The Lymphatic System

10 The Lymph Vessels and Lymph Tissue

Chapter Outline

THE LYMPH VESSELS AND LYMPH TISSUE

Edema and Lymphatic Obstruction

An inability to absorb protein from the tissue fluid into the lymphatic capillary will result in an accumulation of protein in the tissue fluid outside the capillary and cause **edema.** This occurs in several conditions:

- **Congenital lymphatic obstruction (Milroy's disease):** In this condition the lymphatic vessels, especially those of the lower limbs, fail to develop.
- **Surgical removal of lymph nodes and lymph vessels:** This occurs when an attempt is made to completely remove cancer cells that may have spread from their primary locus. This form of edema commonly occurs in the upper limbs following a radical mastectomy for carcinoma of the breast.
- **Filariasis:** In this mosquito-spread disease, common in the tropics, the worm larvae enter the lymphatic vessels and progressively block the lymph nodes. After a number of years, the lymphatic drainage of the leg may become totally obstructed and the grossly edematous lower limb may resemble that of an elephant, hence the name **elephantiasis.**
- **Malignant metastases in lymph nodes and lymphatic vessels:** This condition may cause edema of the skin of the breast or arm in advanced carcinoma of the breast.

Lymphangitis and Lymphadenitis

Lymphangitis is an infection of the lymphatic vessels and is a common occurrence. Red streaks along the course of the lymphatic vessels are characteristic of the condition. For example, a severe infection of the thumb may be followed by the spread of the bacteria into the lymphatic vessels draining the area. Red streaks may be seen on the anterior aspect of the forearm, following the course of the cephalic vein.

Once the infection reaches the lymph nodes, the nodes become enlarged and tender, a condition known as lymphadenitis.

Lymph Flow in Clinical Medicine

The factors responsible for normal lymph flow in lymphatic vessels include muscle activity, local arterial pulsation, valves in lymphatic vessels, tissue fluid pressure, and gravity. There are clinical situations in which it is important to diminish the speed of lymph flow. For example, a patient who has a severe bacterial infection of the hand may have the arm immobilized in a sling as an important part of the treatment. This procedure reduces the muscular activity of the

limb and, consequently, the lymph flow, lessening the possibility of bacterial spread via the lymphatic vessels and diminishing the rate of entry of toxins into the blood stream via the lymph. In some conditions, it may be necessary to have the patient rest in bed to reduce lymph flow.

Other clinical conditions may require an increase in the flow of lymph in lymphatic vessels. In postural edema, an individual who has been standing in one position for hours may experience swelling of the ankles and feet. Increasing lymph flow also may be important in someone who has had a limb immobilized for a long period in a splint. Muscular exercises, raising the limb to use the force of gravity, or massage applied to the area will aid the flow of lymph along the valved lymphatic vessels.

Lymph Vessels and the Spread of Malignant Disease

Lymphatic vessels provide a pathway for the spread of certain types of malignant tumors from their site of origin. When the cancer cells reach a lymph node, they may be temporarily stopped by the network of reticular fibers. However, the cancer cells may continue to multiply in situ, leading to the formation of a secondary growth or metastasis.

Enlargement of the Submandibular Lymph Nodes and Swelling of the Submandibular Salivary Gland

The submandibular lymph nodes are commonly enlarged as a result of a pathologic condition of the scalp, face, maxillary sinus, or mouth cavity. One of the most common causes of painful enlargement of these nodes is acute infection of the teeth. Enlargement of these nodes should not be confused with pathologic swelling of the submandibular salivary gland.

Clinical Significance of the Cervical Lymph Nodes

Knowledge of the lymph drainage of an organ or region is of great clinical importance. Examination of a patient may reveal an enlarged lymph node. It is the physician's responsibility to determine the cause and be knowledgeable about the area of the body that drains its lymph into a particular node. For example, an enlarged submandibular node can be caused by a pathologic condition in the scalp, the face, the maxillary sinus, or the tongue. An infected tooth of the upper or lower jaw may be responsible. Often a physician has to search systematically the various areas known to drain into a node to discover the cause.

Examination of the Deep Cervical Lymph Nodes

Lymph nodes in the neck should be examined from behind the patient. The examination is made easier by asking the patient to flex the neck slightly to reduce the tension of the muscles. The groups of nodes should be examined in a definite order to avoid omitting any.

After the identification of enlarged lymph nodes, possible sites of infection or neoplastic growth should be examined, including the face, scalp, tongue, mouth, tonsil, and pharynx.

Carcinoma Metastases in the Deep Cervical Lymph Nodes

In the head and neck, all the lymph ultimately drains into the **deep cervical group of nodes.** Secondary carcinomatous deposits in these nodes are common. The primary growth may be easy to find. On the other hand, at certain anatomic sites the primary growth may be small and overlooked, for example, in the larynx, the pharynx, the cervical part of the esophagus, and the external auditory meatus. The bronchi, breast, and stomach are sometimes the site of the primary tumor. In these cases, the secondary growth has spread far beyond the local lymph nodes.

When cervical metastases occur, the surgeon usually decides to perform a **block dissection of the cervical nodes.** This procedure involves the removal en bloc of the internal jugular vein, the fascia, the lymph nodes, and the submandibular salivary gland. The aim of the operation is removal of all the lymph tissues on the affected side of the neck. The carotid arteries and the vagus nerve are carefully preserved. It is often necessary to sacrifice the hypoglossal and vagus nerves, which may be involved in the cancerous deposits. In patients with bilateral spread, a bilateral block dissection may be necessary. An interval of 3 to 4 weeks is necessary before removing the second internal jugular vein.

Examination of the Axillary Lymph Nodes

With the patient standing or sitting, he or she is asked to place the hand of the side to be examined on the hip and push hard medially. This action of adduction of the shoulder joint causes the pectoralis major muscle to contract maximally so that it becomes hard like a board. The examiner then palpates the axillary nodes (see text Fig. 10-3) as follows:

- The **anterior (pectoral) nodes** may be palpated by pressing forward against the posterior surface of the pectoralis major muscle on the anterior wall of the axilla.

- The **posterior (subscapular) nodes** may be palpated by pressing backward against the anterior surface of the subscapularis muscle on the posterior wall of the axilla.
- The **lateral nodes** may be palpated against the medial side of the axillary vein. The examiner's fingers are pressed laterally against the subclavian vein and the pulsating axillary artery.
- The **central nodes** may be palpated in the center of the axilla between the pectoralis major (anterior wall) and the subscapularis (posterior wall).
- For the **apical nodes,** the patient is asked to relax the shoulder muscles and let the upper limb hang down at the side. The examiner then gently places the tips of the fingers of the examining hand high up in the axilla to the outer border of the first rib. If the nodes are enlarged they can be felt.

The examination of the axillary lymph nodes always forms part of the clinical examination of the breast.

Carcinoma of the Breast and the Axillary Lymph Nodes

The importance of knowing the lymph drainage of the breast in relation to the spread of cancer from that organ cannot be overemphasized. The lymph vessels from the medial quadrants of the breast pierce the second, third, and fourth intercostal spaces and enter the thorax to drain into the lymph nodes alongside the internal thoracic artery. The lymph vessels from the lateral quadrants of the breast drain into the anterior or pectoral group of axillary nodes. It follows, therefore, that a cancer occurring in the lateral quadrants of the breast tends to spread to the axillary nodes. Thoracic metastases are difficult or impossible to treat, but the lymph nodes of the axilla can be removed surgically.

Approximately 60% of carcinomas of the breast occur in the upper lateral quadrant. The lymphatic spread of cancer to the opposite breast, to the abdominal cavity, or into lymph nodes in the root of the neck is caused by obstruction of the normal lymphatic pathways by malignant cells or destruction of lymph vessels by surgery or radiotherapy. The cancer cells are swept along the lymph vessels and follow the lymph stream. The entrance of cancer cells into the blood vessels accounts for the metastases in distant bones.

In patients with localized cancer of the breast, most surgeons do a simple mastectomy or a lumpectomy, followed by radiotherapy to the axillary lymph nodes and/or hormone therapy. In patients with localized cancer of the breast with early metastases in the axillary lymph nodes, most authorities agree that radical mastectomy offers the best chance of cure. In patients in whom the disease has already spread beyond these areas (e.g., into the thorax), simple mastectomy, followed by radiotherapy or hormone therapy, is the treatment of choice.

Radical mastectomy is designed to remove the primary tumor and the lymph vessels and nodes that drain the area. This means that the breast and the associated structures containing the lymph vessels and nodes must be removed en bloc. The excised mass is therefore made up of the following: a large area of skin overlying the tumor and including the nipple; all the breast tissue; the pectoralis major and associated fascia through which the lymph vessels pass to the internal thoracic nodes; the pectoralis minor and associated fascia related to the lymph vessels passing to the axilla; all the fat, fascia, and lymph nodes in the axilla; and the fascia covering the upper part of the rectus sheath, the serratus anterior, the subscapularis, and the latissimus dorsi muscles. The axillary blood vessels, the brachial plexus, and the nerves to the serratus anterior and the latissimus dorsi are preserved. Some degree of postoperative edema of the arm is likely to follow such a radical removal of the lymph vessels draining the upper limb.

A modified form of radical mastectomy for patients with clinically localized cancer is also a common procedure and consists of a simple mastectomy in which the pectoral muscles are left intact. The axillary lymph nodes, fat, and fascia are removed. This procedure removes the primary tumor and permits pathologic examination of the lymph nodes for possible metastases.

Mediastinoscopy and the Tracheobronchial Lymph Nodes

Mediastinoscopy is a diagnostic procedure whereby specimens of tracheobronchial lymph nodes are obtained without opening the pleural cavities. A small incision is made in the midline in the neck just above the suprasternal notch, and the superior mediastinum is explored down to the region of the bifurcation of the trachea. The procedure can be used to determine the diagnosis and degree of spread of carcinoma of the bronchus.

Lymphatics of the Lower Limb

The superficial and deep inguinal lymph nodes not only drain all the lymph from the lower limb, but also drain lymph from the skin and superficial fascia of the anterior and posterior abdominal walls below the level of the umbilicus; lymph from the external genitalia and the mucous membrane of the lower half of the anal canal also drains into these nodes. Remember the large distances the lymph has had to travel in some instances before it reaches the inguinal nodes. For example, a patient may present with an enlarged, painful inguinal lymph node caused by lymphatic spread of pathogenic organisms that entered the body through a small scratch on the undersurface of the big toe.

THE THYMUS

Allograft Rejection

At about the time of birth, T lymphocytes leave the thymus and populate the peripheral lymphatic tissue; it is these cells that will bring about rejection of an allograft. Grafts between identical twins or from an individual to himself or herself will survive indefinitely, because there is no antigenic response. Although the thymus in the adult continues to influence the activities of the T lymphocytes, possibly by means of **thymosin,** thymectomy has been unsuccessful in preventing the rejection of allografts. Attempts to suppress the immunocompetent lymphocytes with drugs have been moderately successful.

Tumors of the Thymus

Thymomas are tumors of the thymus and are some of the most common tumors found in the anterior mediastinum. Many of the tumors are associated with myasthenia gravis and aplasia of blood cells. It is thought that these diseases are autoimmune in origin and may develop as a result of the formation of T lymphocytes that react to the individual's own tissues. Myasthenia gravis is a disease in which there is a possible reduction of acetylcholine receptors at the motor end-plates of skeletal muscle. Thymomas may be benign or malignant.

Clinical Problem Solving Questions

Read the following case histories/questions and give the best answer for each.

1. A 23-year-old woman is treated in the emergency department for an infected right index finger. Three days previously, she had got a rose thorn in her finger while gardening. On examination, the finger is red, tender, and very swollen. After removing the thorn and applying a dressing, the physician prescribes a course of antibiotics. He asks the nurse to put the patient's right arm in a sling, and warns the patient not to move the arm excessively. Explain why the patient's arm has been placed in a sling.
2. A 54-year-old man visits his doctor complaining of a skin infection of the auricle of the right ear. The patient had scratched his ear 4 days previously and since then his ear has become greatly swollen, and his wife has noted that the right side of his neck is also swollen. The physician's assistant made the diagnosis of impetigo and gave the patient an antibiotic to be taken orally. She advised the patient to place a warm compress over the ear twice daily to reduce the auricular swelling. Using your knowledge of anatomy and physiology, explain the following: (a) Why is the ear swollen? (b) Why is the right side of the neck swollen? and (c) Why will the application of a warm compress to the ear reduce the swelling?
3. A 58-year-old woman following a right radical mastectomy (which involves the removal of the right breast and the right axillary lymph nodes) has lymphatic edema of the right arm because of obstruction of the normal lymph flow. Describe the main factors responsible for lymph flow.
4. Explain the mechanism of allograft rejection. What form of immunity is lacking in a patient who has a congenital absence of the thymus?

   A 70-year-old man complaining of a small painless swelling below his chin visited his physician. On questioning, he said that he had first noticed the swelling 4 months earlier and that it was gradually increasing in size. Because it had not caused any discomfort, he had chosen to ignore it. On examination, a single, small, hard swelling could be palpated in the submental triangle. It was mobile on the deep tissues and not attached to the skin.

5. The following statements suggest that the hard swelling is a secondary malignant deposit in a lymph node **except** which?
   A. The submental lymph nodes are located in the submental triangle just below the chin.
   B. The submental lymph nodes drain the tip of the tongue, the floor of the mouth in the region of the frenulum of the tongue, the gums and incisor teeth, the middle third of the lower lip, and the skin over the chin.
   C. A small, hard-based carcinomatous ulcer was found on the right side of the tongue near the tip.
   D. The deep cervical group of lymph nodes beneath the sternocleidomastoid muscle receive lymph from the submental lymph nodes.

E. The submental lymph nodes lie deep to the superficial part of the submandibular salivary gland.

An 8-year-old boy was examined by a pediatrician and found to have a painful swelling below and behind the angle of the jaw on the left side. The skin over the swelling was red and hot. Palpation of the neck revealed a tender firm swelling beneath the anterior border of the sternocleidomastoid muscle on the left side. The right side of the neck was normal. Examination of the pharynx and palatine tonsils showed marked redness of the mucous membrane and enlargement of both tonsils, especially the one on the left. The left tonsil also showed a yellow exudate draining from the tonsillar crypts.

6. Using your knowledge of anatomy, name the group of lymph nodes involved in the disease.

An 18-year-old woman complaining of severe pain and redness around the base of the nail of the right thumb visited her physician. She stated that she had trimmed the cuticle (eponychium) of her nail with scissors, and the following day the pain commenced. On examination, the skin folds around the root of the nail were red, swollen, and extremely tender. The thumb was swollen, and red streaks were seen coursing up the front of the forearm.

7. The following symptoms and signs in this patient were consistent with a diagnosis of an acute bacterial infection under the nail folds (paronychia) of the right thumb **except** which?
   A. Some tender lymph nodes could be palpated in the infraclavicular fossa.
   B. The patient's temperature was raised.
   C. The infection had spread into the lymph vessels draining the finger.
   D. The red streaks on the front of the forearm were caused by the local vasodilatation of the blood vessels along the course of the lymph vessels.
   E. The lymph vessels from the thumb drain into the supratrochlear node, which was inflamed and enlarged.

A 45-year-old woman having her yearly physical examination was found to have a hard, painless lump in the upper lateral quadrant of the left breast. On examination with her arms at her sides, the left nipple was seen to be higher than the right, and a small dimple of skin was noted over the lump. On examination of the left axilla, three small, hard discrete nodules could be palpated below the lower border of the pectoralis major muscle. The right breast was normal. A diagnosis of carcinoma of the left breast was made, with secondary deposits in the axilla.

8. The following statements concerning this patient are correct **except** which?
   A. The contracting fibrous tissue of the malignant tumor had pulled on the lactiferous ducts of the nipple, raising it above the level of the opposite nipple.
   B. The dimpling of the skin was caused by the fibrous tissue pulling on the suspensory ligaments of the breast.
   C. The upper lateral quadrant of the breast is drained into the pectoral or anterior axillary lymph nodes.
   D. The enlarged pectoral lymph nodes could be palpated against the surgical neck of the humerus.
   E. The malignant tumor had spread by way of the lymph vessels to the pectoral lymph nodes.

A 45-year-old man complaining of a lump in the groin was seen by his physician. The lump, which caused him no pain or discomfort, was first recognized 3 months previously. On examination, a large discrete hard lump was found about 2 in. (5 cm) below and lateral to the pubic tubercle on the front of the right thigh.

9. The following signs indicated that this patient had a melanoma of the right big toe with secondaries in the inguinal lymph nodes **except** which?
   A. Two smaller hard swellings were found immediately below the large swelling.
   B. On flexing the right knee joint, three small hard swellings could be palpated in the popliteal fossa.
   C. The external genitalia were found to be normal.
   D. Examination of the anal canal revealed nothing abnormal.
   E. A small pigmented mole was discovered beneath the nail of the right big toe.

10. A senior medical student taking a surgical examination was asked to look at a 55-year-old man. On examination of the abdomen, he found a hard, fixed mass in the midline, about 4 in. (10 cm) in diameter, lying on the transpyloric plane. On questioning, the patient said that he had recently lost 20 lb and had a poor appetite. The student told the examiner that the patient was suffering from a carcinoma of the stomach and should have an immediate gastrectomy. The examiner then asked the student if he had examined the patient's scrotum, and the student admitted he had not. On examination, the scrotum was found to contain a large, hard mass on the right side that was not tethered to the skin. The inguinal lymph nodes on the right side were normal. Explain the connection between the abdominal swelling and the scrotal swelling. Why were the inguinal lymph nodes normal?

Answers and Explanations

1. The immobilization of the patient's arm in a sling reduces the muscular activity and, thus, the rate of lymph flow from the limb. This serves to limit the spread of toxins and bacteria from the site of infection.

2. (a) The auricle of the ear is swollen by inflammatory edema. Edema is an abnormal accumulation of tissue fluid in the intercellular spaces. The fluid dynamics of inflammatory edema includes the vasodilatation of the arterioles and capillaries at the site of infection with an outpouring of protein-rich plasma into the tissue spaces along with the outpouring of neutrophils. (b) The right side of the neck is swollen because the bacteria have spread from the right auricle via the lymphatic vessels to the right superficial and deep cervical lymph nodes, which are enlarged as a result of the proliferation of the contained lymphocytes. (c) In the early stages of infection, heat causes arteriolar vasodilatation, which in turn raises blood flow through the infected skin, hastening the arrival of neutrophils, antibodies, and antibiotics to the site of infection. Once the infection is controlled, the increased vascular and lymphatic flow will help reduce the local accumulation of tissue fluid and cause the swelling of the ear to diminish.

3. The factors responsible for lymph flow are summarized in the CD paragraph under Lymph Flow in Clinical Medicine.

4. The mechanism of allograft rejection is summarized in the CD paragraph under Allograft Rejection. In congenital absence of the thymus, the patient lacks T lymphocytes and, therefore, cellular immunity.

5. **E** is the correct answer. The submental lymph nodes are not covered by the superficial parts of the submandibular salivary gland (see text Fig. 10-2).

6. This patient had a streptococcal pharyngitis with involvement of the palatine tonsils, especially the one on the left. The infection had spread on the left side to involve the jugulodigastric member of the deep cervical lymph nodes (see text Fig. 10-2). This node had enlarged due to the inflammatory process and was responsible for the tender swelling on the left side of the neck.

7. **E** is the correct answer. The lymph vessels from the index finger drain into the deltopectoral nodes (see text Fig. 10-1).

8. **D** is the correct answer. The enlarged pectoral lymph nodes can be palpated against the posterior surface of the contracted pectoralis major muscle (see text Fig. 10-4).

9. **B** is the correct answer. Melanomas, which are highly malignant tumors, tend to initially spread via the lymph vessels to the local lymph nodes. These become enlarged and firm on palpation. The lymphatic drainage of the big toe is into the vertical group of superficial inguinal lymph nodes (see text Fig. 10-7).

10. The student failed to examine the entire patient and made an erroneous diagnosis. He may have been sidetracked in his thoughts by the patient stating that he had a poor appetite. One thing is certain—the student had forgotten his anatomy! (a) Malignant disease of the testis metastasizes to the lateral aortic nodes lying on the side of the body of the first lumbar vertebra in the abdomen (on the transpyloric plane). This is the normal lymph drainage of the testis. (b) The inguinal lymph nodes are only involved if the tumor spreads locally into the tissues of the scrotum outside the testis.