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The Lymphatic System, Lymphedema, and a Discussion of Methods for Treatment: A Review of the Literature

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THE LYMPHATIC SYSTEM, LYMPHEDEMA, AND A DISCUSSION OF METHODS FOR TREATMENT: A REVIEW OF THE LITERATURE

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This Independent Study, submitted by Lisa L. Schneider in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

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ABSTRACT

The condition of lymphedema has a significant impact of the quality of life of the person affected. Few patients are educated about the possibility of developing lymphedema and methods for prevention of lymphedema following surgical removal of lymph nodes or radiation therapy. Also, most physical therapists have received minimal or inadequate training in the area of lymphedema treatment. Hence, physical therapists may actually damage a patient's lymphatic system by using inadequate techniques.

The purpose of this literature review is to examine the lymphatic system, discuss the condition of lymphedema, and review various methods for prevention and treatment of lymphedema in order to provide physical therapists with an awareness of appropriate clinical techniques. Improving the clinician's awareness of lymphedema and proper treatment techniques will improve the outcome of therapy for the patient. As the outcome of therapy is improved, the quality of life of the patient will likely improve as well.

CHAPTER I

INTRODUCTION

Lymphedema is defined as a "protein-rich edema," whereby the compromised lymphatic system is unable to perform its duty of clearing the interstitial spaces of excess water, protein, and other waste materials.[1] It can affect a person's upper or lower extremity following a surgical or radiation procedure. Lymphedema can also arise as a result of lymphatic dysplasia, or an insufficient lymphatic system at birth. If not properly cared for, this condition may result in multiple physical and emotional impairments.

The condition of lymphedema is one that is often misunderstood. Physical therapists are sometimes called upon to treat patients with this condition, and may lack sufficient knowledge to treat these individuals properly. Complex decongestive physiotherapy is one form of treatment for lymphedema that began in Europe, and is now emerging in the United States. It involves the use of a special manual technique, as well as skin care, bandaging, and exercises. To utilize the manual technique in complex decongestive physiotherapy, the clinician must appreciate how delicate the lymphatic system is. If the physical therapist uses a firm application, the superficial lymphatic system will not be stimulated, but instead injured.

To remedy the possibility of inflicting harm upon a patient instead of helping to resolve their condition, physical therapists must receive training in the area of lymphedema treatment. This area is not often a part of basic physical therapy education

today, and physical therapists must seek knowledge through continuing education courses. Too often a patient is treated improperly or not treated at all, resulting not only in a physically worsened condition, but also possibly the onset of psychological impairments.

Lymphedema has a significant impact on the quality of life of the person affected.[2] Psychosocial support and quality of life improvement programs are a very important part of the realm of treatment for a patient with lymphedema. Some patients reveal that lymphedema "takes over" their life.[3] Others feel overwhelmed with the life-long treatment. A feeling of frustration may be experienced as the patient realizes the wealth of functional limitations secondary to the condition. On top of that, if the physical therapist is improperly treating a patient, the condition may actually grow worse, when it could have been helped.

The purpose of this literature review is to examine the lymphatic system, discuss the condition of lymphedema, and review various methods for prevention and treatment of lymphedema in order to provide physical therapists with an awareness of appropriate clinical techniques. A firm understanding of the anatomy and physiology of the lymphatic system is critical in order to understand how appropriate treatment is achieved. If a clinician neglects the concept of such a fragile system, the outcome of therapy will likely be negative. Also, it is important to understand the pathophysiology of lymphedema, as opposed to other forms of lymphatic insufficiency, in order to realize how the treatment works. A section will be included on the prevention of lymphedema, which will emphasize a patient-active approach. Treatment for lymphedema will focus on the concept of complex decongestive

physiotherapy, but will also include other physical therapy techniques, as well as pharmacologic and surgical treatment.

Ideally, as the physical therapist becomes more educated on the concept of lymphedema, patients will receive better treatment. As this improves, quality of life issues of the patient will also be affected, and ultimately, improve as well.

CHAPTER II

THE LYMPHATIC SYSTEM

The lymphatic system is an important part of the body in that it interacts with virtually every organ.[4] It works closely with the circulatory system to return fluid that has escaped from the vascular system back to the venous blood just before it reaches the heart. The lymphatic system is different from the circulatory system in that there is not a full circuit or ring as there is in the circulatory system.[5] Instead, the lymphatic system begins "blindly" in loose connective tissue and transports fluid through a series of lymphatic vessels and returns the cleansed fluid back to the bloodstream.[4]

Functions

The lymphatic system has three basic functions: absorption of fats from the intestine, defending the body from disease processes, and accumulation of interstitial fluid for return to the circulatory system.[4] Lymph that is drained from the intestine, called chyle, is milky white in color rather than clear because it contains digested fats. The lymphatic system's role in immunity is to produce lymphocytes and filter lymph of any foreign material as it passes through the lymph nodes.

The primary function of the lymphatic system is to accumulate interstitial fluid which has leaked from the blood vascular system, cleanse the fluid, and return it to the blood.[6] Any nutrients that enter the body are first transported by the circulatory system into tissue cells. The tissue cells are encompassed by interstitial fluid, and in order for

the nutrients to pass from the circulatory system to the tissue cells, they must first pass through the interstitial fluid. When the tissue cells metabolize the nutrients, waste products are produced, which are then filtered back into the interstitial fluid for the venous and lymphatic capillaries to remove. Lymphatic vessels must remove some of the waste, as the venous capillaries are only capable of resorbing small molecules, gases, and water. The lymphatic vessels drain the interstitial fluid of water or plasma which was not resorbed by the venous system, and waste materials such as bacteria, dusts, proteins, dyes, and dead or mutant cells. All of these substances are named lymph obligatory load (LOL). The amount of waste the lymphatic system is responsible for draining amounts to approximately two liters per day. If this amount of interstitial fluid was not drained by the lymphatic system, in a brief amount of time the increased fluid would result in edema.[5] The resulting edema would cause damage to tissues.

To further discuss the amount of fluid the lymphatic system is responsible for draining, the balance of Starling will be considered, which is the principle of filtration and reabsorption.[7] This principle determined that the forces that cause a transfer of fluid between blood and interstitial space are hydrostatic and osmotic pressures. The hypothesis stated that hydrostatic and oncotic pressures in the vessels, and tissue and osmotic pressures in the tissues are the variables that cause transport of fluid from the capillaries to the interstitium and from the interstitium to the capillaries. At the arterial end of the capillary, the hydrostatic pressure (pressure pushing out of the capillary) is 5 mmHg greater than the oncotic pressure (pressure due to proteins, which pulls fluid into the capillary). Considering the tissues at the arterial end of the capillary, the osmotic pressure (pressure due to proteins, which pulls fluid into the tissue) is 2 mmHg greater

than the tissue pressure (pressure that pushes fluid into the capillary). Therefore, at the arterial end of the capillary, there is a net filtration of 7 mmHg. In other words, there is a 7 mmHg force that pushes out of the capillary and into the interstitial spaces at the arterial end. At the venous end of the capillary, the oncotic pressure is 5 mmHg greater than the hydrostatic pressure. Considering the tissues at the venous end of the capillary, the osmotic pressure is 2 mmHg greater than the tissue pressure. Therefore, at the venous end of the capillary, there is a net reabsorption of 3 mmHg, which calls for fluid to go from the interstitial space to the capillary. As there is greater pressure pushing out of the capillary than there is returning into the capillary, some fluid remains in the interstitial space. The lymphatic system is responsible for draining this remainder of fluid. See Figure 1.

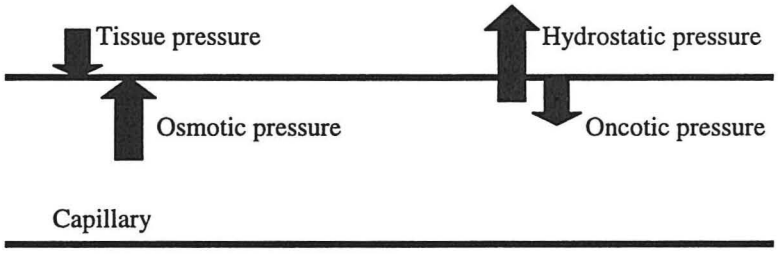


Figure 1. Variables causing transport of fluid from the capillaries to the interstitium and from the interstitium to the capillaries, according to the balance of Starling.

Anatomy

The lymphatic system consists of vessels and organs containing lymphatic tissue.[8] The spleen, tonsils, thymus gland, and lymph nodes are all considered lymphatic organs. Three main types of lymphatic vessels include lymph capillaries, lymphatics, and the largest of all, lymph ducts. A glossary is provided in Appendix A for quick reference to

specific terms included throughout this paper. Also, pictures of the anatomy of the lymphatic system are included in Appendix B.

Lymph formation is the process whereby the lymph capillaries intake interstitial fluid.[7] Once this fluid enters the lymph capillaries, it is called lymph. Lymph is a clear, watery fluid with a composition similar to blood, however lymph does not contain platelets or red blood cells.[9]

Lymph capillaries are very small tubes found almost everywhere blood capillaries are located.[8] They form a dense circuitry in almost all tissues of the body except for avascular structures such as cartilage and the epidermis, and the CNS. Also known as initial lymphatics, these microscopic vessels are closed-ended initially.[7] The diameter of these vessels ranges from 10 to 80 micrometers, which is much larger than the diameter of blood capillaries. Lymph capillary walls are made up of a single layer of overlapping endothelial cells.[8] See Figure 2. The overlapping cells provide a one-way valve system for fluid movement into the lumen of the lymph capillary. As pressure builds up in the interstitial space, the cells swing inward, allowing for fluid to enter into the capillary, but not escape out. When the pressure is greater inside the lymph capillary, the endothelial cells are forced together, which prevents any lymph from leaking out of the lymph capillary.[4] The endothelial cells of the lymph capillary are attached to surrounding connective tissue by anchoring filaments.[7] See Figure 3. These filaments are important during edema. When there is an accumulation of fluid in the tissue, the swelling causes the anchoring filaments to be pulled. This opens the endothelial cells even more, and allows more fluid to enter the lymph capillary.

Lymph capillaries drain into vessels called precollectors, which are situated more deeply than the lymph capillaries and contain valves.[10] Precollectors eventually converge to form lymphatics.[8] Also called lymph veins or lymphatic collecting vessels, these vessels are similar to veins, however lymphatics contain more valves, have thinner walls, and have a larger lumen. See Figure 4. Lymphatics are composed of three endothelial layers.[7] The segment found between each valve in the lymphatics is known as the lymphangion. This is the functional unit of the lymphatics. Lymphangions are innervated by the autonomic nervous system, and are thought to play an important role in the transport of lymph.

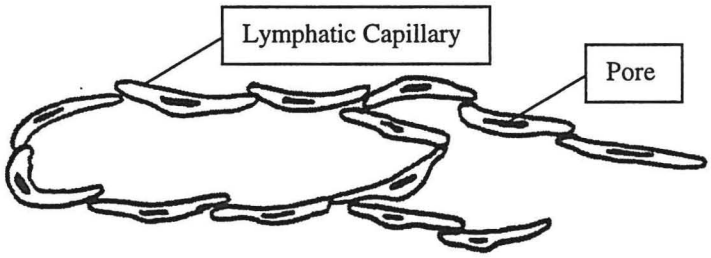


Figure 2. Single layered lymphatic capillaries.

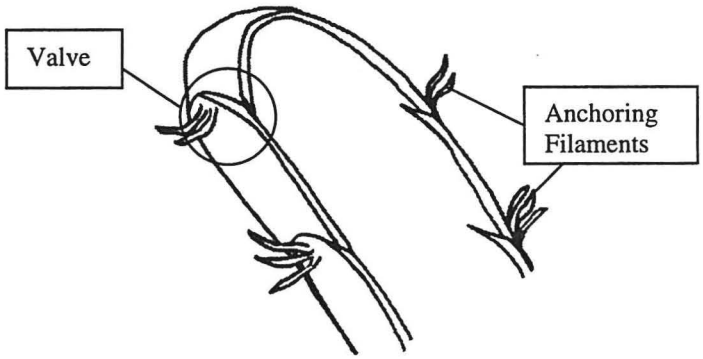


Figure 3. Anchoring filaments and valve structure of lymphatic capillary.

There are two lymph vein compartments or bundles.[7] The superficial compartment is located in the skin and subcutaneous tissue and tends to follow the same paths that veins follow. The deep compartment drains lymph from ligaments, tendons, muscle, nerves, and viscera, and generally follows the paths of deep arteries. There are superficial and deep compartments throughout the extremities, as well as in the thoracic wall. Superficial lymphatic pathways in the thoracic wall are important in that they provide alternate routes for lymph flow following a surgical procedure that has removed lymph tissue, such as a mastectomy. This concept will be discussed in Chapter IV.

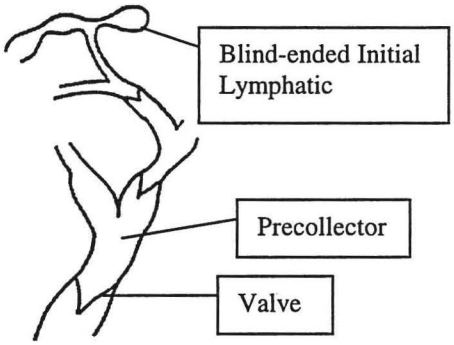


Figure 4. Initial and collecting lymphatics.

Lymphatic collecting vessels enter lymph nodes at various locations.[11] In general, lymph fluid passes through one or more lymph node as it travels through the lymphatic system and enters the blood. Lymph nodes have the shape of an oval or kidney, and are usually found in groups or chains, however their number and size varies.[7] A human has between 500 and 1500 nodes, ranging in size from very small to about 2.5 cm.[11] Areas of greater concentration of lymph nodes include the axillary and inguinal regions, and also

throughout the head, neck and trunk.[12] Lymph nodes are distributed both superficially and deep.

Lymph nodes have an outer capsule composed of collagen fibers.[7] This capsule dips down into the node and forms partitions called trabeculae.[8] Beneath the capsule lies the cortex, paracortex, and the medulla.[12] Lymph nodes consist mainly of reticular and lymphatic tissue, which contains lymphocytes.[8] Blood vessels and efferent lymph vessels enter the node through the hilum, which is the concave side of the node.[7] The afferent lymph vessels enter through the capsule of the node. An afferent lymph vessel is a lymphatic that carries lymph to the lymph nodes, while an efferent lymph vessel is a lymphatic that carries lymph away from a lymph node.[11] An efferent lymph vessel leaving one node will usually become an afferent lymph vessel entering another node. See Figure 5.

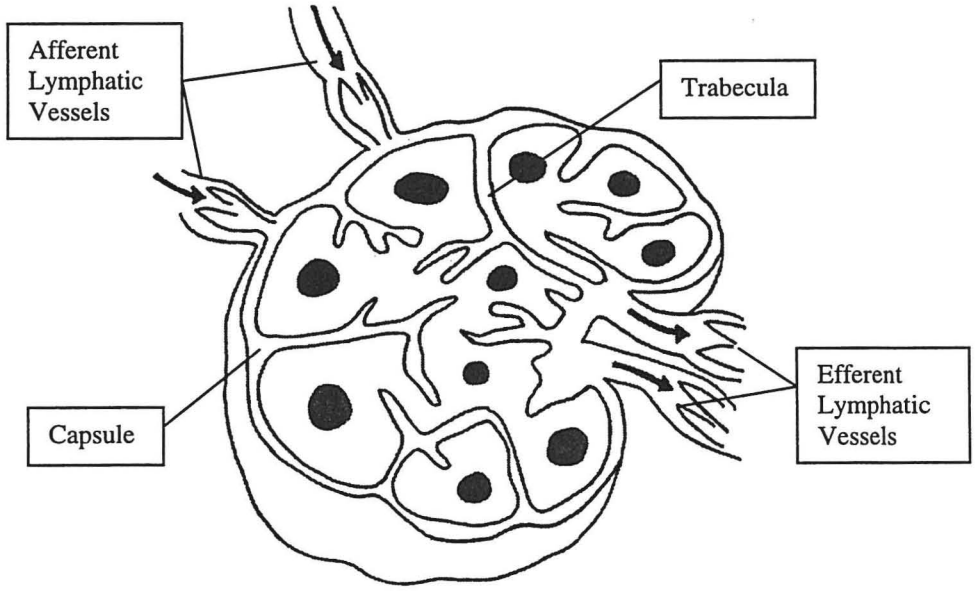


Figure 5. Lymph node structure.

Lymph nodes have three main functions. First, they are "biological filtering stations."[7] Lymphoid macrophages in the nodes have the ability to destroy damaging material.[4] Because of this, harmful debris, bacteria, and antigens are prevented from entering the bloodstream and continuing on to infect another area of the body. Sometimes, not all the damaging material is filtered off at one node. It then passes to the next lymph node and is cleansed again. Usually, by the time the lymph reaches the venous blood, it has been cleansed thoroughly.[8] If the cleansing is incomplete, a lymph node may swell. This is often the result of infection, whereby the lymph node is incapable of cleansing certain inorganic substances.

A second function of lymph nodes is the production of lymphocytes.[7] The types of lymphocytes, T and B lymphocytes, are produced in different areas of the body, however when activated by a foreign substance, can be multiplied in the lymph nodes. Lymph flowing into nodes via afferent lymph vessels contains many less lymphocytes than does lymph flowing out of the nodes via efferent lymph vessels.

A third function of lymph nodes is to regulate the amount of protein in the lymph.[7] The protein concentration in the lymph should remain the same as that in the intercellular fluid. It is the duty of the lymph nodes to assure the concentrations are the same.

As lymph fluid leaves the lymph nodes, it has been cleansed for return to the bloodstream.[11] Lymphatics eventually merge together to form the main lymphatic trunks. The main lymphatic trunks include the lumbar, bronchomediastinal, subclavian, jugular, and intestinal trunks.[4] These lymphatic trunks then unite to form either the right lymphatic duct or the thoracic duct. See Figure 6. The right lymphatic duct receives all

the lymph from the right upper quadrant of the body. This in turn drains into venous circulation at the junction of the right internal jugular and the right subclavian veins.[11] The thoracic duct begins near the lower lumbar spine as the cisterna chyli, which is an enlarged sac that collects lymph from the lower extremities, the lumbar trunks, and from one intestinal trunk.[4] The thoracic duct receives lymph from the entire body, except for the right upper quadrant, and drains into venous circulation at the junction of the internal jugular vein and the left subclavian vein.[11] See Figure 7 for a summary of the entire lymphatic system network.

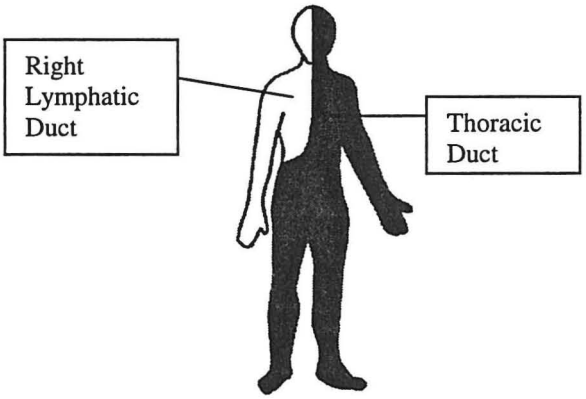


Figure 6. Drainage of the right lymphatic duct and thoracic duct.

Propulsion of Lymph

There are a few mechanisms responsible for propelling lymph throughout the lymphatic system.[7] Activities that cause lymph to flow through the lymphatic system and into the venous circulation are known as lymphokinetic actions.[5] The lymphangion of each lymphatic vessel is responsible for the propulsion of lymph.[7] It is composed of smooth muscle that contains stretch-reactive receptors. When these receptors are

stimulated, a propelling force is generated and the lymphatic walls contract segmentally, moving lymph from one valve segment to the next. Due to the great number of valves in the lymphatics, the fluid is allowed to flow only in one direction, encouraging lymph flow back to the venous blood.

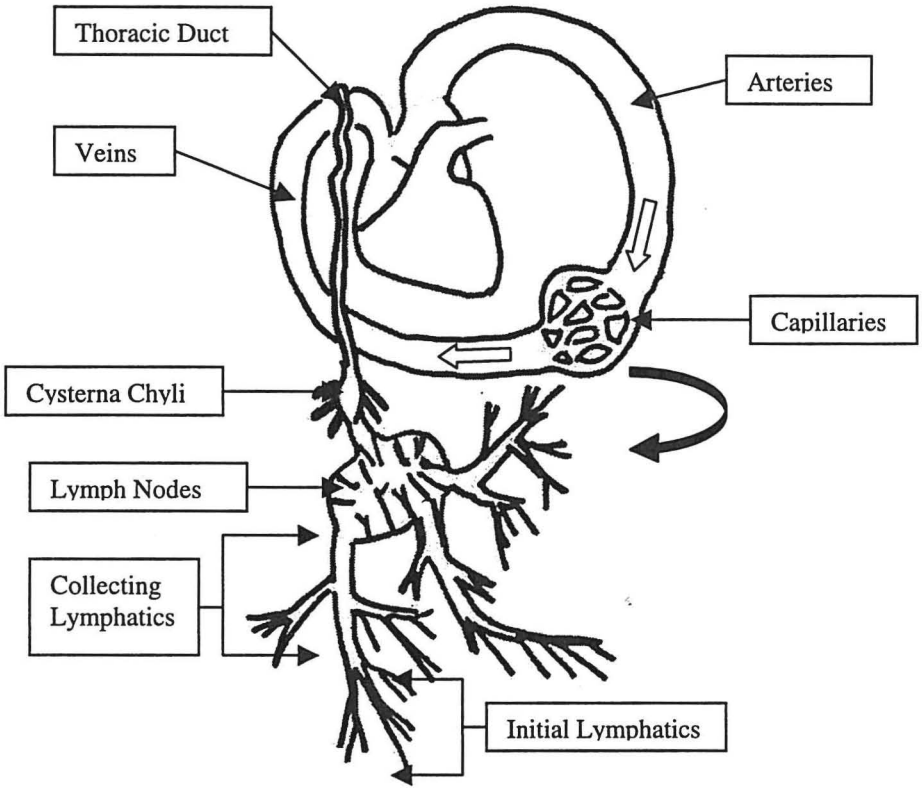


Figure 7. Schematic representation of entire lymphatic network.

Another factor contributing to lymph propulsion is active and passive motion.[7] Passive motion enables interstitial fluid to enter the lymph capillaries. Two factors affecting lymph propulsion in the deep lymph system include arterial pulsations and muscle pumping. Respiration can enhance lymph flow also.[5] X-ray examination has found that lymph flow into venous circulation occurs most rapidly at maximal inhalation.

Inhalation causes the diaphragm to descend, increasing intraabdominal pressure and decreasing thoracic pressure. The amount of lymph that enters into venous circulation is dependent on the rate of breathing and the depth of inspiration. Other factors affecting lymph flow include manual techniques, such as massage, and postural changes.

Summary

Lymph fluid flows through virtually every organ of the body.[13] If this flow is harmed, lymph can become toxic and viscous. In turn, body systems that rely on the lymphatic system for elimination of waste become sluggish as well. As this occurs, the waste material builds up and allows for infection and physical illness to occur more easily. Symptoms of blocked lymph nodes include swollen glands, allergies, chronic sinusitis, loss of energy, chronic fatigue, high blood pressure, viral infections, swollen eyes, bacterial infections, headaches, excessive sweating, and edema.

CHAPTER III

LYMPHEDEMA

According to Fold et al,[14] the lymphatic system becomes insufficient when its transport capacity is lower than the lymphatic obligatory load. Transport capacity is the greatest amount of lymph flow per unit time. There are three types of lymph vascular insufficiency. The first, dynamic insufficiency, occurs when the LOL exceeds transport capacity, however the lymph vessels are still intact and physiologically normal.[1] Due to the increase in LOL, the vessels become overwhelmed and a build-up of protein and water in the tissues is the result. The edema that results secondary to dynamic insufficiency is not related to lymphedema and usually can be treated with elevation of the affected limb, exercise, and compression. Examples are ascites, nephrotic syndrome, and deep venous insufficiency in the lower extremities,.

A second type of lymph vascular insufficiency is caused by a decrease in the transport capacity of the lymphatic system.[14] The transport capacity becomes lower than the level of normal water and protein lymphatic load.[1] The lymphatic system is unable to perform its duty of clearing the interstitial spaces of excess water, protein and other wastes. This decreased lymph flow is called mechanical insufficiency, and results in lymphedema, the "protein-rich edema."[14] Dynamic insufficiency occurs when the lymph obligatory load exceeds the transport capacity, while mechanical insufficiency arises when the LOL is normal, however the transport capacity is impaired.

A third form of lymph vascular insufficiency occurs when the transport capacity is reduced, and the LOL is increased.[14] Foldi et al[14] call this safety valve insufficiency. The result of this type of insufficiency is an edematous area with death of cells occurring in the area.

Pathology

Lymphedema occurs when the insufficient transport capacity of the lymphatic system cannot adequately clear the interstitium of water, protein, and wastes.[1] Since the venous system is unable to reabsorb the large protein molecules and the lymph transport system is compromised, protein-rich fluid will remain in the interstitium.[15] As the transport capacity decreases, the integrity of the lymph vessel walls and one-way valves diminishes.[16] This occurs as a result of an increase in lymph vessel hydrostatic pressure. Lymph may flow in a backward direction as the pressure continues to increase, causing lymph fluid to leak out into the interstitial spaces. As protein-rich fluid accumulates in the interstitial tissues, the tissue oncotic pressure increases, causing even more edema.[17] If the edema is allowed to persist, the high protein concentration can deny tissues of sufficient oxygen and lead to fibrosis and chronic inflammation.[18] When albumin, a protein found in lymph fluid, and other wastes are allowed to stagnate in the interstitial spaces, an environment is created whereby bacteria may easily grow.[19] This can lead to infections such as lymphangitis or cellulitis.[17]

Lymphedema usually occurs in an extremity, but has also been found to occur in the abdomen, face, neck, and lungs.[20] It is estimated that 2.5 million people in the United States are affected, which amounts to one percent of the total United States population.[21] Patients with breast cancer, undergoing either a mastectomy or lumpectomy with

radiation, will have a 15 to 30 percent chance of developing lymphedema in the ipsilateral extremity.[22] As many as 70 percent of individuals having an axillary node dissection will be affected by upper extremity lymphedema.[16]

There are two general classifications of lymphedema.[10] The first, primary lymphedema, is thought to be more common in women than men and occurs more often in the lower extremities than the upper extremities.[23] Primary lymphedema results from lymphatic dysplasia, which is defined as a developmental insufficiency of the lymphatic system.[24] Types of lymphatic dysplasia include aplasia, hypoplasia, hyperplasia, and sclerosis of lymph nodes.[1] When there are no lymph vessels in a localized area of the body, it is considered aplasia. Hypoplasia occurs when there are too few lymph vessels in an area, whereas hyperplasia occurs when the valves of the lymphatics are incompetent.

Most often, primary lymphedema develops later in life, however it can be present at birth (congenital lymphedema).[21] Lymphedema precox is the term given to primary lymphedema arising at adolescence, while lymphedema tardum manifests after the age of 35.[25] The dysplasia associated with lymphedema tardum has been found to be familial, and it is speculated that an early aging process causes the lymphatic system to fail.

The second classification of lymphedema, secondary or acquired lymphedema, is much more prevalent than the primary form.[26] It occurs as a result of a surgical procedure, radiation therapy, infection, trauma, burning, or scarring.[21] For example, during a lymph node dissection, components of the lymphatic system may be removed, resulting in possible mechanical insufficiency or obstruction and a subsequent increase in

lymphatic pressure. In turn, the rise in pressure will cause valves to be compromised, resulting in a backflow of lymph. See Figure 8.

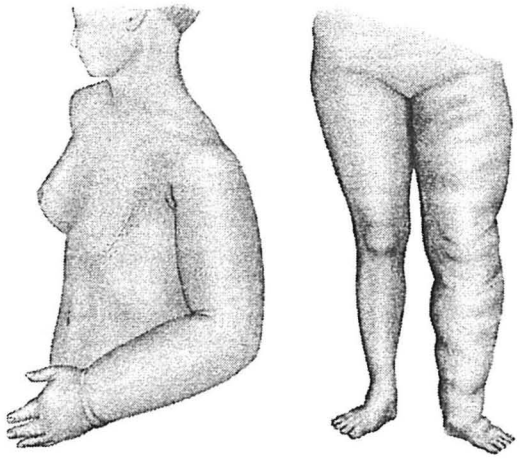


Figure 8. Upper and lower extremity lymphedema.

When the transport capacity is compromised secondary to removal of part of the lymphatic system, the body initially tries to compensate by a few different mechanisms.[14] First, the lymphatics that are still intact following surgery will attempt to keep up with the LOL. Next, lymph anastomoses will become activated, causing collateral lymph flow. Anastomoses are variable from individual to individual. However, a study by Leduc et al[27] showed that there are sufficient substitution pathways to cause collateral lymph flow and adequate drainage. Another compensatory mechanism is the establishment of new junctions between lymphatics and veins, known as peripheral lymphovenous anastomoses.[14] Finally, to encourage removal of fluid from the interstitial spaces, monocytes are transformed into macrophages, which in turn move into the obstructed region and begin proteolytic breakdown of the stagnant proteins.

Other causes of secondary lymphedema include recurrent cellulitis, contact dermatitis, and various connective tissues disorders such as rheumatoid arthritis and psoriatic arthritis.[10] The most common cause of secondary lymphedema in developed countries is radiation therapy and lymph node resection. Worldwide, the most common cause of secondary lymphedema is lymphatic filariasis. Filarial parasites have been found to cause mechanical obstruction of the lymphatic system, as well as depress the contractility of the lymphatics.[25]

Lymphedema has the potential for progressing through three stages.[21] The first stage is reversible and is marked by an accumulation of protein-rich edema which is measurable and palpable. Often times in this stage, the swelling may be reduced simply by elevating the affected extremity and may disappear overnight.[1] Skin texture is smooth, with the presence of pitting when depressed. Associated symptoms occurring with the edema include a sensation of heaviness of the affected extremity, as well as mild pain and warmth.[24] If the lymphedema advances untreated and the protein-rich fluid remains, progressive hardening of the affected limb will occur as fibrotic tissue replaces the large, congested protein molecules.[1]

The second stage of lymphedema is considered spontaneously irreversible.[23] There is a marked increase in the volume of lymphedema as a patient progresses to this stage.[28] Although still a protein-rich edema, no longer is it possible to cause a pit in the overlying skin when attempting to depress it. Proliferation of connective tissue and adipose tissue, along with scarring, will cause the tissues to become progressively harder. Elevating the affected limb will not cause a reduction in edema, and there is diminished mobility of the affected limb.[24]

The third stage of lymphedema, lymphostatic elephantiasis, is marked by a drastic increase in the swelling of the affected limb.[1] The protein-rich edema continues to cause proliferation of connective tissue and adipose tissue, leading to a further increase in the hardening of the tissues. The limb becomes column-shaped, and may resemble an elephant's limb.[28] There may be hanging skin folds present, and the weight of the affected limb is greatly increased. Skin changes occur such as hardening of the dermal tissues, papillomas of the skin, and hyperkeratosis.[21] When a patient reaches this stage, there is usually a loss of function of the affected extremity, along with many other complications.[1] A highly malignant angiosarcoma may arise known as Stewart-Treves Syndrome, though this occurs rarely.

Frequent infections are most common in the second and third stages of lymphedema.[21] Lymphangitis, cellulitis, and erysipelas are three examples of infections that can easily occur in these stages. Infections can worsen the condition of lymphedema, and may result in hospitalization.

The onset of lymphedema may be sudden or insidious.[15] Following a lymph node resection, there is usually acute edema, which often resolves within two to three months.[10] This acute swelling is not associated with lymphedema and does not predict the possibility of lymphedema occurring in the future. Lymphedema can occur anytime (from a few months to years) following a surgical procedure or radiation therapy.[29] Any procedure that damages the lymphatic system can result in lymphedema occurring spontaneously or gradually. The event that triggers the onset of lymphedema may be something as simple as a needle puncture, insect bite, scratch, or sunburn.[24] Infections, such as streptococcus and staphylococcus, are another cause of onset. Many times the

onset of lymphedema has been due to an airplane flight. The transient swelling that occurs in a normal individual after a flight can be easily removed with a competent lymphatic system. However, a patient with a compromised lymphatic system is unable to remove the excess lymph fluid, and the onset of lymphedema may occur.

Methods for Physician Diagnosis

An early and accurate diagnosis of lymphedema is sometimes difficult.[29] This may be because many patients are not properly educated about the impact lymphedema can have on their life. A patient will most likely refer to a physician for evaluation as they begin to notice subtle changes, such as the inability to wear jewelry around the fingers and wrist, or a tightness in clothing in the affected extremity. The patient may also begin to notice a decrease in range of motion or function in the affected extremity, a sensation of heaviness, or mild pain or paraesthesia. Most often, the patient will initially visit his or her primary care physician. If the diagnosis is unclear, further consultation with a clinical lymphologist may be needed.[30]

Although the diagnosis of lymphedema shall only occur after a physician has performed a thorough history and physical examination, both the physician and physical therapist will perform a standard evaluation of the patient.[7] This evaluation will be discussed in the physical therapy assessment section of this chapter. The diagnosis is most often made after assessing the clinical signs. Lymphedema can arise anytime from a few months to many years after radiation or surgery, and it may be difficult to diagnose in the early stages of the disease, as skin and subcutaneous changes have not yet occurred.[20, 29] It is therefore important to distinguish lymphedema from various other differential diagnoses. Some differential diagnoses include venous insufficiency,

infection, arterial reconstruction, malignancy, gastrocnemius muscle tear, and lipedema.[31] Venous insufficiency and lipedema will be discussed further.

In most cases, a physician is able to differentiate between lymphedema and venous insufficiency by comparing the clinical signs.[32] Clinical signs present in venous insufficiency include hyperpigmentation, varices, skin ulceration, brawny edema, and stasis. There are insufficient valves in the veins, which causes venous blood to flow in both proximal and distal directions. Edema occurring as a result of venous insufficiency often resolves with several hours of bed rest and elevation, whereas lymphedema is only mildly affected by elevation, if at all.[33] Also, venous insufficiency is often found bilaterally, whereas lymphedema is ordinarily unilateral.

The condition of lipedema, occurring only in women, is marked by abnormal fat deposition.[34] Often found in women who are obese, this condition is bilateral and symmetrical, and occurs in the lower extremities. The swelling, or accumulation of fat tissue, is found from the highest point of the pelvic bones to the ankles, with the feet being unaffected. This is the primary sign to look for in differentiating lymphedema from lipedema, as lymphedema includes pedal edema. Often, the fatty tissue hangs over the ankles.[35] Upper extremities have also been found to be affected by lipedema, but this occurs rarely. Signs and symptoms of lipedema include easy bruising and extreme sensitivity to pressure in the affected area, with increased skin temperature over the course of the veins. Patients with this condition are at an increased risk of developing lymphedema, as the lymphatic tissues are often damaged with lipedema. Table 1 summarizes the differences between lymphedema, lipedema, and venous insufficiency.

Table 1. Primary differences between lymphedema, lipedema, and venous insufficiency.

	Lymphedema	Lipedema	Venous Stasis
Symmetry	usually unilateral	bilateral	absent
Involvement of buttock	absent	present	absent
Involvement of feet	present	absent	present
Tenderness	usually absent or very slight	usually present	absent
Pitting	present in stage I, absent in stages II & III	none	present

Adapted from: Beninson J, Edelglass JW. Lipedema – the non-lymphatic masquerader. *Angiol.* 1984;35:506-510.

Additional tests are sometimes required to confirm the presence of an impaired lymphatic system.[36] These tests include lymphography, lyphoscinitgraphy, magnetic resonance imaging, and computed axial tomography. Lymphography, or lymphangiography, is performed by injecting a contrast medium into the lymphatic vessels.[2] This procedure gives an accurate visualization of the anatomy of the lymphatic system, however, it is now rarely used. Lymphography is difficult to perform, invasive, not readily reproducible, and painful for the patient. Also, this procedure does not provide information on the rate of lymph flow, as some newer methods of testing can. Due to the invasiveness of lymphography, this procedure may result in worsened inflammation, tissue necrosis, hypersensitivity reactions, or pulmonary embolism.

Magnetic resonance imaging is useful in determining whether a patient has venous insufficiency or lymphedema.[37] It is also effective in providing a visualization of the anatomy of the lymphatic system. Computed tomography also provides a close representation of the anatomy and accurately reveals any skin thickenings in the affected area.

Lymphoscintigraphy is a procedure in which radiolabeled colloids are injected subcutaneously.[38] A physician is able to evaluate both the anatomy of lymph vessels and nodes, as well as examine the rate of lymph flow.[36] This is a relatively simple procedure which is more safe and effective than lymphography. It causes little to no pain, is non-invasive, and has essentially no side effects.

A complete cardiac evaluation should be performed by the physician if he or she suspects a patient to have lymphedema.[32] Cardiac conditions commonly associated with lymphedema are atrial septal defects and pulmonic stenosis. Other conditions to rule out when evaluating a patient for lymphedema include renal failure, cirrhosis, heart failure, and hypoproteinemia.

Physical Therapy Evaluation

The physical therapist can obtain much information through a subjective assessment.[7] An example of an evaluation form is included in Appendix C. Often a questionnaire is given to the patient, for the purpose of saving time in the clinic. It is important to find out the patient's surgical and/or radiation history (when it occurred and if it was successful). Questions need to be asked about the nature of the swollen limb. Specifically, it is important to know when the swelling began, where it began (distally or proximally), how fast the swelling developed, and if it changes from day to day.

The therapist should ask the patient if he or she has an idea of why the swelling began.[7] Some questions to offer at this time pertain to any history of infections, scratches, burns, or injections in the edematous extremity. Questioning the patient about performing any unusual activities may also be appropriate. This may include lifting something unusually heavy, performing more activity than normal, or traveling by air.

The patient may not have any pain, but if so, the quality of pain must be addressed, as well as any other symptoms, such as a feeling of heaviness or loss of function. Determining whether the patient knows of anything that worsens or improves his or her symptoms is essential.

Underlying conditions need to be identified, such as arthritis, obesity, hypertension, heart problems, or diabetes.[7] These conditions may affect the therapist's approach to treatment. Also, the therapist should question the patient about any previous treatment for the condition, including medications. The patient should discuss their current functional limitations, and what their goals are for treatment.

The objective assessment begins with observation of the patient's edematous limb.[7] The therapist should note the location of the swelling (distal or proximal), the amount of swelling (minimal, moderate, or severe), and the presence of any unusual or asymmetrical skin folds. Any skin changes should be noted, which may include any ulcers or lymphatic cysts. Next, the therapist should palpate the skin. The temperature of the skin in the affected extremity should be approximately the same as the rest of the patient's body. It may, however, be one to two degrees Fahrenheit higher. Specifically for an edematous lower extremity, palpation for the Kaposi-Stemmer sign should occur. An inability to pinch a fold of skin on the dorsal aspect of the second toe is a positive Kaposi-Stemmer sign. To determine whether the edema is pitting edema, pressure should be applied to the edematous limb for approximately ten seconds.[39] If the condition is progressed, pitting will not be evident. The therapist should inspect for the presence of "peau d'orange" at this time, which is a thickening of the skin with enlarged pores, and is caused by blockage of the lymphatics.

Range of motion of all affected joints should be assessed and compared with the unaffected limb.[7] It is very important to obtain accurate girth measurements. Accurate measurements provide a valuable means of comparison as the patient progresses through physical therapy. For the upper extremity, circumferential measurements should be taken 10 and 20 cm above the olecranon, 10 and 20 cm below the olecranon, at the styloids, and at the palm.[7] For the lower extremity, measurements should be taken 10 and 20 cm above the superior border of the patella. They should also be obtained 20, 30, and 35 cm below the superior border of the patella, as well as at the lateral malleolus and the foot (10 cm above the first space).

Another method for obtaining girth measurements is volumetric measures by submersing the limb in water.[40] This method is often more accurate than circumferential measurements. However, as long as the therapist remains consistent with their technique throughout the course of therapy, either technique is suitable. Skin tonometry is also sometimes used to assess the quantity of soft tissue compression. Taking photographs of the affected extremity may be beneficial for documenting the patient's progress as he or she proceeds through treatment.

When determining the goals for a patient with lymphedema, it is important to consider what the patient desires for therapy.[7] It is also imperative that the goals are functional and objective. Possible goals may include increasing range of motion, becoming independent with exercises, becoming compliant with bandaging, and decreasing girth. The ability of the patient to independently manage his or her condition, as well as gaining knowledge of ways to prevent infection or disease are other important goals to include.

CHAPTER IV

TREATMENT FOR LYMPHEDEMA

Over the years, there have been many treatments developed for lymphedema. Some treatments have not been deemed effective at reducing this protein-rich edema. Nevertheless, due to lack of education about lymphedema and the lymphatic system, numerous patients are being treated incorrectly. This chapter outlines a variety of treatment methods and discusses their usefulness. Also discussed in this chapter is methods for prevention of lymphedema and psychosocial issues associated with the condition.

Complex Decongestive Physiotherapy

The concept of complex decongestive physiotherapy (CDP) for treatment of lymphedema was initially developed by Winiwarter at the end of the 19th century.[1] Winiwarter was a professor of surgery, and developed the fundamental steps for this type of treatment. Later, in the 1930s, Vodder refined this concept of treatment.[41] Vodder was a physical therapist from France who focused his lymphedema treatment on using light manipulations to stimulate the lymphatic system, which he termed manual lymph drainage. He then organized the Dr. Vodder Center in Denmark and there are now Vodder schools in Canada, Austria, France, Germany, and Belgium.[19] In the 1980s, Foeldi further developed this treatment in Germany, and named the treatment what it is known today, complex decongestive physiotherapy.[24] At the same time, Casley-Smith

refined Vodder's methods in Australia, and named the treatment complex lymphedema therapy. Also in the 1980s, Lerner brought the concept of complex decongestive physiotherapy to the United States and has trained approximately 600 individuals in this method.[42]

Introduction

Complex decongestive physiotherapy is a conservative method of treatment for lymphedema.[14] The goal of conservative treatment is to permanently recover the equilibrium between the transport capacity of the lymphatic system and the lymphatic protein load. Equilibrium is established once there is normal protein concentration in the interstitial fluid. This goal is attainable in both primary and secondary lymphedemas. By applying techniques that stimulate the flow of lymph fluid, CDP works to control capillary filtration and increase lymph drainage through existing pathways as well as collateral pathways.[20]

The technique of CDP must be performed in a skillful manner in order for the goal of removal of excess proteins to be attained.[14] A therapist performing this technique must have a firm understanding of the pathophysiology of lymphedema, as well as knowledge of the anatomy and physiology of the lymphatic system. The physical therapist must also have extensive training in the technique of CDP.

There are four components of complex decongestive physiotherapy: manual lymph drainage (MLD), bandaging and compression, hygiene and skin care, and remedial exercises.[7] The purpose of MLD is to improve the flow of lymph fluid and to decompress and empty the lymph vessels.[28] Following each treatment of MLD, the affected extremity is bandaged using a specific technique to prevent reaccumulation of

the lymph fluid. Hygiene and skin care is very important in order to prevent any infections, such as cellulitis or lymphangitis.[19] Remedial exercise allows for activation of the muscles in the affected extremity and results in a further increase in the propulsion of lymph fluid.[28] All four components will be discussed in detail throughout this chapter.

Complex decongestive physiotherapy consists of two phases.[1] The first phase is called the intensive phase, and involves MLD, skin care, multi-layered bandaging, and remedial exercises.[30] Generally lasting two to four weeks, the primary objective of this phase is to decongest the affected extremity to normal size.[1] The second phase of CDP, the maintenance and improvement phase, begins immediately following the first phase. Preserving the effects of the intensive phase is the primary goal. It is performed at home and involves the use of MLD applied by the patient as necessary, skin care, remedial exercises, and the use of compression garments.[30] Compression is the main component of the maintenance phase.[7] The duration of treatment with CDP varies with the severity of the edematous condition.[43] Table 2 provides a summary of the span of treatment for each stage of lymphedema.

Manual Lymph Drainage

Manual lymph drainage is the term that describes the manual technique used in CDP.[37] The goal of this technique is to use intact superficial lymphatics to augment and redirect the lymph fluid to regions with functioning lymphatic circulation. Manual lymph drainage also promotes lymph flow into venous circulation, which results in a reduction in the size of the affected extremity.[19] Simply stated, the aim of this technique is to move the excess protein and water to an area with functioning lymphatics for return of the fluid back to the venous system.[1]

Table 2. Duration and components of phase I and II of CDP.

Stages	Duration	Phase I (Intensive)	Phase II (Maintenance and Improvement)
I	2-3 wks.	MLD, multi-layer bandaging, skin care, remedial exercises	MLD as needed, compression garments, skin care, remedial exercises
II	3-4 wks.	MLD, multi-layer bandaging, skin care, remedial exercises	MLD 1-2x/week, compression garments, skin care, remedial exercises; Repeat Phase I 1-2 times
III	4-6 wks.	MLD, multi-layer bandaging, skin care, remedial exercises	MLD 1-2x/week, compression garments, skin care, remedial exercises; Repeat Phase I 3-4 times; May require plastic surgery

Adapted from: Zuther, JE. Treatment of lymphedema with complete decongestive physiotherapy. Available at: http://www.acols.com/cdptreatment.html. Accessed November 1, 1999.

Manual lymph drainage has many functions. First, the technique is capable of enhancing lymph circulation by increasing the volume of lymph transported by the lymph vessels.[44] Also, it increases the contractility of lymph vessels. Movement of fluid through connective tissue is influenced by the application of this technique. Therefore, any fibrotic areas can be broken down. Other benefits of manual lymph drainage include relaxation of the sympathetic nervous system, which helps to decrease stress, enhancement of the immune system, reduction of pain, and removal of metabolic wastes and foreign matter from the tissues.[6]

Indications for the use of manual lymph drainage fall into five general catogories.[6] Table 3 lists each category and various diagnoses that may fall under each category. There are also many conditions in which MLD should not be performed.[45] Table 4 describes general precautions and contraindications for its use.

Table 3. Indications for the use of MLD.

Category	Examples of Diagnoses
Surgical Procedures	Post-mastectomy lymphedema, post-hysterectomy lymphedema, post-amputation, post-vein stripping
Musculoskeletal	Muscle and ligament tears, tendinitis, chronic pain
Ear, Nose, and Throat	Allergies, Meniere's disease, hay fever
Neurological	Tension headaches, carpal tunnel syndrome, multiple sclerosis, reflex sympathetic dystrophy
Dermatology	Acne, leg ulcers, burns
Other	Fibromyalgia, toxic poisoning, chronic fatigue

Adapted from: Lovell VA. What is manual lymph drainage? Available at: http://www.boulderwellness.com/lovell.html. Accessed March 19, 1999.

Table 4. Contraindications and precautions for the use of MLD.

Contraindications	Precautions
Congestive heat failure	Chronic inflammation
Thrombosis within the last six months	Asthma
Acute inflammation (cellulitis, erysipelas, active tuberculosis)	Thyroid dysfunction
Active cancer	Previous history of thrombosis
Superior vena cava obstruction	

Adapted from: Lovell VA. What is manual lymph drainage? Available at: http://www.boulderwellness.com/lovell.html. Accessed March 19, 1999; British Lymphology Society. Guidelines for the use of manual lymphatic drainage. Available at: http://www.netservices.co.uk/bls/blsm0030.html. Accessed March 19, 1999.

The first step in the sequence of MLD is to stimulate normally functioning areas that are free of lymphedema.[14] Treatment is usually first applied over the quadrant of the trunk contralateral to the site of lymphedema. The goal is to stimulate the lymphatics in this area free of lymphedema, and increase their lymphokinetic activity. This will create a "reservoir" for the edema to empty into.[46] Between each trunk quadrant are lymphatic watersheds, or anastomoses, that allow for movement of lymph fluid between quadrants.[5] As the reservoir is created, lymph fluid will begin to move from the ipsilateral trunk quadrant, across the watershed, to the contralateral trunk quadrant.[14] The ipsilateral trunk

quadrant must be treated (or decongested) before lymph fluid will move from the congested extremity to the decongested trunk. After treatment is performed on the trunk, the lymph nodes proximal to the edematous extremity are drained.[7] Once the proximal lymph nodes are drained, treatment on the affected extremity is commenced. There is a specific sequence used to treat the edematous area, using the strokes described below.

There are two basic strokes used in the technique of MLD, both of which serve different purposes and are performed in a specific sequence.[7] The application of these strokes is very gentle.[47] Vodder avoids the term "massage" and describes handling the tissues with a "cat's paw." Too much pressure will damage the sensitive lymphatics.[7] The first stroke is called "call up." Call up causes the anchoring filaments of the lymph capillaries to be pulled. When this occurs, the single layer of endothelial cells separates, allowing for fluid to flow into the capillary. This stroke also provides mild mechanical stimulation to any functioning lymphangions in the edematous area. When the stretch-reactive receptor of the lymphangion is stimulated, the lymphangion will contract and increase the propulsion of lymph. Refer to Chapter II for further review of the mechanisms of anchoring filaments and lymphangions. The second stroke used in MLD is called "reabsorption." Once the lymphatics are stimulated by the call up stroke, the function of the reabsorption stroke is to push the lymph fluid away from the edematous area and into an unaffected area where it can be easily reabsorbed by functioning lymphatics. The lymph fluid is directed toward normally functioning lymph node regions, milking it away from the edematous area.[20]

For treatment of the upper extremity, the arm is divided into four sections: deltoid and shoulder, upper arm, forearm, and hand.[7] As discussed, treatment of the

edematous area occurs only after the trunk quadrants have been stimulated and drained. Treatment of the arm begins by draining the proximal, or axillary, lymph nodes. They are stimulated and drained with a very light stroke ten times. Call up is then performed on the deltoid and shoulder area, stroking five times over this area to stimulate the functioning lymphangions. Then, the axillary lymph nodes are drained again. Each sequence always ends by draining the axillary lymph nodes with ten strokes. Next, the reabsorption stroke is performed five times over the deltoid and shoulder area to push the fluid into the decongested lymph nodes. Call up is then performed once on the deltoid and shoulder area, followed by five to ten strokes to the axillary lymph nodes. The deltoid and shoulder area is now considered decongested.

Treatment then moves to the upper arm area.[7] As the axillary lymph nodes had just been drained, call up is performed once on the decongested deltoid and shoulder area, then five times on the upper arm area to stimulate the lymphangions in this area. Working the treatment back to the proximal lymph nodes, call up is performed once on the deltoid and shoulder area, then the axillary lymph nodes are stroked ten times. Working back to the edematous upper arm area, call up is performed five times on the decongested deltoid and shoulder area, then reabsorption is performed five times on the upper arm. Working proximally again, call up is performed once on both the upper arm and deltoid areas, ending this sequence by stimulating the axillary lymph nodes ten times. The upper arm area is now considered decongested.

The focus of treatment moves further distally to the edematous forearm.[7] As the proximal axillary lymph nodes had just been stimulated, call up is performed once on both the deltoid and the upper arm areas. When the elbow is reached, stimulation of the

lymph nodes in this area occurs ten times. Call up is then performed on the forearm five times, followed by stimulation of the lymph nodes at the elbow five times, and call up once on both the upper arm and deltoid areas. As always, the axillary lymph nodes are stimulated five to ten times. One call up stroke is performed on both the deltoid and shoulder area and upper arm, followed by stimulation of the lymph nodes at the elbow. Next, the reabsorption stroke is performed five times on the forearm. The lymphatics of the forearm are most prevalent on the ventral aspect, so reabsorption should be centered over this area. Reabsorption of the forearm is followed by one call up stroke, then stimulation of the elbow lymph nodes five times, then call up once at both the upper arm and deltoid areas. The sequence ends with stimulation of the axillary lymph nodes. The forearm is now considered decongested.

The focus of treatment is now on the hand.[7] Treatment progress distally as described for treatment of the forearm, only moving one section further to the hand. Lymphatics of the hand are most prevalent on the dorsal aspect, while lymphatics in the fingers are located laterally. With this in mind, strokes should be modified to concentrate on these areas.

For treatment of the lower extremity, the limb is again divided into sections: upper thigh, lower thigh, lower leg, and foot.[7] Treatment of the lower extremity begins when the trunk quadrants have been stimulated and drained. The sequence of manual lymph drainage is the same as that for the upper extremity. A step by step description of MLD sequencing is also located in Appendix D.

To summarize the sequencing for manual lymph drainage, proximal segments are always drained before distal segments are attended to.[7] Frequent emptying of the

proximal segments will occur throughout the treatment session. Each segment must be cleared before progressing to the next distal segment. Once the most distal edematous area is decongested (the hand or foot), MLD is concluded. The extremity is then bandaged using multi-layer bandaging. During the intensive phase of CDP, manual lymph drainage may be performed twice a day, with each session taking up to one hour to complete.[43]

Hygiene and Skin Care

Patients with lymphedema have an altered immune response.[48] Because of this, they are more susceptible to certain infections and skin conditions, such as dry skin, contact dermatitis, and hyperkeratosis. Due to the stagnant protein-rich fluid in the interstitial space, a medium for various bacteria is created. Hence, the first goal of skin care is to reduce the risk of infection. Hydrating the epidermis and dermis in order to keep the skin soft and intact is the second goal of skin care.

Patients with lymphedema must be educated on the signs of infection, which include swelling, redness, and increased temperature locally, as well as systemic fever and general malaise.[49] Another sign of infection is the presence of red streaks on the affected extremity. If a patient suspects infection, he or she is to seek medical care immediately.

Each day, a patient with lymphedema must inspect their skin.[48] The best time for this skin check is just before bathing. It is important for the patient to pay special attention to areas of skin folds, and also areas of reduced sensation. Any skin opening, such as an insect bite, hangnail, ingrown toenail, or abrasion, are potential sites for infection. If any compromise in skin integrity is found, the patient must clean the area

thoroughly. An over-the-counter antibacterial cream or antiseptic can be used. Keeping the compromised area covered is very important to prevent infection. Many mild skin conditions can be easily treated by the patient without referring to a dermatologist.[45] There are, however, certain problems that must be treated by a dermatologist, including febrile cellulitis, eczema, and fungus.

To elude infection, the affected extremity must be kept very clean.[7] It is recommended that the patient wash the extremity twice a day using mild soap. Antibacterial soap should be avoided as it often leaves the skin too dry. Following gentle bathing, the extremity must be thoroughly dried, paying special attention to drying between the fingers or toes, as well as any other creases that may be present. It is not recommended to use powder, as this may accumulate in skin folds. Also, if the upper extremity is affected, deodorant should not be used, as the active ingredients may further irritate the skin. A moisturizer should be applied twice daily. Time should be allowed after applying a moisturizer before a patient's bandage or compression stocking is applied.[48] If the bandage is applied too soon, the lotion may soak into the bandage and impair its effectiveness as well as limit the amount of absorption by the dry cells. Moisturizers should be lanolin-based and have a low pH. If a patient is using a product for the first time, it is advised that he or she use a small amount on the unaffected extremity to test if an allergic reaction may occur.[7]

Multi-layer Bandaging and Compression Garments

Multi-layer bandaging is applied following each session of MLD.[19] The purpose of this type of bandage is to maintain the effects of the manual lymph drainage. The bandages compensate for decreased tissue pressure, and keep the affected extremity from

filling with lymph fluid. Multi-layer bandages also improve the effectiveness of the muscle, and break up fibrosed tissue. During the intensive phase, the bandages are worn overnight and stay in place until the next treatment session.

There are many goals for the use of multi-layer bandaging.[50] One goal is to protect the skin and bony prominences from harm, while allowing for movement of muscles and joints. Although the bandage is semi-rigid, it must allow for mobility.[7] The bandage should permit squatting if applied to the lower extremity, and reaching if applied to the upper extremity. The patient should have enough mobility to perform activities of daily living. A final goal is to apply the bandage so that the patient can remain comfortable.

Multi-layer bandaging is applied in three layers.[7] The first layer is simply a cotton stockinette which is applied to protect the skin. See Figure 9. A foam bandage makes up the second layer, and it is applied to provide an even distribution of the pressure caused by the third layer. See Figures 10 and 11. A short-stretch, or minimally elastic bandage, is applied over the foam layer. See Figures 12 and 13. Multi-layer bandaging is actually more similar to a cast than it is to an elastic bandage. It allows for an increase in pressure when a muscle contracts, but relatively low pressure when the patient is at rest.[20]

Once the affected extremity is normal or near-normal size, the patient is fitted with a compression garment.[1] This garment must be custom-made and follow the contour of the edema in order for it to be effective.[7] The purpose of the compression garment is to keep the tissue pressure permanently high. It increases reabsorption and decreases filtration. A compression garment is used in the maintenance phase to preserve

Figure 9. First layer of multi-layer bandaging for the upper extremity.

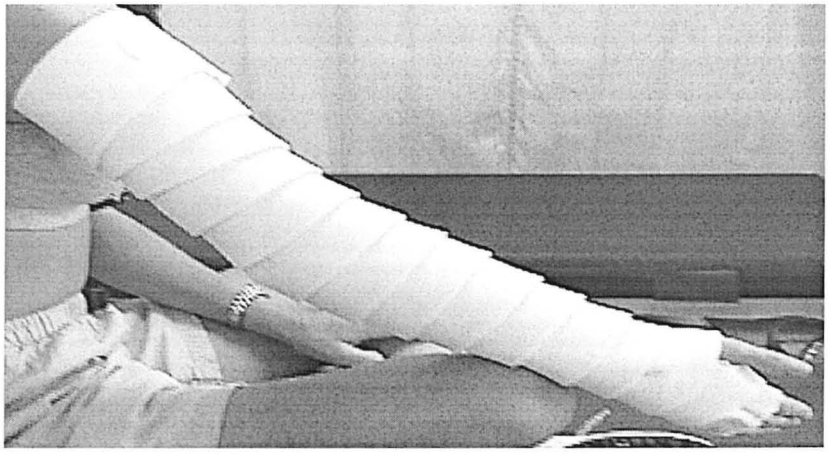


Figure 10. Foam bandage layer of multi-layer bandaging for the upper extremity.

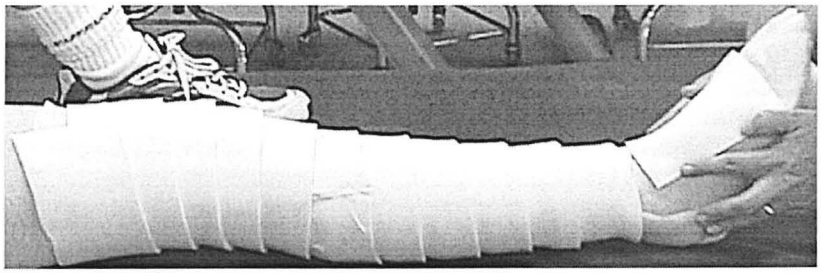


Figure 11. Foam bandage of multi-layer bandaging for the lower extremity.

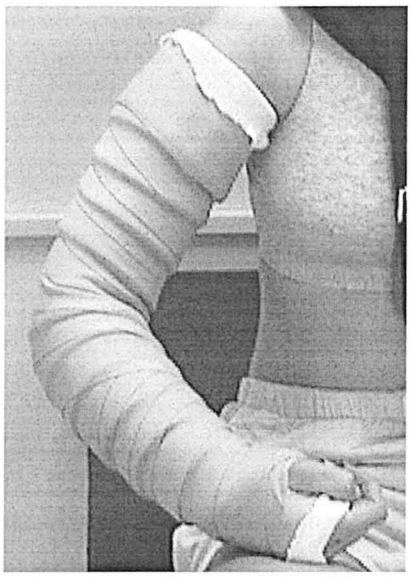


Figure 12. Short-stretch bandage of multi-layer bandaging for the upper extremity.

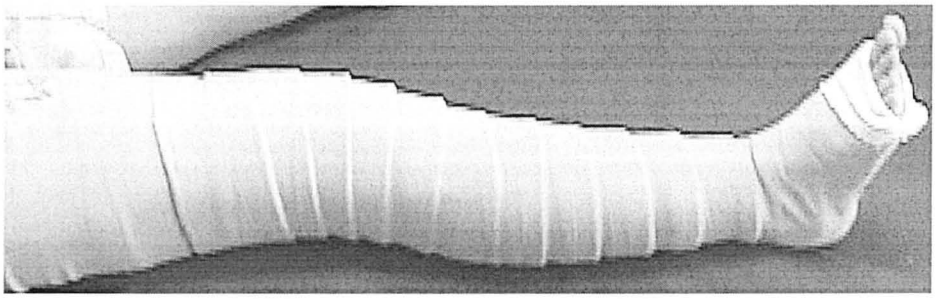


Figure 13. Short-stretch bandage of multi-layer bandaging for the lower extremity.

the results gained during the intensive phase. It must be worn during the daytime to be effective, although the patient is allowed to wear bandages with mild compression at night.[1] Parameters for the amount of compression used varies.[51] Usually, the pressure will range from 30-60 mmHg.

Bandages and compression garments will last long only if properly cared for.[52] They should be washed regularly, using mild detergents in luke warm water. Bleach and fabric softeners should be avoided. It is recommended that the patient own two sets of

bandages and compression garments so one set may be laundered while the other is being worn.[20] When drying, it is important to allow them to air dry, with avoidance of sunlight and any other sources of heat.[52] The bandage or garment should be folded in half if it will be hung, as this will decrease the chance of stretching.

Remedial Exercises

The remedial exercise program is beneficial to the patient in many ways. First, exercise can help to mobilize joints and swollen or fibrous areas.[53] As the patient progresses with the exercises, muscle wasting can be avoided, and the affected extremity can begin to be strengthened. Finally, a patient's sense of well-being can be enhanced as he or she performs a daily routine of exercise. A consequence to sedentary living and a lack of exercise is further progression of the lymphedema and a further loss of limb mobility.

Remedial exercises must be performed while the patient is wearing a bandage or compression garment.[7] It has been found that exercise will not encourage protein reabsorption or drainage of lymphedema when the bandage is not in place. With the bandage in place the muscles have something to contract against, which helps the propulsion of lymph fluid, as well as increases muscle tone.[28] In other words, with the bandage in place, lymphokinetic effects of the muscles can occur.[14]

An important component of each exercise program is abdominal breathing.[53] This is vital in that it will help to increase the efficiency of the thoracic duct and increase lymphangion activity. Breathing exercises are often performed before and after each session.[50] Usually, the exercises begin proximally and work distally, much the same as the sequence of manual lymph drainage.[46] Trunk exercises are often performed first to

stimulate the lymphatics in that area. Next, exercises are performed using the affected extremity. The entire program may take fifteen to thirty minutes to complete, and should be performed once or twice daily.

There are many factors a patient must consider as he or she begins an exercise program.[50] The first consideration is to always wear a bandage or compression garment while exercising. Also, restrictive clothing, such as tight undergarments, must be avoided while exercising. Exercises must be performed in a slow and gentle manner. Complete relaxation of the muscle should occur before proceeding on to the next exercise. The amount of time the patient contracts the muscle should equal the amount of time spent relaxing. Any movements that cause pain or are strenuous should be avoided.

Patients who have upper extremity lymphedema may perform the exercises in a sitting or lying position, while patients with lower extremity lymphedema benefit most by performing exercises on the floor.[50] After each session, the patient should elevate the affected extremity for fifteen to twenty minutes.

Examples of an upper and lower extremity exercise regime are located in Appendix E. It is to be noted that many exercise programs are available to each patient, and those included in this paper are simply examples. Again, it is important to keep in mind that each patient's exercise program will vary according to their needs and abilities, and it is the duty of the physical therapist to asses these needs. Things to consider when designing an exercise program are the patient's age, compliance, and prior level of physical activity.

Various exercises can be performed using a soft ball.[50] Some exercises with the ball include hand squeezes, elbow squeezes, axillary squeezes, and finger rolls. Soft ball

exercises can also be performed for the lower extremity, using a larger ball. The ball can be used for isometric contractions between the knees, behind the knee, or beneath the foot.

Stick or wand exercises are also beneficial.[50] Hand walking is an exercise with the wand in which the patient holds the wand vertically between the thighs, and alternates grasps up and down the wand. Other motions to perform with the wand include a paddling motion, swaying from one side to the other, and attempting to stretch the wand, which elicits an isometric contraction.

Walking is an excellent exercise for a patient with lower extremity lymphedema.[7] It is recommended that the patient use a normal gait pattern when walking, avoiding limping or dragging the affected extremity. Any abnormal gait pattern may result in muscle strain. The patient must not over-exert himself or herself when walking. If the patient is sore after walking, they have walked too strenuously.

Summary of Complex Decongestive Physiotherapy

Assessments must be made daily in order to determine whether the patient is benefiting from the current treatment.[45] Success of treatment is determined by considering various objective factors. Some factors to observe include improvements in skin condition, reduction in circumference of the extremity, and softening of the edema. Also, it is important to know the patient's assessment of his or her condition. Other factors to consider are extremity mobility, pain, and function. If adequate improvement is not being made, the treatment program must be altered.

There are various physical limitations to the treatment of lymphedema with CDP.[52] They include obesity, age, excessive pain, hypertension, arthritis, asthma, and

cardiovascular weakness. Any of these factors can limit the success of treatment. Some general contraindications to the use of CDP include cardiac edema, deep vein thrombosis, acute bronchitis, malignancy, and acute infections.

The success of CDP is dependent on many factors.[7] One crucial constituent is the stage of lymphedema the patient is in when treatment begins. If treatment begins when the patient is in the initial stage of lymphedema, the edema first has to be removed, then prevention of any reaccumulation must occur. When treatment begins in the second or third stage of lymphedema, the edema must be removed, however, any fibrosed tissue must also be removed. This leads to more lengthy treatment sessions, and the ability to completely reverse the signs and symptoms of lymphedema in the second and third stage is questionable. In fact, Foldi[54] reports that any treatment begun in the second or third stage of lymphedema will reduce, but not eliminate swelling. He goes on to demonstrate that the goal of therapy in these later stages is to reduce the edema gradually with time (two to three years).

Intermittent Pneumatic Compression

Intermittent pneumatic compression (IPC) has been widely used for the treatment of lymphedema.[20] The device used consists of an inflatable boot or sleeve which is connected to a motor-driven pump. Single or multiple chamber pumps have been used for the treatment of lymphedema.[37] Some sources have found that sequential pumps may be more effective for treatment of a lymphedematous limb, however this is still debatable.

Intermittent pneumatic compression has been used as the primary form of treatment for some patients with lymphedema and has also been used in conjunction with

other forms of treatment, such as CDP.[37] Intermittent pneumatic compression acts by "milking" the lymphedematous fluid in a distal to proximal fashion.[55] The pumping action allows for softening of the affected limb as the tissue fibrosis is disrupted.[20] Intermittent pneumatic compression drains interstitial tissues of fluid, but it does not allow for protein reabsorption by the lymphatic system.[7] In this way, IPC works as a diuretic acts.

The pressure gradient of the IPC unit will vary for each patient, however, lower pressures (approximately 40 mmHg) have been found to be effective and will have a lower chance of damaging the delicate lymphatics.[37] In fact, a pressure greater than 40 mmHg may cause the lymphatics to collapse.[56]

Intermittent pneumatic compression has often been used in conjunction with MLD.[39] It has been found that IPC is more effective when MLD is first used to stimulate the lymphatics and open up the lymph channels. The pumping action of the IPC can then be used to direct the fluid into the lymphatic system. Because IPC itself does not affect the resorption of proteins, Leduc et al[56] recommend that it never be used alone, but always in conjunction with MLD. Nevertheless, IPC is still being used as a primary form of treatment for lymphedema in some physical therapy facilities.

There are various complications that may result if intermittent pneumatic compression is used improperly.[37] First, too much pressure has the potential for damaging the lymphatics. Also, as IPC does not allow for protein reabsorption, the residual proteins may induce a secondary inflammation and increase the chance for formation of fibrous tissue. When used alone, a fibrous ring or band may form at the proximal end of the inflatable sleeve, which can further obstruct or constrict lymph flow.

Other complications reported with improper use of IPC include peroneal nerve palsy and aggravated lymphangitis. Intermittent pneumatic compression should never be used with a patient with a cardiac condition or an insufficient arterial system.

A study was performed by Johansson et al[57] to compare MLD and IPC and their ability to decrease post-operative arm lymphedema. The study found that both types of treatment significantly reduced arm lymphedema. The researchers also found that there was no significant difference between the two treatment methods in their ability to decrease the arm lymphedema.

The Lerner Lymphedema Services Academy of Lymphatic Studies is strongly opposed to the use of IPC for treatment of lymphedema.[58] The Academy's arguments are summarized in Table 5.

Table 5. Explanation of opposition to the use of IPC for lymphedema by the Lerner Lymphedema Services Academy.

1. Evacuation from the ipsilateral body quadrant, which is also congested, does not occur with IPC use.
2. Swelling of the external genitalia may occur when using IPC for an edematous lower extremity.
3. Due to the presence of scar and fibrous tissue in stages II and III, IPC has no value.
4. IPC may traumatize the limb in a similar manner as blood pressure cuffs, impeding on still functioning lymphatics.
5. The limb will fill with fluid after treatment with IPC, unless wrapped.
6. Over time, lymphedema has been found to worsen in patients who have been treated with IPC.

Pharmacologic and Surgical Treatment

There are various pharmacologic and surgical treatments that have been used to attempt to treat lymphedema.[16] Pharmacologic management is often used in conjunction

with conservative management, such as CDP. Surgical management occurs only after conservative management has failed.

Three types of pharmacologic management include the use of diuretics, antibiotics, and benzopyrones.[30] The use of diuretics is now discouraged for patients with lymphedema. Diuretics work by drawing off water from the edematous area.[21] However, the protein molecules remain in the tissue spaces, and continue to draw water into the edematous area. Diuretics are sometimes useful for low-protein edemas, however they usually make high-protein edemas, such as lymphedema, worse.

Antibiotics are often used for patients who are in the progressed stages of lymphedema.[16] They can be used to prevent conditions such as lymphangitis, cellulitis, and folliculitis. A common complication of lymphedema is a fungal infection, which is readily treated with antibiotics.[30]

Benzopyrones are not a substitute for CDP, but do have a moderate therapeutic effect.[14] Two drugs in the benzopyrone group include coumarin and flavonoid.[59] Benzopyrones work by increasing the number of macrophages in the edematous area, and stimulating their proteolytic activity, resulting in phagocytosis of the excess protein. Other functions of this drug include increasing the pumping capacity of the lymphatics, and reducing both capillary resistance and hyperpermeability. As a result, there is a reduction in the amount of protein lost from blood vessels.

Benzopyrones have the ability to decrease all high-protein edemas.[59] This includes lymphedema and elephantiasis. This group of drugs reduces the edema more slowly than CDP, however it does have the capacity to decrease both acute and chronic lymphedema. The amount of edema this drug is able to reduce in five years is similar to

the amount of edema reduction that can be accomplished in four weeks of CDP. Benefits of this drug include decreased limb circumference, increased limb mobility, and reduced fibrosis.[16] There are few side effects associated with benzopyrones, which include mild nausea and diarrhea. This drug is not yet approved by the Food and Drug Administration in the United States. Countries that are presently using benzopyrones include Australia, Japan, India, China, and parts of Europe.[2]

Surgical procedures are often inferior to CDP, and are rarely performed.[30] In fact, most are not successful and produce unsatisfactory results.[33] Indications for surgery include: excessive size or weight of the affected limb, cosmetic issues, extreme pain or fatigue, recurrent cellulitis, and lymphangiosarcoma. There are two categories of surgical management for lymphedema: physiological management and excisional management. Physiological management for lymphedema includes any surgical procedure that attempts to restore the lymphatic flow by directing lymph fluid into areas deeper in the body.[33] Excisional management includes any surgical procedure to remove diseased tissue. It encompasses any procedure used to debulk or remove any skin or subcutaneous tissue.[16] Discussion of the specific surgical techniques is beyond the scope of this paper. However, it is important to realize that surgical procedures do exist as an alternative method for treatment of lymphedema.

Prevention of Lymphedema

As the onset of lymphedema can occur suddenly or insidiously, and anytime following damage to the lymphatics, it is important that a patient is educated on prevention of its occurrence. Many times lymphedema can be entirely prevented.[15] The National Lymphatic Network has developed eighteen steps to prevention of lymphedema

for both the upper and lower extremities.[24] These steps help to educate a patient about activities that can increase lymphatic load either directly or indirectly, and activities that can decrease the already compromised transport capacity. Appendix F provides the National Lymphedema Network's eighteen steps to prevention of lymphedema in the upper and lower extremities. A recommendation for the clinician is to provide each at-risk patient with this valuable list in order to enhance his or her awareness of the condition and ways to prevent it.

Without hesitation, a person should consult his or her physician immediately if he or she notices any change in the size of their fingers, hand, arm, neck, or chest wall for the upper extremity.[60] For the lower extremity, any change is size of the genitals, abdomen, toes, foot or leg should be reported.[61] Often times a person may not be aware of the factor that triggers lymphedema to begin, so any increase in swelling in the area must not be ignored. The physician is also to be notified if there is any appearance of redness or warmth.[62] Any inflammation or redness can be the sign of infection, which could trigger the onset of lymphedema.[60]

Psychosocial Issues

The focus of this literature review thus far has been on the physical treatment of a patient with lymphedema. While this is the primary task of the clinician, it is also important to look at each patient as a whole being, not just a disease. The condition of lymphedema may result in psychological or emotional disturbance in the individual affected. It is important to take these factors into consideration when treating each patient. Often times, when a patient may be struggling with therapy, the underlying cause may be an emotional issue. It is the duty of the clinician to recognize any

underlying issues the patient may have, and take appropriate and professional measures to assist the patient in resolving these issues.

One solution to resolving the mental stress associated with lymphedema may be to incorporate relaxation exercises into the patient's plan of care. There are several techniques that can be taught to the patient to achieve relaxation. If the therapist is utilizing CDP, the patient is already experiencing two forms of relaxation. The first is achieved through manual lymph drainage. This technique is very gentle and comfortable, and should allow the patient to relax easily. Also, the patient will be performing remedial exercises. Alternating contraction of a muscle, followed by gradual relaxation, is an excellent way to reduce stress. Other techniques include deep breathing, autogenic training, yoga, transcendental meditation, and Benson's relaxation response.[63] Autogenic training uses three aspects to achieve a state of relaxation: rhythm (deep breathing), sensation (warmth and relaxation), and imagery. Imagery involves mentally visualizing a favorite place or time. Yoga involves slow stretching and bending activities, without causing any strain or discomfort. If a patient opts to begin yoga, it is very important to remind them only to perform activities through a comfortable range of motion, or else it may cause more harm than good. Transcendental meditation involves concentrating on a specific word, and silently repeating the word to still the mind. Benson's relaxation response is a technique involving four components: a repeated word, quiet environment, passive attitude, and low muscle tone with a comfortable position. It is important to realize that the above techniques are simply examples, and the patient should be allowed to experiment with a few techniques in order to determine what is ideal for them.

CHAPTER V

CONCLUSION

The condition of lymphedema, if left untreated, can result in multiple physical impairments. The edematous limb may grow to a very large size and result in a decrease in function of the extremity. Activities that were once very effortless may require extra exertion, or may not be achievable at all. A person with untreated lymphedema may be faced with the inability to perform activities of daily living, such as grooming or cooking. Other activities, that were once used to relieve stress, may actually place a burden on the person both physically and mentally. Some individuals may be forced to leave a job, which could result in financial predicaments.

The purpose of this literature review was to provide physical therapists with an awareness of appropriate clinical techniques for the treatment of lymphedema. In order to gain a firm understanding of how the clinical techniques work, the anatomy and physiology of the lymphatic system was discussed, as well as the pathophysiology of lymphedema. With basic knowledge of the lymphatic system and lymphedema, various methods for treatment of lymphedema were then examined. Specifically, complex decongestive physiotherapy was discussed. Other forms of treatment, including the use of intermittent pneumatic compression, as well as pharmocolgical and surgical treatments, were also discussed. Finally, methods for prevention of lymphedema and psychosocial issues associated with this disease were examined.

The treatment of lymphedema is something of utmost importance in order for the individual to lead a physically and mentally healthy life. It is the duty of the physical therapist to take an active role in assisting this population of patients to returning to their ideal lifestyle. With appropriate training in this area, along with developing a respect for treating each patient as a whole being, a greater number of individuals with lymphedema can be successfully treated. As successful treatment prevails, so will the quality of life of each individual.

APPENDIX A

GLOSSARY

Anchoring filaments: Structures attached to the endothelial cells of lymph capillaries. Augment opening of the endothelial cells for entrance of fluid into the capillary.

Benzopyrones: A drug used in the treatment of lymphedema. Benzopyrones work by increasing the number of macrophages in the edematous area, and stimulating their proteolytic activity, resulting in phagocytosis of the excess protein.

Chyle: Lymph that is drained from the intestine. Contains digested fats, resulting in a milky white color.

Complex decongestive physiotherapy (CDP): A conservative method for treatment of lymphedema. Goal is to permanently recover the equilibrium between the transport capacity of the lymphatic system and the lymphatic obligatory load. Contains four components: manual lymph drainage, skin care, multi-layer bandaging, and remedial exercise.

Congenital lymphedema: Primary lymphedema that is present at birth.

Cysterna chyli: An enlarged sac that collects fluid from the lower extremities and lumbar trunks. Marks the beginning of the thoracic duct.

Dynamic insufficiency: A type of lymph vascular insufficiency that occurs when lymph obligatory load exceeds transport capacity. The lymph vessels are still intace and physiologically normal.

Hydrostatic (capillary) pressure: The pressure that pushes fluid out of the capillary and into the interstitium.

Kaposi-Stemmer sign: A positive sign is indicated by the inability to pinch a fold of skin on the dorsal aspect of the second toe. Procedure used to differentiate between lymphedema and lipedema. With lipedema, the foot is not involved, hence the Kapost-Stemmer sign would be negative.

Lacteals: Lymph capillaries originating in the small intestine.

Lipedema: A condition occurring only in women, which is marked by an abnormal fat metabolism. The foot is unaffected.

Lymph: A clear, watery fluid that is formed once the lymph capillaries intake the required interstitial fluid.

Lymph capillaries: The smallest of the lymphatic system vessels, found almost everywhere blood capillaries are located. Also known as initial lymphatics.
Lymph formation: The process whereby the lymph capillaries intake interstitial fluid.

Lymph nodes: An organ of lymphoid tissue that lies in intervals along the pathway of the lymphatic system. Lymphatic vessels enter and exit through lymph nodes. Contains lymphocytes and macrophages for filtering lymph of harmful substances.

Lymph obligatory load (LOL): Any water or plasma that has not been resorbed by the venous system, along with waste materials such as bacteria, dusts, proteins, dyes, and dead or mutant cells. The lymphatic system is responsible for draining the interstitial tissues of LOL.

Lymphangion: The functional unit of the lymphatic vessel. Innervated by the autonomic nervous system. Contains a stretch-reactive receptor, and, when stimulated, causes a segmental contraction, enhancing the flow of lymph.

Lymphatic dysplasia: An insufficiently developed lymphatic system. Can be aplasia, hypoplasia, or hyperplasia.

Lymphatics: The vessels into which precollectors drain. Contain valves and lymphangions. Also called lymph veins or lymphatic collecting vessels.

Lymphatic system: A one-way system of vessels and lymph nodes designed to accumulate interstitial fluid that has leaked from the blood vascular system, cleanse the fluid, and return it to the blood.

Lymphatic trunks: Large vessels into which lymphatics drain. Examples include the lumbar, bronchomediastinal, subclavian, jugular, and intestinal trunks.

Lymphedema precox: Primary lymphedema arising around the adolescent age.

Lymphedema tardum: Primary lymphedema manifesting after the age of 35.

Lymphography: A procedure used by a physician in order to visualize the anatomy of the lymphatic system.

Lymphokinetic actions: Activities that cause lymph to flow through the lymphatic system and into the venous circulation.

Lymphoscintigraphy: A procedure used by a physician in order to evaluate both the anatomy of lymph vessels and nodes, as well as examine the rate of lymph flow.

Manual lymph drainage (MLD): The manual technique of complex decongestive physiotherapy. Goal is to improve the flow of lymph fluid and to decompress and empty the lymph vessels.

Mechanical insufficiency: A type of lymph vascular insufficiency that is caused by a decrease in the transport capacity of the lymphatic system. Results in lymphedema.

Milroy's disease: A form of congenital lymphedema where the lymph capillaries appear to be absent.

Oncotic pressure: The pressure due to proteins that pulls fluid into the capillary.

Osmotic pressure: The pressure due to proteins that pulls fluid into the tissues.

Precollectors: The vessels into which lymph capillaries drain. Contain valves and are situated more deeply than lymph capillaries.

Primary lymphedema: A form of lymphedema the results from lymphatic dysplasia. Can arise later in life, or be present at birth.

Right lymphatic duct: One of two structures into which lymphatic trunks drain. Receives all the lymph from the right upper quadrant of the body.

Secondary lymphedema: A type of lymphedema occurring as a result of a surgical procedure, radiation therapy, infection, trauma, burning, or scarring. Also called acquired lymphedema.

Thoracic duct: One of two structures into which lymphatic trunks drain. Receives lymph from the entire body, except for the right upper quadrant.

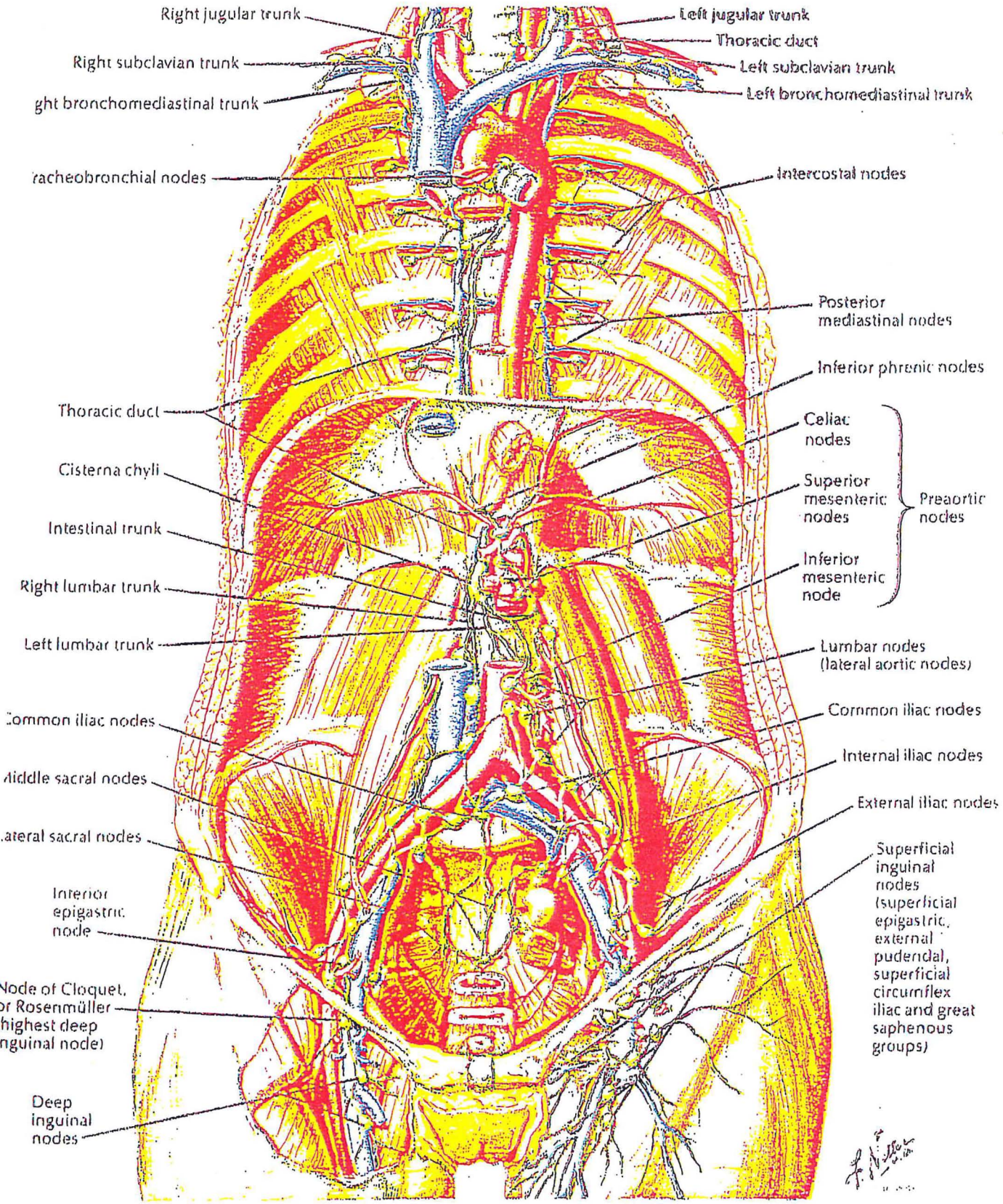
Tissue pressure: The pressure in the interstitium, pushing into the capillary.

Transport capacity: The greatest amount of lymph flow in a given time.

APPENDIX B

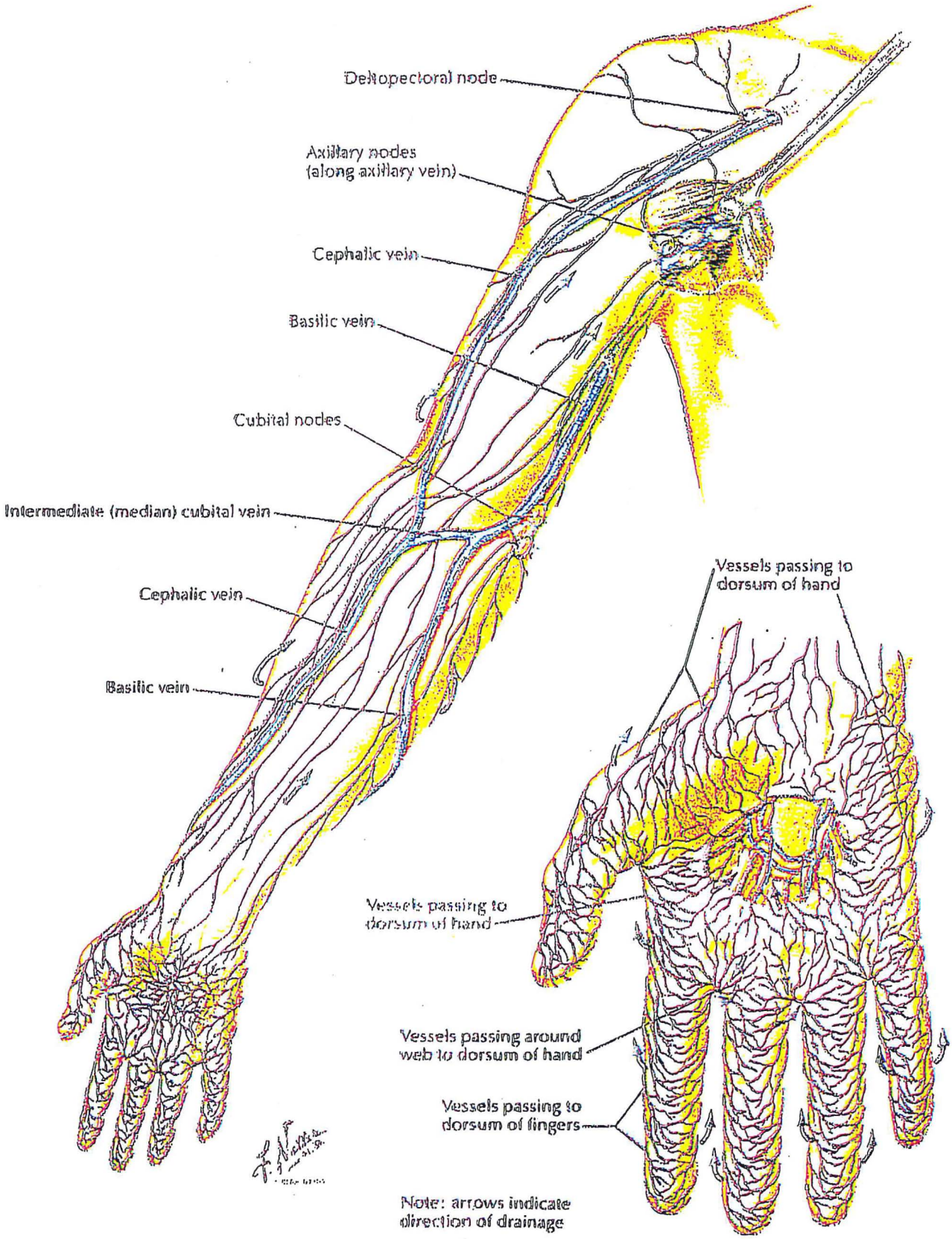
Lymph Vessels and Nodes of Posterior Abdominal Wall

SEE ALSO PLATE 382



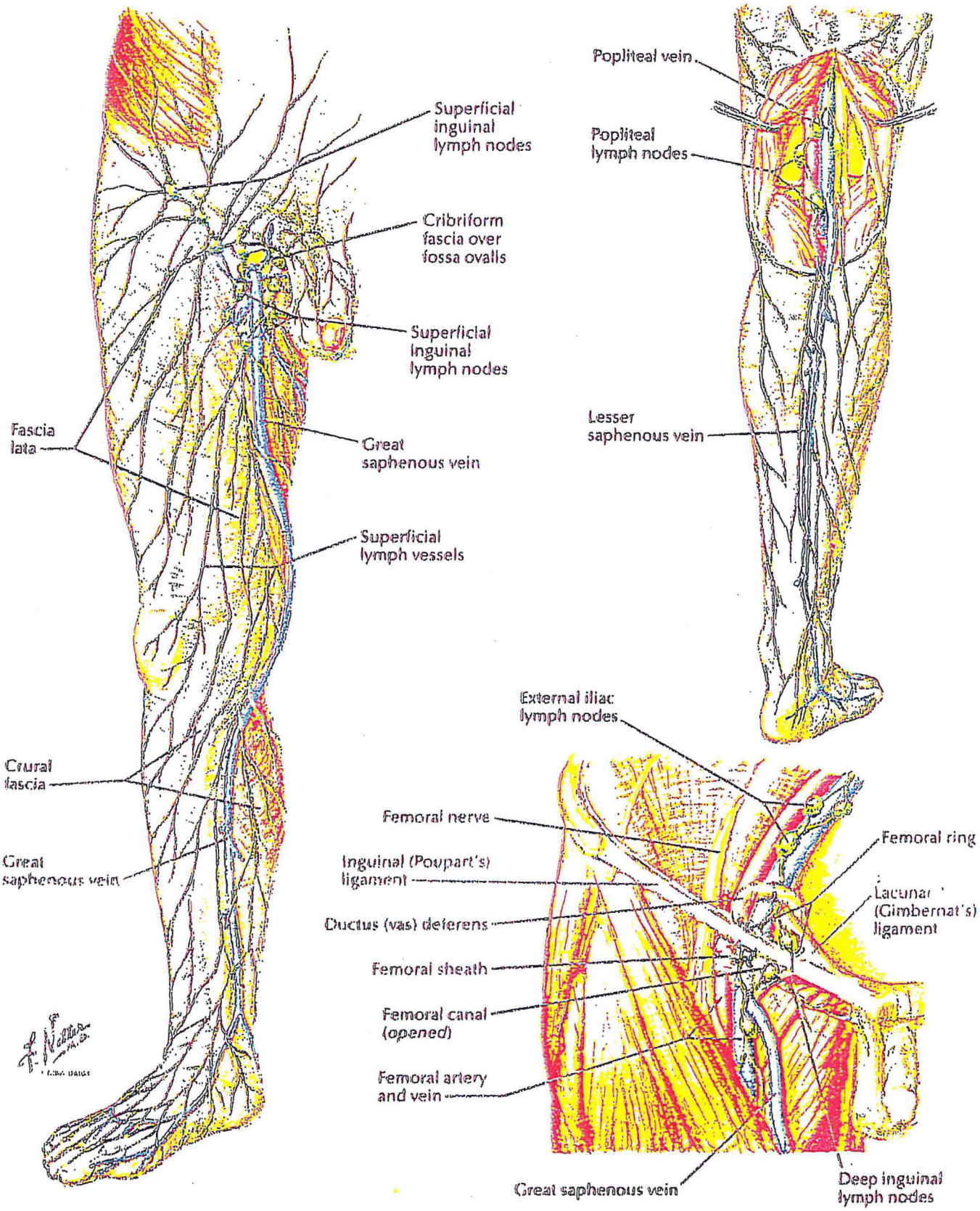
Lymph Vessels and Nodes of Upper Limb

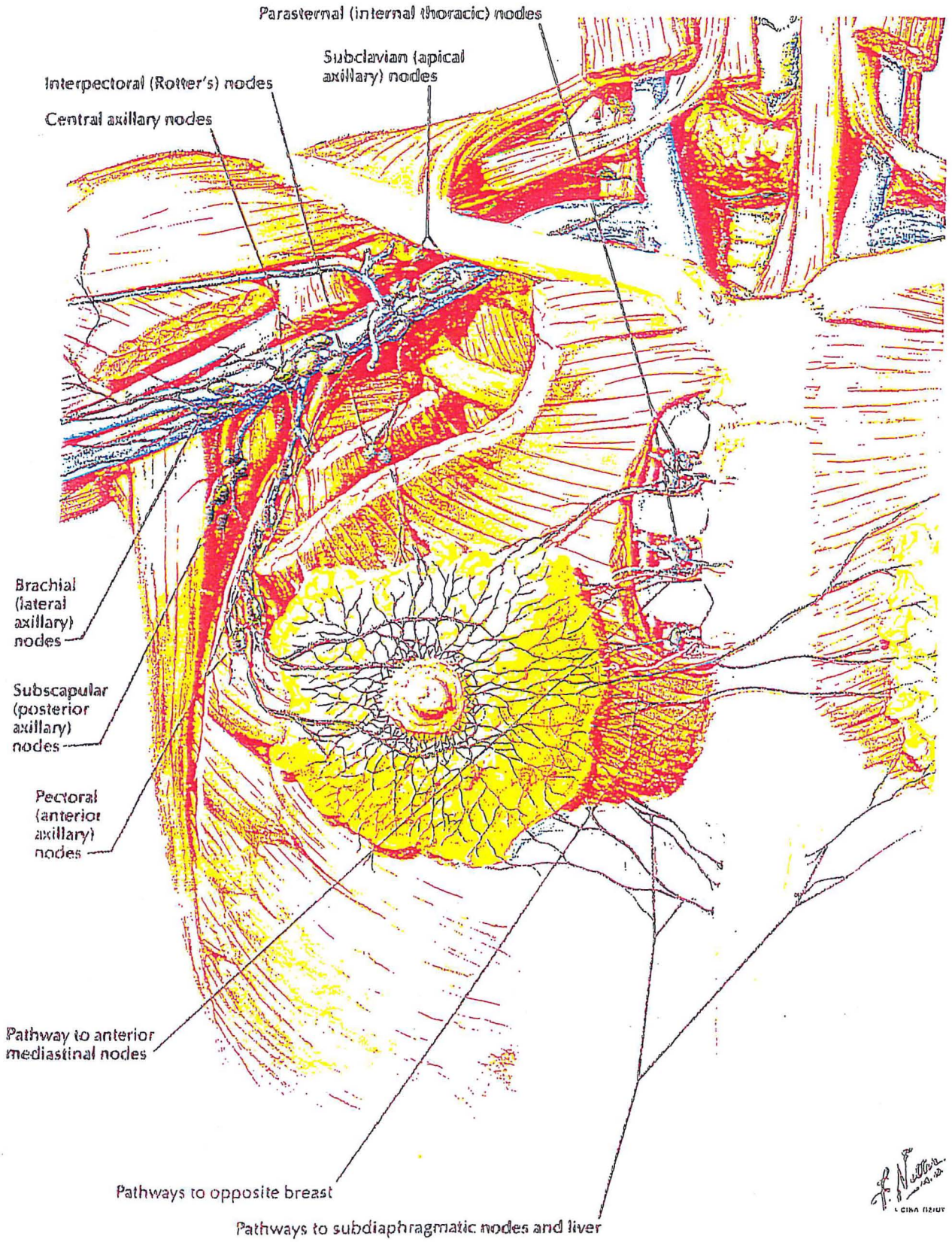
SEE ALSO PLATES 169, 441



Lymph Vessels and Nodes of Lower Limb

SEE ALSO PLATES 382, 383





Lymph Vessels and Nodes of Pelvis and Genitalia: Female

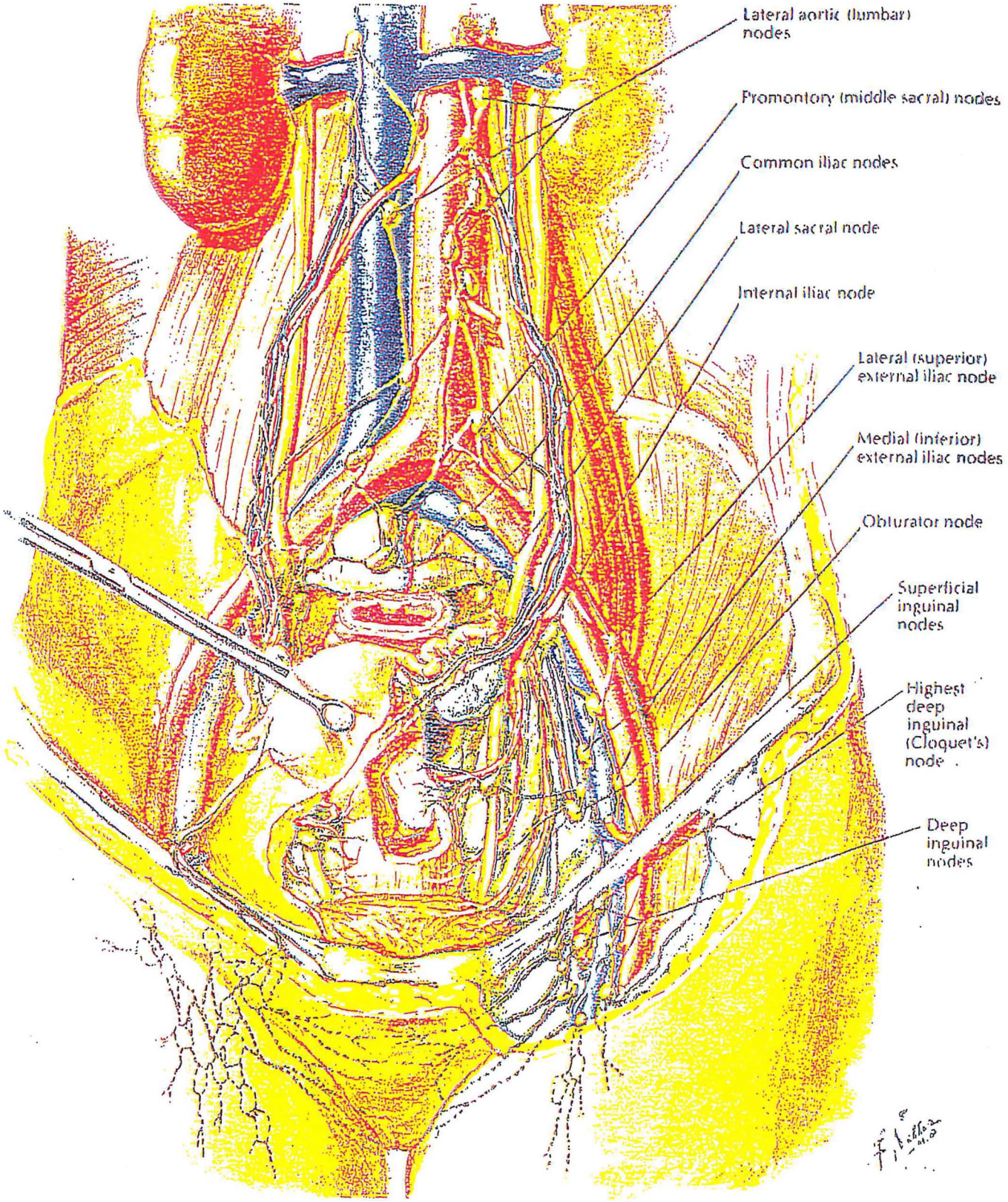


PLATE 381

PELVIS AND PERINEUM

APPENDIX C

Physical Therapy Lymphedema Evaluation

Patient name: _____ Date of Birth: ___/___/___

Date: ___/___/___ Physician: _____

Involvement (circle): (R) Upper Extremity (L) Upper Extremity
(R) Lower Extremity (L) Lower Extremity

Subjective

- Surgical hx: _____
  _____
- Radiation/Chemotherapy hx: _____
  _____
- Dominant Hand (circle): Right Left Smoker?: Yes No
- Pain Characteristics: _____
- History of Infections: _____
- Onset of Swelling (when & where it began, etc): _____
  _____
- Edema Characteristics (fluctuation in swelling, etc): _____
  _____
- Other related symptoms (heaviness, loss of function, etc): _____
  _____
- Underlying Conditions (circle): Arthritis Obesity Hypertension Diabetes
  Heart Problems Neck/Back Pain Other_____
- Previous Treatment for Lymphedema: _____
  _____
- Medications: _____
- Current Functional Limitations: _____
  _____
- Occupation/Hobbies: _____
- Patient's Goals for Treatment: _____
  _____

Objective

Observation of Swelling

- Location: _____
- Amount (circle): Minimal Moderate Severe
- Presence of Skin Folds: Yes No If yes, location: _____

Other Observations

- Skin Changes: _____
- Hair Growth: _____

Palpation

- Skin Temperature (circle): Normal Increase Decrease
- Pitting Edema? Yes No
- For Lower Extremity, Kaposi-Stemmer Sign: Positive Negative

Range of Motion

- Affected Limb: _____
- Unaffected Limb: _____

Girth Measurements

Upper Limb Involvement	Affected Limb	Unaffected Limb	Difference
20 cm above olecranon			
10 cm above olecranon			
10 cm below olecranon			
20 cm below olecranon			
Styloids			
Palm			

Lower Limb Involvement	Affected Limb	Unaffected Limb	Difference
20 cm above patellar base			
10 cm above patellar base			
20 cm below patellar base			
30 cm below patellar base			
35 cm below patellar base			
Lateral malleolus			
Foot (10 cm above 1st space)			

Assessment

_____

_____

_____

_____

- Long Term Goals: _____

_____

_____

_____

- Short Term Goals: _____

_____

_____

_____

Plan for Treatment (circle those that apply)

Patient Education (precautions, skin care) Manual Lymph Drainage

Remedial Exercises Multi-Layer Bandaging IPC

Other: _____

_____

_____

_____

Attach Photograph of Limb:

Therapist Signature: _____ Date:___/___/___

APPENDIX D

Flow Chart of MLD Sequencing

1. Proximal lymph nodes (axillary or inguinal) x 10
2. Call-up limb segment #1 x 5
3. Proximal lymph nodes x 5
4. Reabsorption limb segment #1 x 5; call-up x 1
5. Proximal lymph nodes x 5
6. Call-up limb segment #1 x 1
7. Call-up limb segment #2 x 5
8. Call-up limb segment #1 x 1
9. Proximal lymph nodes x 5
10. Call-up limb segment #1 x 1
11. Reabsorption limb segment #2 x 5; call-up x 1
12. Call-up limb segment #1 x 1
13. Proximal lymph nodes x 5
14. Call-up limb segment #1 x 1
15. Call-up limb segment #2 x 1
16. Distal lymph nodes (elbow or popliteal) x 5
17. Call-up limb segment #3 x 5
18. Distal lymph nodes x 5
19. Call-up limb segment #2 x 1
20. Call-up limb segment #1 x 1
21. Proximal lymph nodes x 5
22. Call-up limb segment #1 x 1
23. Call-up limb segment #2 x 1
24. Distal lymph nodes x 5
25. Reabsorption limb segment #3 x 5; call-up x 1
26. Distal lymph nodes x 5
27. Call-up limb segment #2 x 1
28. Call-up limb segment #1 x 1
29. Proximal lymph nodes x 5
30. Call-up limb segment #1 x 1
31. Call-up limb segment #2 x 1
32. Distal lymph nodes x 5
33. Call-up limb segment #3 x 1
34. Call-up limb segment #4 x 5
35. Call-up limb segment #3 x 1
36. Distal lymph nodes x 5
37. Call-up limb segment #2 x 1
38. Call-up limb segment #1 x 1
39. Proximal lymph nodes x 5
40. Call-up limb segment #1 x 1
41. Call-up limb segment #2 x 1
42. Distal lymph nodes x 5
43. Call-up limb segment #3 x 1
44. Reabsorption limb segment #4 x 1; call-up x 1
45. Call-up limb segment #3 x 1
46. Distal lymph nodes x 5
47. Call-up limb segment #2 x 1
48. Call-up limb segment #1 x 1
49. Proximal lymph nodes

Key:
Limb segment #1 = Shoulder/Deltoid Area; Upper Thigh Area
Limb segment #2 = Upper Arm Area; Lower Thigh Area
Limb segment #3 = Forearm Area; Lower Leg Area
Limb segment #4 = Hand Area; Foot Area

APPENDIX E

Remedial Exercises for a Patient with Upper Extremity Lymphedema

Exercise	Repetitions	Comments
Abdominal Breathing	3 full breaths	Relax, inhale deeply through nose, exhale through mouth
Head Turns	Performed 2x to both sides for each exercise	Side bends, rotations, chin tucks Avoid rolling neck in circles
Shoulder Shrugs	3 repetitions each side	Inhale while shrugging, exhale while lowering shoulders
Shoulder Rotation	5 repetitions each side	Alternate shoulders, rotating backward and forward
Fist Clenches	5 repetitions each side, alternating hands each time	Squeeze fist for 2 seconds, then relax for 2 seconds
Wrist Rotations	5 repetitions each side	Rotate both clockwise and counterclockwise
Fist-to-Shoulder	5 repetitions each side, alternating hands each time	Touch fist to opposite shoulder
Apple Picking	5 repetitions each side	Stretch out arm and lean forward, then clench fist and bring to opposite shoulder
Reach-Above	Perform for 30 seconds	Reach both hands above head and alternate making a fist with each hand
Hand/Knee Squeeze	5 repetitions each side	Push hand down on opposite knee while lifting upwards with knee, hold for 2 sec
Arm Overhead	5 repetitions each side	Lift arm overhead and rotate shoulder internally and externally
Finger Dexterity	Perform each exercise 30 seconds	Abduction and adduction of fingers and thumb, thumb opposition

Remedial Exercises for a Patient with Lower Extremity Lymphedema

Exercise	Repetitions	Comments
Abdominal Breathing	3 full breaths	Relax, inhale deeply through nose, exhale through mouth
Low Back Exercises	5 repetitions each exercise	Heels to buttocks, swing legs side-to-side, knees to chest
Leg Extensions	5 repetitions each side	Bring heel to buttocks, then extend leg as far as possible
Bicycle Kicks	Perform one minute on each side	Each leg should be performed separately
Elevated Leg Exercises	5 repetitions each side	Begin with heel to buttocks, elevate one leg at a time
Hand/Knee Squeeze	5 repetitions each side	Push hand down on opposite knee while lifting upwards with knee, hold for 2 seconds
Ankle Exercises	5 repetitions each exercise	Ankle pumps and rotations
Toe Exercises	5 repetitions each exercise	Toe flexion and abduction, hold for 2 seconds

APPENDIX F

NLN

NLN

Prevention

18 Steps to Prevention for Upper Extremities
18 Steps to Prevention for Lower Extremities
Lymphedema Awareness: Before, During And After Breast Cancer Surgery

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Eighteen Steps To Prevention - UPPER Extremeties
For the patient who is at risk of developing lymphedema, and for the patient who has developed lymphedema.

WHO IS AT RISK?
At risk is anyone who has had either a simple mastectomy, lumpectomy or modified radical mastectomy in combination with axillary node dissection and/or radiation therapy. Lymphedema can occur immediately postoperatively, within a few months, a couple of years, or 20 years or more after cancer therapy. With proper education and care, lymphedema can be avoided, or, if it develops, kept well under control. (For information regarding other causes of upper extremity lymphedema, see What is Lymphedema?) *The following instructions should be reviewed carefully pre-operatively and discussed with your physician or therapist.*

1. Absolutely do not ignore any slight increase of swelling in the arm, hand, fingers, or chest wall *(consult with your doctor immediately).*
2. Never allow an injection or a blood drawing in the affected arm(s). Wear a Lymphedema Alert bracelet.
3. Have blood pressure checked on the unaffected arm, or on the leg (thigh), if bilateral lymphedema/at-risk arms.
4. Keep the edemic or at-risk arm(s) spotlessly clean. Use lotion (Eucerin, Lymphoderm, Curel, whatever works best for you) after bathing. When drying it, be gentle, but thorough. Make sure it is dry in any creases and between the fingers.
5. Avoid vigorous, repetitive movements against resistance with the affected arm (scrubbing, pushing, pulling).
6. Avoid heavy lifting with the affected arm. Never carry heavy handbags or bags with over-the-shoulder straps on your affected side.
7. Do not wear tight jewelry or elastic bands around affected fingers or arm(s).
8. Avoid extreme temperature changes when bathing or washing dishes, and it is recommended that saunas and hottubs be avoided (at least keep arm out of the hottub). Protect the arm from the sun at all times.
9. Try to avoid any type of trauma (bruising, cuts, sunburn or other burns, sports injuries, insect bites, cat scratches) to the arm(s). (Watch for subsequent signs of infection.)
10. Wear gloves while doing housework, gardening or any type of work that could result in even a minor injury.
11. When manicuring your nails, avoid cutting your cuticles *(inform your manicurist).*
12. Exercise is important, but consult with your therapist. Do not overtire an arm at risk: if it starts to ache, lie down and elevate it. *Recommended exercises*: walking, swimming, light aerobics, bike riding, and specially designed ballet or yoga. *(Do not lift more than 15 lbs.)*
13. When travelling by air, patients with lymphedema (or who are at risk) must wear a well-fitted compression sleeve. Additional bandages may be required on a long flight. Increase fluid intake while in the air.
14. Patients with large breasts should wear light breast prostheses (heavy prostheses may put too much pressure on the lymph nodes above the collar bone). Soft padded shoulder straps may have to be worn. Wear a well-fitted bra: not too tight, ideally with no underwire.
15. Use an electric razor to remove hair from axilla. Maintain electric razor properly, replacing heads as needed.
16. Patients with lymphedema should wear a well-fitted compression sleeve during all waking hours. At least every 4-6 months, see your therapist for follow-up. If the sleeve is too loose,

most likely the arm circumference has reduced or the sleeve is worn.
17. **Warning:** If you notice a rash, itching, redness, pain, increase of temperature or fever, see your physician immediately. An inflammation (or infection) in the affected arm could be the beginning or worsening of lymphedema.
18. Maintain your ideal weight through a well-balanced, low sodium, high-fiber diet. Avoid smoking and alcohol. Lymphedema is a high protein edema, but eating too little protein will not reduce the protein element in the lymph fluid; rather, this may weaken the connective tissue and worsen the condition. The diet should contain easily digested protein (chicken, fish, tofu).

Unfortunately, prevention is not a cure. But, as a cancer and/or lymphedema patient, you are in control of your ongoing cancer checkups and the continued maintenance of your lymphedema.

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18 Preventive Steps For LOWER Extremities
For the patient who is at risk of developing lymphedema, and for the patient who has developed lymphedema.

WHO IS AT RISK?
At risk is anyone who has had gynecological, melanoma, prostate or kidney cancer in combination with inguinal node dissection and/or radiation therapy. Lymphedema can occur immediately postoperatively, within a few months, a couple of years, or 20 years or more after cancer therapy. With proper education and care, lymphedema can be avoided or, if it develops, kept under control. (For information regarding other causes of lower extremity lymphedema, see What is Lymphedema?) *The following instructions should be reviewed carefully pre-operatively and discussed with your physician or therapist.*

1. Absolutely do not ignore any slight increase of swelling in the toes, foot, ankle, leg, abdomen, genitals *(consult with your doctor immediately).*
2. Never allow an injection or a blood drawing in the affected leg(s). Wear a Lymphedema Alert Necklace.
3. Keep the edemic or at-risk leg spotlessly clean. Use lotion (Eucerin, Lymphoderm, Curel, whatever works best for you) after bathing. When drying it, be gentle, but thorough. Make sure it is dry in any creases and between the toes.
4. Avoid vigorous, repetitive movements against resistance with the affected legs.
5. Do not wear socks, stockings or undergarments with tight elastic bands.
6. Avoid extreme temperature changes when bathing or sunbathing (no saunas or hottubs). Keep the leg(s) protected from the sun.
7. Try to avoid any type of trauma, such as bruising, cuts, sunburn or other burns, sports injuries, insect bites, cat scratches. (Watch for subsequent signs of infection.)
8. When manicuring your toenails, avoid cutting your cuticles *(inform your pedicurist).*
9. Exercise is important, but consult with your therapist. Do not overtire a leg at risk; if it starts to ache, lie down and elevate it. Recommended exercises: walking, swimming, light aerobics, bike riding, and yoga.
10. When travelling by air, patients with lymphedema and those at-risk should wear a well-fitted compression stocking. For those with lymphedema, additional bandages may be required to maintain compression on a long flight. Increase fluid intake while in the air.
11. Use an electric razor to remove hair from legs. Maintain electric razor, properly replacing heads as needed.
12. Patients who have lymphedema should wear a well-fitted compression stocking during all waking hours. At least every 4-6 months, see your therapist for follow-up. If the stocking is too loose, most likely the leg circumference has reduced or the stocking is worn.
13. **Warning:** If you notice a rash, itching, redness, pain, increase of temperature or fever, see your physician immediately. An inflammation or infection in the affected leg could be the beginning or a worsening of lymphedema.
14. Maintain your ideal weight through a well-balanced, low sodium, high-fiber diet. Avoid smoking and alcohol. Lymphedema is a high protein edema, but eating too little protein will

not reduce the protein element in the lymph fluid; rather, this may weaken the connective tissue and worsen the condition. The diet should contain easily-digested protein such as chicken, fish or tofu.

15. Always wear closed shoes (high tops or well-fitted boots are highly recommended). No sandals, slippers or going barefoot. Dry feet carefully after swimming.
16. See a podiatrist once a year as prophylaxis (to check for and treat fungi, ingrown toenails, calluses, pressure areas, athelete's foot).
17. Wear clean socks & hosiery at all times.
18. Use talcum powder on feet, especially if you perspire a great deal; talcum will make it easier to pull on compression stockings. Be sure to wear rubber gloves, as well, when pulling on stockings. Powder behind the knee often helps, preventing rubbing and irritation.

Unfortunately, prevention is not a cure. But, as a cancer and/or lymphedema patient, you are in control of your ongoing cancer checkups and the continued maintenance of your lymphedema.

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