
- efferents reach the inferior deep cervical nodes or directly to the jugular trunk

Inferior deep cervical nodes

- related to the lower internal jugular vein and to the brachial plexus, one node is at the intermediate tendon of omohyoid (*Nodus juguloomohyoideus*)
- drain anterior 2/3 of the tongue, submandibular and submental lymph nodes
- efferents join the jugular trunk

Nodi accessorii – accompany CN XI

Nodi supraclaviculares – accompany transverse cervical artery

Lymphatic drainage of the upper extremity (*Nodi lymphoidei membri superioris*)

All lymphatics from the upper limb drain to the axillary nodes.

Deep lymphatics follow the principal vascular bundles (radial, ulnar, interosseous and brachial) and drain to the lateral axillary nodes. Several nodes in the cubital fossa (*Nodi cubitales profundi*) are inserted in their course.

Superficial lymphatic vessels begin in the hand by palmar and dorsal plexuses. The palmar plexus is denser. Plexuses constitute three sets of collectors:

- lateral vessels accompany the cephalic vein to the tendon of the deltoid, where most incline medially to reach the lateral axillary nodes, a few may continue to the **infraclavicular nodes** (1–2 nodes in the deltoideopectoral groove which drain to the apical axillary nodes);
 - medial vessels follow the basilic vein and proximal to the medial epicondyle some end in the **supratrochlear node (*Nodus supratrochlearis*)** – its efferents together with other medial collecting vessels pierce the deep fascia with the basilic vein to join the deep lymphatics;
 - anterior vessels join median vein of forearm, proximal to the elbow follow the medial border of the biceps, then pierce the fascia at the anterior axillary fold to end in the axillary nodes. *Nodi cubitales superficiales* may be inserted in their course in the cubital fossa.
- Dorsal vessels curve successively round the borders of the limb to join the ventral vessels.

Nodi axillares – about 30 nodes draining the upper limb and a wide area of the ipsilateral trunk. They are subdivided into:

Nodi axillares laterales

- 4–6 nodes posteromedial to the axillary vein
- receive deep vessels and lymphatics accompanying the basilic vein
- efferents pass partly to the central and apical axillary, partly to the deep cervical lymph nodes

Nodi axillares pectorales

- 4–5 nodes near the lateral thoracic vessels
- drain supraumbilical anterolateral body wall including breast
- efferents pass to the central and apical axillary nodes

Nodi axillares subscapulares

- 6–7 nodes along the subscapular vessels
- drain the skin and superficial muscles of the posterior thoracic wall and breast
- efferents pass to the central and apical axillary nodes

Nodi axillares centrales

- 3–4 large nodes embedded in axillary fat
- receives afferents from all preceding groups

- efferents drain to the apical axillary nodes

Nodi axillares apicales

- 6–12 nodes in the apex of the axilla medial to the axillary vein
- receive direct lymphatics from the lateral side of the limb and upper lateral quadrant of the mammary gland, but most afferents are from all other axillary nodes
- efferents unite as the subclavian trunk, a few efferents reach the inferior deep cervical nodes

Mammary lymphatic drainage

Cutaneous **subareolar plexus** around the nipple communicates with the plexus in the interlobular connective tissue. Efferents pass in several directions to:

- pectoral axillary nodes
- central axillary nodes
- apical axillary nodes (sometimes through the infraclavicular nodes)

Axillary nodes receive more than 75% of lymph from the gland, the remainder drain to:

- parasternal nodes (from the medial quadrants), but also anastomose across the sternum
- “epigastric pathway” – along the superior epigastric vessels, joins the hepatic vessels – drains the inferomedial quadrant
- diaphragmatic nodes

Lymph nodes of the thorax (*Nodi lymphoidei thoracis*)

Superficial lymphatic vessels of the thoracic wall converge on the axillary nodes, those from the medial region pass between costal cartilages to the parasternal nodes, a few vessels from the upper pectoral region ascend over the clavicle to the inferior deep cervical nodes. Lymph vessels from deeper layers of the thoracic wall drain mainly to the:

Nodi parasternales

- along each internal thoracic artery
- drain the mammary gland, anterior thoracic wall, supraumbilical anterior abdominal wall, superior hepatic surface
- efferents unite with those from tracheobronchial and brachiocephalic nodes to form the bronchomediastinal trunk

Nodi intercostales

- in intercostal spaces near the necks of ribs
- drain the posterolateral aspect of the chest and mammary gland
- efferents from lower spaces unite into a trunk descending to the abdominal confluence of lymph trunks (to the thoracic duct), efferents from upper spaces end in the thoracic duct or right lymph trunk

Nodi prevertebrales

- nodes around the thoracic aorta

Nodi phrenici superiores

- on the thoracic surface of the diaphragm (anterior, lateral and posterior groups)
- drain the diaphragm and convex hepatic surface
- efferents pass to the parasternal, posterior mediastinal and brachiocephalic nodes

Lymphatic drainage of thoracic contents

Nodi brachiocephalici (mediastinales anteriores)

- in the superior mediastinum anterior to the brachiocephalic veins
- drain the thymus, thyroid gland, pericardium, heart, lateral diaphragmatic nodes
- efferents unite with those of the tracheobronchial nodes to form the right and left bronchomediastinal trunks

Nodi juxtaoesophageales (mediastinales posteriores)

- behind the pericardium, near the oesophagus and thoracic aorta
- drain the oesophagus, posterior pericardium, diaphragm, lateral and posterior diaphragmatic nodes
- efferents pass to the thoracic duct

Lymphatic drainage of the lungs and pleurae

The subpleural (superficial) lymphatic plexus of lungs sends efferents into the bronchopulmonary nodes. The deep lymphatic plexus (accompanies bronchi) is drained through the pulmonary nodes also to bronchopulmonary lymph nodes. There is little anastomosis between the superficial and deep lymphatics.

Nodi pulmonales

- in the lung on bronchial larger branches

Nodi bronchopulmonales

- in the hilum of each lung

Nodi tracheobronchiales inferiores

- in the angle between the principal bronchi

Nodi tracheobronchiales superiores dextri et sinistri

- in the angles of the trachea and bronchi

Nodi paratracheales

- flank the trachea

These groups are not sharply demarcated. Afferents of these nodes drain not only lungs, bronchi and trachea, but also the heart and some posterior mediastinal nodes. Their efferents unite with efferents of the parasternal and brachiocephalic nodes as the right and left bronchomediastinal trunks.

The right lung drains primarily through respective sets of nodes on the right side. Superior lobe of the left lung drains primarily through the respective nodes of the left side, lymphatics from the lower lobe of the left lung through the inferior tracheobronchial nodes to the right superior and further to right paratracheal nodes. The lymph nodes around lungs are colored by inhaled dust to grey or black.

Lymph nodes of the abdomen (*Nodi lymphoidei abdominis*)

Lymph from most of the abdominal wall and all abdominal viscera is returned via the thoracic duct. Lymphatic vessels run with their corresponding arteries, the lymphatic nodes forming chains along the arteries concerned.

Parietal lymph nodes:

Nodi lumbales dextri

- around the inferior vena cava

Nodi lumbales intermedii

- between the inferior vena cava and abdominal aorta

Nodi lumbales sinistri

- around the abdominal aorta

Efferents of lumbar nodes form the lumbar trunks that join in the abdominal confluence with the intestinal trunk to form the thoracic duct.

Nodi phrenici inferiores

- on the abdominal surface of the diaphragm, efferents end in lumbar nodes

Nodi epigastrici inferiores

- accompany the epigastric vessels, drain anterior abdominal wall

Visceral lymph nodes:

Nodi coeliaci

- anterior to the abdominal aorta around the origin of the coeliac trunk
- afferents are from the nodes along branches of the coeliac trunk

Nodi gastrici dextri et sinistri

- along the lesser curvature of the stomach, receive lymph from both stomach and abdominal part of the oesophagus, efferents pass to the coeliac nodes.

Nodi gastromentales dextri et sinistri

- along the greater curvature of the stomach, receive lymph from the stomach, efferents of the right nodes mostly pass to the pyloric nodes

Nodi pylorici

- in the angle between the superior and descending parts of the duodenum, receive lymph from the pyloric part of the stomach, first part of the duodenum and right gastromental nodes, efferents pass to the coeliac nodes

Nodi pancreatici superiores et inferiores

- receive lymph from the pancreas, drain to the hepatic, coeliac and superior mesenteric nodes

Nodi lienales

- in the continuation of the superior pancreatic nodes to the hilum of the spleen

Nodi pancreaticoduodenales superiores et inferiores

- between the head of the pancreas and duodenum, receive the lymph from these organs

Nodi hepatici

- in the porta hepatis and along the common and proper hepatic arteries, drain to the coeliac nodes, the lymph from the liver flows also through the lymphatics accompanying the inferior vena cava to the posterior mediastinal nodes, the superior surface of the liver is drained to the phrenic and parasternal nodes

Nodi mesenterici superiores

- in the mesentery, drain to coeliac nodes and then intestinal trunk
 - ***nodi juxtaintestinales*** – at the wall of the intestine
 - ***nodi superiores centrales*** – along the trunk of the superior mesenteric artery
 - ***nodi ileocolici*** – around the ileocolic artery
 - ***nodi precaecales*** – anterior to the caecum, efferents pass to ileocolic nodes
 - ***nodi retrocaecales*** – posterior to the caecum, efferents pass to ileocolic nodes
 - ***nodi appendiculares*** – in the mesoappendix
 - ***nodi mesocolici (paracolici, colici dextri, medii, sinistri)*** – at the wall of the colon, along the corresponding arteries

Nodi mesenterici inferiores

- along the trunk of the inferior mesenteric artery
 - ***nodi sigmoidei*** – at the sigmoid colon
 - ***nodi rectales superiores*** – along the superior mesenteric artery

Lymph nodes of the pelvis (*Nodi lymphatici pelvis*)

Parietal lymph nodes:

Nodi iliaci communes (mediales, intermedii, laterales)

- grouped around the artery, efferents pass to the lumbar nodes
 - ***nodi subaortici*** – inferior to the aortic bifurcation
 - ***nodi promontorii*** – anterior to the sacral promontory

Nodi iliaci externi (mediales, intermedii, laterales)

- lateral, medial and anterior to the external iliac vessels, efferents pass to the common iliac nodes

Nodi iliaci interni

- surround the vessels, receive afferents from all the pelvic viscera, efferents pass to the

common iliac nodes

- ***nodi gluteales*** – along the gluteal vessels
- ***nodi sacrales*** – along the median and lateral sacral vessels

Visceral lymph nodes:

Nodi paravesicales

– efferents end in the external iliac vessels

Nodi pararectales

– efferents pass to the inferior mesenteric nodes, internal iliac nodes, and superficial inguinal nodes

Drainage of the female genital organs

Nodi parauterini

– collecting vessels from the uterine cervix pass laterally to the external iliac nodes, posterolaterally to the internal iliac nodes, and posteriorly to the sacral and rectal lymph nodes; from the upper part of the uterine body, fundus and uterine tubes the lymph is drained to the lumbar nodes; from the uterine horns – to the superficial inguinal nodes along the round ligament of uterus; lymphatics from the ovary ascend along the ovarian artery to the lumbar lymph nodes

Nodi paravaginales

– efferent pass to the internal and external iliac nodes, superficial and deep inguinal nodes

Drainage of the male genital organs

– collecting vessels from the testis ascend in the spermatic cord and accompany the testicular vessels ending in the lumbar nodes, collecting vessels from the ductus deferens end in the external iliac nodes, lymphatics from the seminal vesicles in the external and internal iliac nodes, and vessels from the prostate pass mainly to the internal iliac nodes. Lymphatics from the skin of the penis and scrotum follow the external pudendal vessels to the superficial inguinal nodes, vessels from the glans penis end in the deep pudendal and external iliac nodes and vessels from the erectile tissue and urethra pass to the internal iliac nodes.

Lymphatic drainage of the lower extremity (*Nodi lymphoidei membri inferioris*)

Most lymph from the lower limb traverses the inguinal nodes to reach the external iliac, common iliac, and then lumbar nodes. However, the deep gluteal lymph reaches the common iliac and lumbar nodes through the internal iliac nodes.

Deep lymphatic vessels accompany blood vessels. Deep vessels from the foot and leg are interrupted by popliteal nodes; those from the thigh pass to the deep inguinal nodes.

Nodi lymphatici poplitei profundi

– around the popliteal vessels, receive deep lymphatics from the leg and knee joint, efferents ascend along the femoral vessels to the deep inguinal nodes.

Nodi lymphatici inguinales profundi

– situated medial to the femoral vein, receive deep lymphatics accompanying the femoral vessels, lymph vessels from the glans penis/clitoridis. Efferents traverse the femoral canal to the external iliac nodes.

Superficial lymphatic vessels begin in subcutaneous plexuses, collecting vessels accompany the great and small saphenous veins.

Medial vessels – larger, more numerous, begin on the tibial side of the foot and ascend along the great saphenous vein to the distal superficial inguinal nodes.

Lateral vessels – begin on the fibular side of the foot, some join the medial vessels in the leg, others accompany the small saphenous vein to the popliteal nodes.

Superficial lymph vessels of the gluteal region direct anteriorly to the proximal superficial inguinal nodes.

Nodi lymphatici poplitei superficiales

- one or two nodes near the end of the small saphenous vein, drain the superficial region served by the vein

Nodi lymphatici inguinales superficiales

- form proximal and distal groups.

The proximal group is just distal to the inguinal ligament, receive afferents from the external genital organs, inferior anal canal and perianal region, infraumbilical abdominal wall and the uterine vessels accompanying the round ligament of the uterus.

The distal group – along the termination of the great saphenous vein, receives all superficial vessels of the lower limb, except those from the posterolateral calf.

Superficial inguinal nodes drain to the external iliac nodes, some via deep inguinal nodes.

THE SPLEEN (*LIEN, SPLEN*)

- see the chapter Digestive system

THE THYMUS

- consists of 2 asymmetrical lobes joined together by a connective tissue
- the left lobe is usually bigger and longer
- superiorly, extensions into the neck are common
- situated in the superior mediastinum anterior to the great vessels (***Area interpleuralis superior***)
- the size of the thymus changes with age – relatively biggest in newborns, age involution
- yellow, soft, elastic
- has a lobular surface
- connective tissue capsule at its surface (***Capsula thymi***)
- connective tissue septa divide it into **lobules (*Lobuli thymi*)**
- a dense and darker zone at the periphery (***Cortex***)
- a thin and lighter inner zone (***Medulla***)

Functions: Maturation of lymphocytes to form the immuno-competent T-lymphocytes, maintenance of necessary amount of lymphocytes in blood circulation and in peripheral tissues, control of normal development of lymphatic organs and production of lymphocytes

Vessels and nerves of the thymus

A. thyroidea inf., a. thoracica int. (a. subclavia)

Vv. brachiocephalicae, v. thoracica int., vv. thyroideae

Nodi lymph. mediastinales ant., parasternales, tracheales

Sympathetic fibres – *nn. cardiaci*, parasympathetic – CN X.

Sensory nerves – *n. phrenicus*

TONSILS (*TONSILAE*)

- patches of lymphatic tissue in the throat
- trap and dispose of the harmful materials which enter the throat through breathing, eating, and drinking
- form the **pharyngeal lymphoid ring of Waldeyer (*Angulus lymphoideus pharyngis*)** palatine, lingual, tubal, and pharyngeal tonsils

The ‘mucosa associated’ lymphoid tissue – lymphoid tissue in the alimentary and respiratory tract