The Lymphatic System

1

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Key Points

- The lymphatic system travels parallel to the cardiovascular system.
- In the extremities there are both superficial and deep lymphatics.
- The thoracic duct is the main lymphatic collecting vessel; it obtains lymph fluid from the entire body except the upper right quadrant.

Introduction

The lymphatic system parallels the cardiovascular system. It consists of lymphatic vessels and secondary lymphoid organs. It returns lymph fluid to the circulation via a one-way system [1]. Lymphatic vessels were first described as "white blood" by Hippocrates who coined the term "chyle" from the Greek *chylos,* meaning juice [1, 2]. Gaspar Aselli first illustrated the lymphatic system in 1622. As he was studying the abdomen of a well-fed dog, he noted a large number of mesentery cords that were very white and extremely thin. A white milk-like substance discharged from the vessels as he dissected them. *De lactius sive lacteis venis* was the first color-printed medical publication [1, 3]. An additional 300 years passed before it was discovered that the lymph system is responsible for returning protein molecules from tissues back to the central circulation. It also was determined that blocking lymphatic vessels led to lymphedema [4].

The lymphatic system is an open, linear structure. In the extremities it consists of an epifascial and a subfascial arrangement. It begins by collecting lymph fluid in tissue, delivers the fluid to filtering nodes through many small afferent vessels, exits the nodes via large efferent channels, and ends at the lymph–vein connection of the thoracic duct [5]. The lymphatics are absent in the brain, spinal cord, retina, bone, and cartilage [1].

Lymphatic Anatomy

Vasculature

Lymphatic capillaries are designed to obtain drained lymph fluid. They only have a single layer of overlapping lymphatic endothelial cells that are attached by filament bundles. In comparison to blood capillaries, they are not lined by a basement membrane or smooth-muscle like pericytes. This allows them to be highly permeable to interstitial fluid and macromolecules [6, 7]. Lymphatic capillaries normally are collapsed because they do not have the type of hemodynamic pressure that blood capillaries have that forces them to stay open [1, 8, 9]. An increase in interstitial pressure leads

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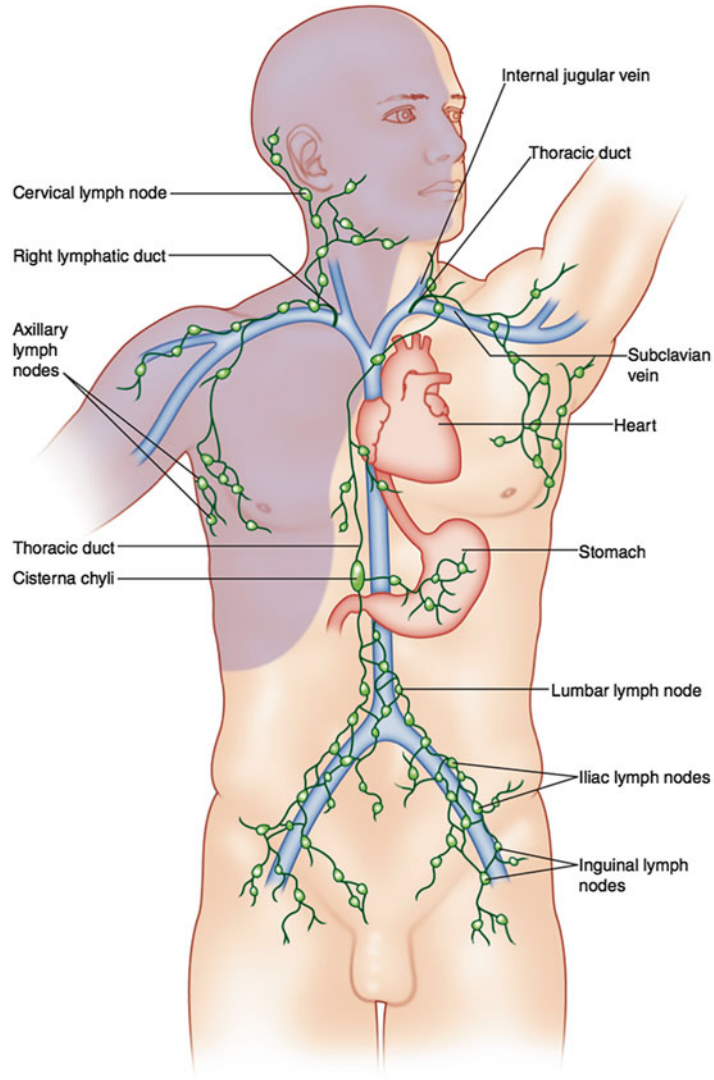

Fig. 1.1 Schematic of the lymphatic collection system. The right lymphatic duct obtains lymph fluid from the *shaded area*, while the thoracic duct accumulates lymph from the *non-shaded region*

to the anchoring filaments pulling the lymphatic endothelial cells apart and opening the capillaries. Lymph fluid then drains into the lymphatic capillaries [7, 10]. These capillaries are connected to precollecting lymphatic vessels, which eventually merge into secondary lymphatic collecting vessels.

Unlike lymphatic capillaries, lymphatic collecting vessels are constructed to return drained fluid into the circulation. They have lymphatic endothelial cells that are surrounded by a continuous basement membrane and pericytes. These endothelial cells tightly line up side by side [1, 11]. The collecting vessels possess valves that inhibit retrograde lymph flow. Muscle contraction propels lymph fluid through the collecting vessels [1].

Thoracic Duct

The thoracic duct is the main lymphatic collecting vessel of the body. It obtains lymph fluid from the entire body except the right head and neck, right hemithorax, and right upper extremity (Fig. 1.1).

It measures approximately 45 cm in length and 5 mm in width [12]. The thoracic duct is divided into three parts: abdominal, thoracic, and cervical. The duct originates with the abdominal portion at the cisterna chyli and ascends upward to form the thoracic portion as it traverses the aortic hiatus of the diaphragm into the posterior mediastinum [13]. The duct continues posteriorly along the esophagus until it reaches the fifth thoracic vertebra where it ascends on the left of the esophagus. The cervical segment of the duct begins when it descends across the subclavian artery at the seventh cervical vertebra [13]. The cervical thoracic duct is the widest of the three parts and has the greatest amount of variability between patients. There also are move valves in the "cervical" region than any other portion of the duct [14].

Several researchers have studied the termination of the thoracic duct. One anatomist reviewed over 500 patients and cadavers and determined 36 % of ducts end in the internal jugular vein, 34 % terminated in the junction of the internal jugular and subclavian veins, 21 % had multiple closures, and 17 % concluded in the subclavian vein [15]. Another group found the most common location of cessation was the venous angle (38 %) followed by the external jugular vein (28 %) and internal jugular vein (27 %) [16]. They noted 7 % of patients had a complex configuration. These individuals had a higher likelihood of metastasis in the cervical region [16]. Surgeons should take extra caution when dissecting in the vicinity of the thoracic duct because of its highly variable anatomy.

Right Lymphatic Duct

The right lymphatic duct drains the upper right body including the right head and neck, right upper extremity, right diaphragm, right lung, lower left lung, most of the heart, and part of the right lobe of the liver [13]. It is formed by the joining together of the right jugular, right subclavian, and right bronchomediastinal lymphatic trunks and measures 2 cm in length, respectively. The right bronchomediastinal trunk is the vestigial portion of the embryologic right thoracic duct [13]. The right lymphatic duct mainly terminates in the junction of the right subclavian and right internal jugular veins; however, it has numerous variations like the thoracic duct [13].

Cisterna Chyli

The cisterna chyli is a 2–5 cm elongated sac located retroperitoneally approximately at the second lumbar vertebra. It is the beginning of the thoracic duct. It drains lymph from the right and left lumbar trunks, the intestinal trunk, and the lowest intercostal vessels. These vessels either form a single sac or multiple sacculations. The union of the individual vessels may occur in the thoracic region instead of the abdomen [14]. The lumbar trunks obtain lymph from the pelvis, kidneys, adrenal glands, and area of the abdominal wall below the umbilicus. The intestinal trunk drains lymph from the celiac and superior mesenteric arteries [13].

Lymphatics of the Extremity

In the extremities there is an epifascial and a subfascial lymphatic system. The epidermal valveless lymphatics drain toward the subdermal valved lymphatics which then flow to collecting vessels above the fascia. The subdermal lymphatics are responsible for draining the integument and normally follow along with the veins. The epifascial and subfascial lymphatics communicate via perforators. The deep lymphatics flow below the deep fascia and course parallel with the main vascular structures [5]. In both the superficial and deep lymphatic system several small afferent lymphatic vessels lead lymph fluid to lymph node sinuses. The fluid exits the lymph node hilum via large efferent channels on its return to the cardiovascular system [5, 17]. The epifascial lymph nodes interconnect into four central draining chains: the paired axillary and inguinal lymph node systems [5].

The superficial lymphatic system of the upper extremity is divided into an ulnar bundle and a

radial bundle. The ulnar bundle drains the medial arm and follows the basilic vein to the axillary lymph nodes [5]. Part of the ulnar bundle branches at the hiatus basilicus and connects with the deep lymphatic system of the upper extremity via perforators. The radial bundle obtains lymph from the lateral arm and accompanies the cephalic vein until it joins the axillary lymph nodes at the lower margin of the pectoralis major muscle [5]. Lymph will then drain from the axillary lymph nodes to either the supraclavicular and/or infraclavicular lymph node and then to either the thoracic duct (left upper extremity) or the right lymphatic duct (right upper extremity) [5].

The epifascial system of the lower extremity collects lymph from the skin and subcutaneous layers and is divided into two bundles: ventromedial and dorsolateral bundles [5]. The dorsolateral bundle parallels the lesser saphenous vein, passes through the popliteal nodes, continues as the subfascial lymphatics of the thigh, and ends either in the deep inguinal or anterior iliac nodes. The ventromedial bundle runs with the greater saphenous vein but has greater variability in how it terminates [5]. The subfascial system accompanies the anterior and posterior tibial vasculature until they join with the dorsolateral bundle at the popliteal nodes. These collector vessels drain the muscles and fascia of the lower extremity [5].

Lymphatic Function

The lymphatic vasculature recycles interstitial fluids from veins back to the circulatory system, contributes to the immune response, and participates in the digestive tract [1, 5, 18]. Fifty to 100 % of plasma exits into the interstitium daily and provides nourishment to surrounding tissues [19, 20]. Ninety percent is recycled via venous capillaries; however, the remaining fluid has a molecular weight that is too large to pass through these vessels [5, 19, 20]. The differences in hydrostatic pressure and colloidal pressure in surrounding tissues and the lymphatic vasculature force the high molecular weight plasma through collecting lymphatics [5]. The lymph is then transported back to the cardiovascular system. The lymphatics also function in the immune system both by activating inflammatory responses in lymphatic endothelial cells and trafficking lymphocytes and antigen-presenting cells to lymph nodes [1, 21]. The lymphatics final purpose is to assist in the digestive tract. Lacteals are specialized lymphatic vessels located in the intestines. They carry fats and lipids in the form of chylomicrons [1, 22].

Conclusion

The lymphatic system runs one-way. The extremities have an epifascial and a subfascial system for collecting lymph. Lymph fluid drains from capillaries to afferent collecting vessels to lymph nodes to efferent lymphatic vessels to either the thoracic duct or the right lymphatic duct and back to the cardiovascular system.

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