Lymphedema Treatment in Physical Therapy

PDH Academy Course #PT-18XX
4 CE Hours

Course Abstract

This course refreshes and refines the learner's understanding of lymphedema and lymphedema treatment. It opens with a review of the lymphatic system; lymphedema's etiology, characteristics, and patient presentations; how to diagnose, identify, stage and classify lymphedema; and lymphedema evaluation. It then turns to treatment, taking a detailed look at evidence-based practice for Complete Decongestive Therapy for lymphedema patients, as well as several alternative treatment approaches. Case studies are provided.

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Approvals

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Target Audience & Prerequisites

PT, PTA, OT, OTA, MT – no prerequisites

Learning Objectives

By the end of this course, learners will:

- Recognize relevant facets of the cardiovascular and lymphatic systems
- Identify common patient presentations and related conditions
- Distinguish between types and stages of lymphedema
- Recall aspects of lymphedema evaluation
- Recognize elements of Complete Decongestive Therapy
- Differentiate between alternative treatment approaches

Timed Topic Outline

I. Lymphatic System Anatomy and Function (30 minutes)
    Cardiovascular System, Lymphatic System, Capillary Exchange
II. Introduction to Lymphedema (5 minutes)
III. Typical Patient Presentations (10 minutes)
IV. Diagnosing Lymphedema (15 minutes)
    Related Conditions
V. Lymphedema Evaluation (15 minutes)
    From Medical Records, From the Patient, Outcome Measures, Putting it Together
VI. Lymphedema Treatment (120 minutes)
    History, Complete Decongestive Therapy

VII. Alternative Treatment Approaches (25 minutes)
Hands-on Techniques, Therapeutic Movement & Proprioception Stimulating Techniques, Electrical Therapy, Complementary Therapies
VIII. Conclusion, References, and Exam (20 minutes)

Delivery Method
Correspondence/internet self-study, with a provider-graded multiple choice final exam. *To earn continuing education credit for this course, you must achieve a passing score of 80% on the final exam.*

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Course Author Bio and Disclosure
Debora Chasse, MPT, DPT, WCS, CLT-LANA, CMRP, is the Founder and Owner of Function Ability Physical Therapy, where she offers an integrative approach of osteopathic and traditional physical therapy treatments. Some people say it looks like magic; however, Dr. Chasse states she is an abstract thinker and by learning the techniques thoroughly, she is able to approach physical therapy treatment with increased accuracy to more efficiently find the primary problems and resolve the patient's dysfunction and pain. Manual therapy using an integrative therapeutic approach is very effective in making permanent changes in the body. Dr. Chasse wants to increase the patient's control and make change with movement exercises.

Debora began practicing Women's Health Physical Therapy in 1999 and is one of the few experts in both pelvic floor physical therapy and lymphedema. She earned a Doctor of Physical Therapy degree from Loma Linda University in 2006; received her Master's degree in Physical Therapy and Bachelor of Health Science from Loma Linda University in 1996; and has committed her career to learning and training from elite instructors in North America and Europe. In 2009, she received board certification in women's health physical therapy, and is currently a Content Expert for the State of California Licensing Board.

DISCLOSURE: Financial – Debora Chasse receives fees from Function Ability Physical Therapy as an owner, consultant, speaker, trainer, and copyright-holder (DVDs); Franklin Method and Vyne Education as a consultant, speaker, and trainer; Matrix

Repatterning as a consultant and speaker; Young Living Essential Oils and DoTerra as a consultant and distributor; and received a stipend as the author of this course.
Nonfinancial – Debora Chasse supports the use of, and provides, Frequency Specific Microcurrent treatment; no other relevant nonfinancial relationship exists.

Introduction

When one of your patients presents with lymphedema, are you confident that you know what to do?

This course will improve your understanding of lymphedema and lymphedema treatment. We'll review the lymphatic system; lymphedema's etiology, characteristics, and patient presentations; how to diagnose, identify, stage and classify lymphedema; and lymphedema evaluation. We'll then move to treatment, taking a detailed look at evidence-based practice for Complete Decongestive Therapy for lymphedema patients, as well as several alternative treatment approaches.

Lymphatic System Anatomy and Function

Let's begin with a review of the relevant bodily systems.

Cardiovascular System

The **cardiovascular system** consists of the heart, blood, arteries, arterioles, venules, and veins. The heart is a muscle that pumps blood, a liquid substance that contains plasma, red blood cells, white blood cells and platelets, through the blood vessels throughout the body. The blood supplies oxygen and nutrients to all the tissues in the body and removes metabolic wastes from the body. The right half of the heart receives low oxygenated blood and pumps it through the lungs where it receives oxygen and removes carbon dioxide. From here the oxygenated blood returns to the left side of the heart where it is pumped out through the aorta and distributed into systemic circulation.

Lymphatic System

The **lymphatic system** is a one-way subsystem of the circulatory system. It filters excess blood plasma and unwanted material from the capillary bed and returns it to the venous circulation via the left and right venous angle. It absorbs fats into the bloodstream and helps the body support the fight against disease. The lymphatic system also produces lymphocytes and regulates the concentration of protein in the blood. The lymphatic system consists of lymph organs, lymphatic capillaries, lymph precollectors, lymph collectors, lymph nodes, lymphatic trunks, and lymphatic ducts. Sympathetic, parasympathetic, and sensory nerve endings are found in lymph vessels and lymph nodes and can regulate the contraction of the lymph angion.

Lymph fluid becomes lymph fluid when it enters the lymph capillary, and contains white blood cells, lymphocytes, fat cells, water, proteins, and waste products. There is no lymph fluid in the central nervous system or in non-vascular tissue (Wikipedia/Lymph). Approximately 24 liters of fluid move out of the blood plasma and into the interstitial fluid every 24 hours. Of those 24 liters of fluid, 2-4 liters is

processed by the lymphatic system each day. Each day 50-100% of the proteins are taken up by the lymphatic system.

Lymph flow begins with lymph capillaries and pre-collecting vessels. Lymph collectors transport the high protein fluid to the lymph nodes. Once proteins and waste products are processed, the lymph fluid is then transported to the lymphatic trunks and ducts. Then it re-joins the venous system via the brachiocephalic veins (Chasse: Video). The **lymph capillaries** are found at the capillary bed in the interstitium near the arterioles and venules. The circumference of a lymph capillary is slightly larger than that of the blood capillary. The lymph capillary consists of endothelial flat cells that passively allow excess plasma and unwanted waste products to move from the interstitial fluid into the lymphatic system. The intake of fluid into the lymph capillary is controlled by anchoring filaments that are attached to the endothelial flat cell, and the relationship between the protein concentration and fluid pressure gradient in the interstitium. When the anchoring filament, made mostly of elastin fibers (Wikipedia/Lymph), senses an increase in pressure due to an increase in fluid within the interstitium, the endothelial flat cell will passively open to allow lymph fluid to enter the lymph capillary. When the pressure is greater inside the lymph capillary, the endothelial flat cells close, not allowing fluid to reverse its direction.

Once in the lymph capillary the lymph fluid passes through semilunar valves and lymph vessels, beginning with pre-collectors and collectors. The **semilunar valves** allow fluid to move in and out. When the smooth muscle senses an increase in lymph fluid through the stretch reflex, the smooth muscle contracts, pushing the fluid through a valve into the next lymph angion. The valves are spaced 6-10 millimeters apart. The flow of lymph fluid is intrinsically controlled by the stretch receptor causing a stretch reflex and by contractions of the smooth muscle. When the pressure decreases, the valve closes to not allow lymph fluid to flow backwards. The fluid movement in the lymph system is transported by the accumulation of lymph fluid within the lymph angion, the closing of the proximal valve in the lymph angion, and the smooth muscle contraction within the lymph angion.

Extrinsic lymph flow is controlled by other factors as well. The lymph vessels parallel the arteries and veins. The pulsation of the arteries stimulates smooth muscle contraction of the lymph vessels. As you contract your skeletal muscles with movement and exercise, it also stimulates the lymph vessels to contract. Deep diaphragmatic breathing not only increases oxygenation of the blood but it also stimulates the parasympathetic nervous system that is needed for increasing lymph flow in the body. Respiratory pressure changes occur during breathing. When the diaphragm contracts in a downward force, it causes the lungs above it to lengthen, allowing for an increase in oxygen into the cells. Humans are negative air pressure breathers. As the lungs lengthen during a diaphragmatic contraction this creates a respiratory pressure changes. The respiratory pressure change causes the lymph fluid to be suctioned into the lymphatic ducts. Picture a Chinese lantern, representing the lungs, being pulled down by a strong cloth, representing the

diaphragm. As the cloth pulls on the Chinese lantern, it expands to let more air in. This is what is meant by a negative pressure change. This negative pressure change stimulates lymph flow not only in the thoracic duct but in the entire body. This causes a negative intrathoracic pressure during inspiration in the lungs (Chasse 2015). The lymph angion contracts 6-10 times per minute; this rate increases to 60-100 times per minute during aerobic activity.

The **lymph vessels** constitute 60% of the lymphatic system and are made of three layers. The inner layer, the endothelium, is made up of simple squamous epithelial cells and helps with mechanical transport of lymph fluid. The endothelium sits on a basement membrane made out of extracellular matrix that distinguishes it from other layers. The endothelium allows interstitial fluid to flow into the vessel when the hydrostatic pressure on the blood capillary is high enough (Chasse 2015). The next layer is smooth muscles around the endothelium that contract when they sense increased pressure within the lymph vessel and relax to allow more fluid to fill the lymph angion. They allow for a slow contraction and refilling approximately every 4 seconds in a normal healthy lymphatic system. This is different from the smooth muscles in the blood vessels that pump blood via vasoconstriction and vasodilation. The outer layer, the adventitia, consists of fibrous tissue. It is made out of collagen, and anchors the lymph vessels to structures within the body for stability (Chasse 2015). Larger lymph vessels have more layers of adventitia than the smaller lymph vessels.

Lymphatic fluid transport begins at the lymph capillary once the high protein fluid passively enters the flat endothelial cells and continues on to pre-collecting lymph vessels and collecting lymph vessels. The next destination is to the afferent vessel of the lymph node, to filter the lymph and make antigens to present to the immune system. Lymph fluid exits the efferent vessel of the lymph node and empties into the lymphatic trunk along with other efferent lymph vessels. Many lymphatic trunks unite together to empty lymph fluid into its respective lymphatic duct. From the lymphatic ducts, the lymph fluid returns to the circulatory system via the subclavian veins.

Lymph organs consist of lymph vessels, lymph nodes, bone marrow, thymus gland, Peyer's patches, spleen, and tonsils. Each lymph organ supports the immune system as well as the production of B and T lymphocytes, macrophages, and dentrite cells. We have already discussed how lymph vessels transport lymph fluid.

Lymph nodes are two millimeters to two centimeters in size. They store B cells and T cells and keep them isolated from the rest of the body by a fibrous capsule around the lymph node which extends to the inside of the cell, forming the trabeculae. There are 600-700 lymph nodes in the body. The lymph node is made up of the lymphatic sinuses, blood vessels and parenchyma. The parenchyma is divided into the cortex, paracortex and medulla. B cells are located mostly in the cortex, whereas T cells are mostly found in the paracortex. The lymph sinuses are found in the space between the fibrous capsule and the cortex of the parenchyma. This is where

reticular cells, fibroblasts and macrophages are predominately found. The lymph node ranges in size between 2 mm and 2 cm. Lymph is transported to the afferent vessels on the convex side of the lymph nodes and exits on the concave side via the efferent lymph vessels. In the lymph node, the lymphocytes (white blood cells) collect and destroy bacteria and filter out noxious material to protect the body from cancer, viruses and infections. The lymph node swells when the lymphocytes are multiplying to fight off these foreign substances. The lymph node stores the foreign cells.

The lymphatic system supports the **immune system** of the body. Lymphocytes are produced and mature in the **bone marrow**. B cells produce antibodies and send them to the lymph nodes. Once in the lymph node they will produce more antibodies or make memory cells to help the body fight the infection in the future. T cells mature in the **thymus gland**, which secretes a hormone called thymosin. Too much thymosin can produce abnormal T cells and too little thymosin can cause autoimmune disorders. When antigens such as pollen attack the body, these antigens are sent from the tissues to the lymph vessels and lymph nodes. In the lymph nodes the macrophages and dendrite cells phagocytize the antigen, process it, and present the antigen to the lymphocytes to produce antibodies or make memory cells the body can recognize in the future.

The **spleen** purifies the blood and lymph fluid. It also breaks down unhealthy red blood cells and stores blood for later use.

The **tonsils** are the body's first line of defense as they test bacteria that enter through the nose and mouth. They destroy bacterial and unwanted materials that protect the body from viruses or infections. Remember, when the lymph node is fighting off an inflammatory condition, the lymph nodes swells because the lymphocytes are multiplying.

Lymphatic circulation begins at the lymph capillary and ends at the venous angle where the subclavian vein and jugular vein meet. The lymph fluid is transported from the lymph capillary to the pre-collecting and collecting lymph vessels. From the lymph vessels it is transported to each regional lymph node group via the lymph nodes' afferent vessels. Each lymph node group region collects fluid from a specific part of the body. The lower extremities, genitals and portions of the pelvis transport lymph fluid to the inguinal lymph nodes. Portions of the abdomen and pelvis drain into the abdominal lymph nodes. The intestinal lymph trunk has its own lymphoid follicles, known as **Peyer's patches**, in the ileum of the small intestines. These Peyer's patches monitor and prevent growth of bacteria in the intestine (Innerbody.com). The axillary lymph nodes receive lymph fluid from the upper extremities, the pectoral region and the upper back. The mediastinal lymph nodes receive lymph fluid from the organs in the thorax and include the esophagus. The cervical lymph nodes receive lymph fluid from the head and neck including the manubrium.

Lymph fluid flows from the efferent vessel of the lymph nodes to the lymph trunks. In other words, there are many lymph nodes' efferent vessels emptying into their designated lymph trunk. There are nine **lymphatic trunks,** each related to a designated region for lymph fluid to be transported. The right and left lumbar trunks drain lymph fluid from the lower extremities, the pelvis, and deep lymphatics of the abdominal wall, the kidneys, and adrenal glands. The lumbar trunks empty into the cysterna chyle where the intestinal trunk also empties. The intestinal trunk receives lymph and fats (chyle) from the intestines. The right and left bronchomediastinal lymphatic trunks drain lymph fluid from the lungs, heart, mediastinum, and mammary glands. The right and left subclavian lymph trunks are found inferior to the clavicle and empty lymph fluid from the axillary lymph nodes. The axillary lymph nodes drain fluid from the arms. The right and left jugular lymph trunks are found in the neck and drain lymph fluid from the cervical lymph nodes. These lymph nodes drain lymph fluid from the head and neck. These lymph drainage divisions are referred to as **anastomoses** or watersheds. In other words, lymph fluid doesn't naturally transport lymph fluid into another region, other than its designated region.

Each region of the body empties lymph into a specific lymph node location. The lymph fluid exits the lymph node via the efferent vessel to the lymphatic trunk and from there, the lymphatic trunks empty into the **lymphatic ducts**. The thoracic duct is 38-45 cm in length. It begins at the level of T12 and extends to C7 where it drains into the brachiocephalic vein located between the left subclavian and jugular veins. The thoracic duct drains lymph from the lower extremities, pelvis and left side of the body. The right lymphatic duct is 1.25 cm in length and travels alongside the anterior border of the medial scalenes at the neck. The right lymphatic duct is found between the left subclavian and jugular veins and empties the upper right one-quarter side of the body. The thoracic duct drains lymph into the left brachiocephalic vein located between the left jugular and left subclavian veins. Respectively, the right lymphatic duct drains into the right brachiocephalic vein.

Capillary Exchange

Capillary exchange (Biological Sciences) is the exchange of fluid in the blood out of the capillary. To understand the exchange of fluids we need to understand the function of the heart and circulatory system, the lymphatic system, and movement of fluid and concentration gradients. Imagine the capillary bed to be more like a river than a pond where there is lack of fluid movement. This river flows from the heart and back to the heart and has many streams.

The left ventricle of the heart contracts and pumps oxygen out of the heart into the aorta, arteries, and to many branches called arterioles. The arterioles empty blood into the capillary bed for all the systems of the body, including the musculoskeletal system and the skin, to receive nourishment, remove waste products, and exchange gases. At the beginning of the capillary bed the oxygenated blood, glucose, and nutrients feed the tissues. The blood in the interstitium hands over the deoxygenated blood and waste products before it moves to the venule end of the

capillary. The deoxygenated blood is then returned to the heart via venules, veins, and the vena cava. The blood returns to the right atrium on the right side of the heart and pumps into the right ventricle. From the right ventricle, the blood is pumped to the lungs to get oxygenated and returns to the left atrium where it pumps blood to the left ventricle. From the left ventricle, blood is pumped to all the tissues of the body. Every minute 5 liters of blood is leaving the right ventricle to go to the lungs and another 5 liters is leaving the leftventricle to send blood to the tissues of the body.

Blood is moved from the heart via a pumping mechanism of contraction and relaxation and is transported to all the tissues of the body. The contraction of the left side of the heart pushes blood out with a specific amount of pressure. As the blood pumps into the arteries, it exerts 120 mm Hg of pressure on the walls of the arteries; this is called systole. Diastole measures the amount of pressure on the walls of the arteries when the heart is at rest and is approximately 80 mm Hg. As the blood is going through the arteries the mean arterial pressure of blood exerted on the walls of the arteries is 93 mm Hg. This amount is calculated from the systolic and diastolic pressure. The blood pressure drops as the blood moves through the arteries. When the blood reaches the capillary bed, the amount of pressure the blood is pushing on the arterial wall is approximately 30 mm Hg.

In the capillary bed at the arteriole end, the oxygenated and nutrient-rich blood is being distributed to the tissues in the interstitium; at the venule end, deoxygenated blood, waste products and proteins are being delivered back to the heart via the vena cava. Since there are no holes in the arteries or arterioles, blood cannot leak out of these vessels. Once the blood reaches the capillaries where it is porous, blood is pushed out into the interstitium to allow for oxygen and carbon dioxide exchange, and to deliver glucose and nutrients to the tissues. These spaces between the endothelial cells are too small to let the red blood cells, platelets, white blood cells and proteins get through into the interstitium. Blood leaks out through the endothelial cell gaps through a process called diffusion and osmosis. Let's now discuss that process and how it relates to capillary exchange.

Diffusion (Wikipedia/Diffusion) is the net movement of a substance from a region of high concentration to a region of low concentration to balance the concentration of the substance in the fluid. Osmosis is the movement of water across a semipermeable membrane from an area of high water concentration to an area of low water concentration. Let's say side A is filled up with salt and water, side B is filled with no substance and water and in between is a semipermeable membrane. Under the phenomena of diffusion, side A wants to diffuse into side B to balance the water and salt concentration. Since there is a semipermeable membrane, this particular salt is unable to diffuse into side B. Because of osmosis, the salt on side A exerts a pull on the water in side B and water moves from side B to side A. This movement of water will increase the water volume on side A and decrease the water volume on side B so that the concentrations are equal.

IMAGE: diffusion

To relate these physics concepts to capillary exchange: the fluid at the arterial end is being pushed against the walls of the arterioles at 30 mm Hg, causing fluid to leak out in between the endothelial cells in the capillary. The particles that can leak out are oxygen, red blood cells, platelets, white blood cells, glucose, and small proteins. This process is happening in the interstitium located near the beginning of the capillary bed as nutrients go nourish the nearby tissue. The proteins such as albumin are unable to pass through because of the semipermeable membrane. Because of this higher concentration of proteins, and because the proteins are unable to diffuse out of the vessel, the proteins exert a pull of fluid in through osmosis. The pull of fluid back into the vessel along with the de-oxygenated blood occurs closer to the venule end of the capillary. At the arterial end of the capillary, the strength of the push of fluid out of the arterial end is 30 mm Hg and the pull in is 20 mm Hg. Since there is more force pushing out at the arterial end, fluid is diffusing into the interstitium. As more fluid leaks out in the capillary, the protein concentration increases and the fluid pressure drops. Due to the decrease in pressure near the venule end of the capillary, there is a net fluid push out of 10 mm Hg and increased protein concentration pull in of 15 mm Hg resulting in 5 mm Hg of the net fluid pull in. The pressure of the blood against the walls of the arteries and arterioles is referred to as the hydrostatic pressure. The pull from the proteins in the capillary on the fluid back in to the capillary is called the colloid osmotic pressure.

If the pores in the capillaries were larger the proteins would also leak out. Can you imagine what would happen with the capillary exchange on the fluids pulled in? This would change the pull back into the capillary because the protein concentration pull (colloid osmotic pressure) would be lowered and could cause the push out to be greater than the pull in. This would cause the fluid accumulation outside the capillaries, further causing edema.

These larger gaps in the capillaries could be the result of inflammation from an injury to the tissues. The four common characteristics of inflammation are redness, swelling, heat, and pain. The swelling, which occurs because of the release of histamines, is important in tissue healing because it increases the gaps in the capillaries to allow white blood cells that destroy bacteria into the interstitium. The white blood cells bring more fluid to help cleanse and dilute the tissues. There is a small percentage of tissue that does not get pulled back in to the capillary. The lymphatic system will bring the fluid back into the circulatory system when the capillary exchange between the blood vessels and the interstitium is not able to. The lymph capillary senses the increase in fluid pressure in the interstitium and pulls the excess fluid back in. The lymph system is responsible for regulating the concentration of protein to maintain fluid equilibrium in the body.

The lymphatic system can increase its speed of lymph angion activity to transport an increased amount of lymph fluid back to the venous system. However, if the load

is too great, it will not be able to remove the fluid, causing an increase in high protein fluid in the interstitium. In time, the high protein concentration will cause connective tissue damage from the chronic inflammation. Initially, the affected region will swell. The skin will become scarred and appear hard. The skin and nails will be susceptible to fungus growth. The skin will develop papillomas and skin damage. Without treatment, the limb will change its shape, causing regions of the limb to balloon out into lobular protrusions. The skin will fold in between the lobular protrusions, causing lobular folds characteristic of stage 3 lymphedema.

Introduction to Lymphedema

There are many medical conditions that can cause damage to the lymph nodes and/or the lymph vessels, or cause the lymph system to be weakened. The lymphatic system relies on a healthy circulatory and respiratory system. If there is breakdown in any of these systems the lymphatic flow can also be impaired.

Lymphedema is most often found in the legs and arms but can also develop in the head, genitals and chest. It is characterized by a high protein concentration and water in the interstitial tissues that causes a chronic inflammation. An increase in blood circulation makes it difficult for the lymphatic system to transport fluid to the designated lymph nodes, lymph trunks and lymph ducts. Each lymph node group is responsible for phagocytizing lymph fluid from a designated region. When the lymph vessels and lymph nodes are unable to transport and process the lymph fluid quickly enough, the lymph fluid backs up and becomes stagnant. The inflammatory process causes fibrosis, a scarring of the connective tissue (Weissledger, Schuchhardt 1997).

"High output failure" occurs when there is excess low protein lymph fluid in interstitial spaces. A "functional reserve" is initiated by the lymphatic system to speed up lymph flow in the lymph collecting vessels to remove excess debris. An ankle sprain is a good example of high output failure. In an ankle sprain, there are increased waste products and dead red blood cells that need to be removed. The lymph system increases its speed to transport the unwanted waste products in the lymph fluid more quickly for a short period of time. When the functional reserve is used up, this natural process can cause damage to the lymph collectors or lymph nodes, resulting in low output failure.

IMAGE: high output failure

"Low output failure" occurs when the lymphatic system is unable to increase the velocity of lymph flow due to impairment in the lymphatic vessels or lymph nodes. An abnormal amount of fluid begins to accumulate in the limb, further slowing down lymph transport. Fluid in the limb becomes stagnant and puts increased pressure on the skin's touch receptors, causing increased pressure on the skin's superficial layers. This causes a lack of skin movement, further preventing normal lymphatic

vessel function. The impairment can be due to congenital faulty lymphatic system structures, trauma to the body causing damage or blockage to the lymph vessels, or a medical condition such as Chronic Obstructive Pulmonary Disease (COPD).

IMAGE: low output failure

Typical Patient Presentations

The most common cases of lymphedema in the world are due to **filariasis**, which is endemic in tropical and subtropical parts of the world. The nematode worm larvae are transmitted to people by a mosquito bite. The adult filarial live, reproduce, and die in the lymph vessel. The current hypothesis is that the death of the parasite causes a chronic inflammation in the lymph vessel causing damage and blockage in lymph flow.

IMAGE: filariasis

The most common cases of lymphedema in North America are due to cancer treatment, while other cases are due to congenital defect, medical procedures, and the like.

Air travel and high altitudes decreases the hydrostatic pressure on the tissues. Although planes adjust the cabin pressure it is not sufficient to give enough hydrostatic pressure on the tissues for people with a compromised lymph system. Research shows that 5% of people who fly experience deep vein thrombosis (DVT). The elasticity integrity in the skin in people with a normal lymph system provides sufficient external pressure on the connective tissue and lymphatic vessels to stimulate lymph fluid transport 24 hours a day. When the skin loses its natural integrity (the hydrostatic pressure) in air travel and high altitudes, lymph fluid transport slows down and becomes stagnant. In some people this causes increased swelling of the limb and the prolonged stagnation can develop into lymphedema.

Trauma to the body can cause lymphedema. Trauma causes a histamine release to the tissues causing swelling in the body. If the lymphatic system is overloaded, the high protein fluid will accumulate at the interstitium and cause a chronic inflammation in the tissues. The chronic inflammation will slow down the function of the lymphatic transport system resulting in lymphedema.

Medical procedures can cause trauma to the nearby connective tissue and skin. In a person with a faulty functioning lymphatic system, injections, punctures, blood pressure measurements, deep tissue massages and surgeries can cause an excessive load of lymph fluid that needs to be transported back to the circulatory system or can cause damage to lymph vessels resulting in a back up of lymph fluid transport in the capillary bed.

In some cases, this can become **cellulitis.** The skin is the largest organ and the body's main line of defense against foreign materials. In a person with a normal functioning lymph system who has a skin abrasion or cut, the body's natural defense system would send in mast cells to clear the developing infection in the interstital space of waste products and debris and send it to the lymph system to be phagocytized. In a person with an impaired lymph system, the lymph fluid is unable to be transported quickly enough. The foreign fluid becomes stagnant in the capillary bed and is a perfect medium for an infection to develop. In people with a normal lymph system, the lymph vessels would contract faster to remove the lymph fluid and the lymph nodes would phagocytize faster. However, since this is not a normal lymph system, the infection festers, causing **cellulitis**. Cellulitis is a localized skin infection that can develop into **lymphangitis**, a skin infection of the entire limb. Often, these skin infections can lead to lymphedema due to the scarring of the surrounding connective tissue.

IMAGE: cellulitis

Some **medical conditions** can have an effect on blood flow causing patients to develop lymphedema.

Cardiovascular disease is caused by a buildup of plaque, narrowing in the arteries and making it difficult for blood to flow through them. If a blood clot forms in the arteries it can stop blood flow and cause a heart attack or a stroke. The heart receives blood from the veins and lungs and pumps blood to the lungs and the body.

Congestive heart failure is a condition when the heart is unable to pump out all the blood that it receives. This will cause blood to sit in the heart waiting to be pumped out; this condition also creates an increased pressure in the veins. This increased pressure causes fluid to leak out into the tissues resulting in edema. Right-sided heart failure causes swelling in the feet and legs.

A **deep vein thrombosis,** as mentioned above, is a serious medical condition where blood thickens and clumps together in the deep veins. Most often the blood clots occur in the legs. The signs and symptoms are engorgement of the superficial veins, pain, swelling, erythema, warmth and a pale blue discoloration. The veins drain the blood from the extremities back to the heart. The valves in the veins prevent the blood from flowing backwards and pooling in the veins. During the healing process in a patient with a DVT, the valves are often damaged, causing impaired blood flow. The abnormal or damaged veins can cause fluid from the damaged veins and valves to overflow into the interstitial space. This can cause chronic swelling, pressure and pain in the legs. A blood clot can become a serious medical condition if it loosens and lodges in the lungs causing a pulmonary embolism.

Chronic venous insufficiency is a condition where the veins in the legs are not sufficiently pushing the blood back to the heart. The valves in the veins are not completely closing, causing the blood to back up and leak into the tissues. This can

cause increased pressure in the veins. This type of edema is not a high protein edema and therefore not lymphedema. However, if it is left untreated, it can progress into a combination of venous-related lymphedema. Treatment for this is the same treatment used for lymphedema. Another venous insufficiency-related condition is **venous leg ulcers**. The early signs for chronic venous insufficiency are: leg swelling and pain, skin discoloration and a shallow sore with unevenly shaped borders. **Varicose veins** is another condition caused by lack of valve closure and blood backing up in the veins. This condition is caused by a weakening of the vein wall elasticity causing the veins to distend and the vein valves to not work properly. The increased blood pressure in the veins causes the veins to bulge or swell and may cause fluid to leak outside the veins. This leaking can cause swelling in the ankles and feet.

Cancer treatment, such as **radiation** and surgery are designed to destroy the cancer and sometimes destroys the nearby tissue. When tissue is damaged, it affects the function of the tissue. When cancer has spread to nearby lymph nodes it is common medical practice to remove the lymph nodes to stop the spread of the cancer. **Lymph node dissection** reduces the number of functioning lymph nodes that can phagocytize lymph fluid waste products and can damage the function of nearby lymph nodes due to the scar tissue surrounding them. Lymphatic stagnation slows lymphatic transport and causes lymph system damage.

Diagnosing Lymphedema

A person suffering from lymphedema may first begin to notice heaviness in an arm or leg, with some related numbness or tingling due to the swelling. Pitting edema may be observed: they place finger pressure on their shin or forearm and it doesn't return to normal within 3 seconds. Oozing lymph fluid may occur. Joint mobility may be impaired. As their condition progresses they may see increased skin thickness as their limb takes on a different shape. Abrasions, cuts and wounds may be slow to heal and are susceptible to skin infections. Skin color and texture may change.

Lymphedema is classified as either Primary lymphedema or Secondary lymphedema.

Primary lymphedema is caused by lymphangiodysplasia, a genetic anomaly of the lymph vessels and/or lymph nodes during the first trimester of fetal development (Lawenda et al 2009). Primary lymphedema normally occurs in the lower extremities; however, there are rare cases of occurrence in the upper extremities (McFarlane 2017). The distribution of primary lymphedema is higher in females (Weissledger, Schuchhardt 1997). The lymphatic system malformations of dysplasia are aplasia, hyperplasia, hypoplasia of the lymph vessels and lymph nodes, and Kinmonth syndrome (Liu et al 2012). Aplasia is characterized by the absence of lymph vessels or lymph capillaries in the affected area. Hyperplasia is characterized

by an increased diameter of lymph collectors, whereas hypoplasia is characterize by a decreased diameter of lymph vessels. Kinmonth syndrome involves fibrosis, fibrosclerosis, and fatty degeneration changes in the iliac and inguinal lymph nodes (Lawenda 2009).

IMAGE: primary lymphedema

Primary lymphedema is divided into **Type I and Type II**.

Type I, known as **Milroy's disease**, is a familial congenital and genetic disease that is present at birth or develops during infancy. The genetic presentation is autosomal dominant meaning that a copy of the gene has been changed enough to cause a mutation. Milroy's disease affects females more than males and normally occurs bilaterally in the lower extremities. In males the affected areas genital hydrocele and urethral abnormalities in males, upslanted toe nails, dysplastic toenails (deep creases in the toes), papillomatosis (wart-like growths), prominent leg veins and or cellulitis. Diagnosis is made with lymphoscintigraphy imaging (Brice et al 1993). Incidents of cellulitis and lack of management may cause the swelling to worsen. People with Milroy's disease should avoid wounds to the edematous limbs, long periods of immobility, prolonged standing, and calcium channel-blocking drugs that can cause increased leg swelling. There is no cure for Milroy's but it can be managed with Complete Decongestive Therapy (Kitsious-Tzeli et al 2010).

Type II appears before the age of 35 and is known as lymphedema praecox, or after the age of 35 and is known as lymphedema tarda. Type II primary lymphedema is of an hereditary autosomal dominant pattern. **Meige's disease**, the most common type II lymphedema, is a hereditary autosomal dominant pattern of the lower legs and feet and is usually present at the onset of puberty or shortly thereafter. In Meige's disease, genetic testing shows hypoplasia of the lymph vessels. Not only are the legs involved but also arms, face and larynx can be involved. In lymphedema tarda, the legs are most often involved but arms and other areas can be affected as well (McFarlane 2017).

Primary lymphedema is also associated with genetic syndromes and skin disorders including Turner syndrome, Klinefelter syndrome and neurofibromatosis type I. Primary lymphedema can worsen or improve over time depending on how well it is managed and if there are bacterial infections of the skin (cellulitis) or lymph vessels (lymphangitis).

Secondary lymphedema is caused by filariasis, previously described, or by a soft tissue traumatic event in which the lymph nodes or lymph vessels have been damaged. Medically it is described as a known cause. This can include lymphatic system damage from a post traumatic event, self induced, tissue lesions caused by force or tissue burns, infectious skin episodes such as cellulitis or erysipelas, burns, malignant tumors, and surgical procedures. Lymphedema can occur in combination with rheumatoid arthritis, obesity, lipedema and chronic venous insufficiency.

Immediate swelling following a post traumatic event causes a hematoma and an increased volume of lymphatic transport waste. This healing process is usually temporary due to the increase in circulation in the lymphatics. In contrast a chronic posttraumatic lymphedema causes permanent damage to the lymphatic system. Skin infections can damage the lymph collecting vessels and cause fibrous growth in the lymph nodes restricting the flow of lymph fluid. Mechanical traumas can cause lesions of the lymphatics resulting in a reduced transport capacity. This means that the lymphatic system cannot work fast enough to transport the lymph fluid. Lymphedema can occur after cancer surgery or cancer treatment and can become prevalent anytime following treatment. Norman et al (2009) cite a 42% five year cumulative incidence of lymphedema in breast cancer survivors. Of the 433 women observed for 3 years following medical treatment of breast cancer, 23% reported being diagnosed with mild lymphedema, 12% reported moderate to severe lymphedema and 2% reported chronically moderate to severe lymphedema. Beesley et al (2010) researched the prevalence of lower extremity lymphedema in gynecological cancer survivors, and found it in 10% of those diagnosed plus an additional 15% of those who reported symptoms.

Both primary and secondary lymphedema cause tissue damage within the body. There is damage between the tissue structures in the interstitium, insufficiency of endothelial cell function, valvular insufficiency and thrombosis of the lymph vessel. The lymph muscle pump becomes inefficient and the lymph vessels are surrounded by a fibrinoid material. The inflammatory reactions affect the lymph nodes as the lymph node sinuses become dilated and the lymphatic tissues are diminished. Blood vessels also become edematous. A damaged lymphatic system can also cause sclerosis of arteries and veins (Olszewski 2012).

According to the *Diagnosis and treatment of peripheral lymphedema: Consensus document of the international society of lymphology,* published in 2003, staging is described as 0, 1, 2, and 3 (Chasse 2015).

Stage 0 is a subclinical condition where lymphedema is not yet evident although there is impairment in the lymphatic drainage system.

Stage 1 is an early accumulation of protein rich fluid in the interstitium causing swelling of the limb. Pitting edema may occur and swelling is reversible. In other words, when the limb is elevated, it will return to the normal size.

Stage 2 describes swelling that does not return to the normal size with limb elevation. At this stage they may also develop scarring of the connective tissue. This is when the skin begins to feel firm and stretched. When this happens, the elasticity in the skin has been damaged and the limb will not return to normal. This is the reasoning that they will need a compression garment to take the place of the elasticity on their skin.

Stage 3 is when lobular folds of skin are present with a presentation of elephantiasis and trophic changes in the skin are occurring. Some of these trophic changes consist of fat deposits and wart like papillomas and skin color changes. Often time people in stage 3 lymphedema also develop fungus in the nails.

The above staging does not quantify the amount of edema in the limb, which is quantified as minimal, moderate, and severe to describe the degree of swelling involved. Minimal lymphedema is less than a 20% increase in limb volume compared to the contralateral limb. Moderate lymphedema is a 20-40% increase in limb size, and severe is more than a 40% increase compared to the contralateral limb. The most accurate measuring device is using water displacement, but this method is usually impractical in a clinical setting. The degree of severity can also be determined by using a calculation designed to measure the volume of a cone. You'll start by taking the circumference (c) of the limb, which is normally collected using a tape measure: every 5 cm for the upper limb, and every 10 cm for the lower limb. This is considered your height (h). You'll then need to calculate the radius (r) for each circumference – since radius is half of the diameter, your calculation is $r = c/\pi 2$. Then you can plug each radius into the calculation for the volume of a cone: $V = (\pi r^2 h)/3$. (It can be much simpler to put the numbers into an excel sheet that is set up to make these calculations.)

<u>Related Conditions</u>

Lipedema is a chronic familiar disease primarily found in 11% of the female population. It is an auto immune system disorder: it is not caused by a damaged lymph system but is due to a fat cell disorder. It is characterized by symmetrical impairment of disproportionate adipocyte hypertrophy primarily found throughout the lower extremities and pelvis from the iliac crest to the ankle (Buck, Herbst 2016). The fat cells are unevenly spaced in the subcutaneous tissues, which are usually found in the legs and abdomen. There are also incidents of lipedema distribution to the upper extremities, trunk and head. With specialized examination, other regions of the body may show an uneven distribution of the adipose tissue. In addition to hypertrophy of the adipocytes (Bilancini et al 1995), hyperplasia of the adipose tissue is surrounded by a weak connective tissue. The growth of the adipose tissue causes compression on the superficial lymph collectors (Weissledger, Schuchhardt 1997). Affected persons may appear to be obese with reports of unsuccessful attempts at weight loss. Additional symptoms are: minimal pitting edema, pain, tenderness with pressure, easy bruising due to vascular fragility, and increasing enlargement of the extremities after elevation or weight loss. Lipedema treatment consists of complete decongestive therapy for 2-4 weeks for 1.5 hours five to six days per week including night time compression.

IMAGE: lymph vs lip

One of the most significant complications of lipedema is a tendency towards **lipo-lymphedema** due to the secondary damage to the lymphatic system. The

pathophysiology in lipedema supports that the increase in lymph capillary filtration, the lack of support in the connective tissue and the weakness in the vascular walls contributes to the development of edema. A chronic increase in lymph fluid causes a temporary edema due to the lymphatic system being unable to increase its velocity sufficiently to transport the lymph fluid. The increased workload in the lymphatics causes lymph stagnation and damage to the lymph vessels proliferating to lipo-lymphedema. Due to the weakness in the vascular walls, other complications may include deep venous system impairments as well as varicosities. Also, the increased weight combined with the increased pain and fatigue further affects joint function and mobility, thus exacerbating obesity (Herbst 2012). The signs and symptoms differ from lymphedema. The swelling extends from the abdomen to the ankles and is symmetrical with a concentration of nodular fat in the abdomen and thighs, skin turgor is rubbery with a cottage cheese appearance and texture, pitting edema is not present, easily bruises and Stemmer's sign is negative (Buck, Herbst 2016). In patients with lipo-lymphedema the treatment time needs to be extended beyond lipedema's. The disease is minimized with maintenance of hormone balance and body weight management (Okhovat, Alavi 2015).

Other rare adipose disorders include multiple symmetric lipomatosis, also known as adiposis dolorosa, also known as **Madelung's disease** and **Dercum disease**. Madelung's disease is characterized by unusual fatty benign tumors around the neck, shoulders, upper arms and trunk. It is most common in adult alcoholic males and is less common in women and non-alcoholics. The body is unable to adequately metabolize fat causing associated disorders such as diabetes mellitus, hypertension and liver disease (Rarediseases.org). Dercum disease is characterized by growths of subcutaneous fat found anywhere on the body from the head to the feet. The benign fat tumors are unencapsulated. They can be small or large nodules or diffuse nodules. In addition to an association with metabolic disorders, it is also an autoimmune disorder. The best treatment for both of these disorders is Complete Decongestive Therapy (Lipomadoc.org, Rarediseases.org).

Lymphedema Evaluation

Now that you understand the anatomy, physiology, and function of the lymphatic system as well as common conditions affecting it, we will discuss lymphedema evaluation.

A lymphedema evaluation must be conducted prior to treatment. Use a multidisciplinary approach: communicate with the health care professionals involved in each case. And remember, throughout, to show respect to all your patients via your intention, proper draping, and touch.

Begin with the patient's pertinent information such as name, date of the exam, date of birth, height, weight, physician referral and medical diagnosis. The possible ICD 10 codes are: I89.0 for lymphedema, Q82.0 for congenital lymphedema, I97.2 for

post-mastectomy lymphedema, L90.5 for scar condition and fibrosis of skin, and E78 for lipedema.

Conduct a multi-systems review to determine the effects of medical treatment on the patient's condition. It should consider diagnoses that impact the cardiovascular system (such as heart disease), the musculoskeletal system (including limited joint immobility and painful regions), the neuromuscular system (including upper motor or lower motor neuron deficits), the integument system (including skin lesions, discoloration, papillomas, past cellulitis), and the immune system (consisting of autoimmune diseases and their level of involvement). This will also help you identify any contraindications and/or precautions that may impact your use of manual lymph drainage: malignant tumors, infections, malnutrition, cardiac edema, kidney disease, hyperthyroidism, thyroid or liver disease, hypersensitivity of the carotid sinus, recent abdominal surgery, radiation fibrosis, aortic aneurism, acute deep vein thrombosis (DVT), diverticulitis, pregnancy, and unexplained pain.

From Medical Records

Collect past medical history, including past and current oncological history as relevant.

If the lymphedema is cancer-related, document the stage of the tumor as well as all treatments, complications, and progress. Knowledge of the TNM cancer staging system, which describes the extent of cancer in a patient's body, may prove helpful: it classifies the size and extension of the primary tumor (T) as well as its lymphatic involvement (N), and also indicates the presence of metastasis (M).

If the lymphedema is hereditary or related to another cause (motor vehicle accident, surgical procedure, etc.), review the patient's medical records and document their history. You'll also want to know if the patient has been previously treated for lymphedema, and how was it treated. Did they have any complications such as increased redness, cellulitis, or reactions to their treatment?

Note the patient's signs and symptoms: typical signs and symptoms of lymphedema are swelling, numbness, fibrosis, decreased mobility, heaviness in the limb, frequent infections, and in more severe cases, hyperkeratosis and papillomas.

From the Patient

What is the patient's perception of their general health? Are they overweight? Do they suffer from extreme fatigue, depression, anxiety, or reduced cognitive function? Do they have any physical restrictions or disabilities, and/or any balance impairments? Do they receive any medical routine interventions? Do they have any other complaints that you or their physician are unaware of?

Collect the patient's perception of their current status and symptoms related to their lymphedema. On a scale of 0-10, how do they rank the severity of their condition? Do they feel that their lifestyle or quality of life has changed? How so? Do they

currently require assistance? What was their prior level of function, and what do they hope they can do once their lymphedema size has decreased?

What is the patient's environmental status? Do they live in high altitudes, or fly on an airplane regularly? Do they live where there's a lot of snow or rain? Are they able to maneuver around the home without difficulty; are there stairs or loose rugs in the home? Do they live alone? Do they have a caregiver, and is the caregiver willing and able to learn and assist with their home program?

What is the patient's functional status and activity level? Are they able to perform all their activities of daily living without assistance? Have they noticed changes in diet or fluid intake? Does the lymphedema (or any other medical diagnosis) limit or prevent social activity? Are they currently working, and what is their work title and work description? How will wearing multilayered bandages affect them – will they be able to perform their work duties while being treated?

What is the patient's health literacy? Are they familiar with the lymphedema treatment program? Also, there is a significant emotional impact "snowball effect" related to lymphedema. Do they have coping strategies related to their medical diagnosis, lymphedema, and body image in place? Are they familiar with relevant social media support groups or educational groups?

Outcome Measures

Classify and stage your patient's lymphedema. Perform an integumentary assessment for their skin color and condition, the presence of fibrosis, the volume of the limb and observation of the limb returning to normal when elevated. Examine the skin for color changes, the presence of fungus in the nails and between the toes, and regions of skin fibrosis. Measure the volume of the limb, as well as the contralateral limb, as discussed above.

Collect data related to their involved limb and pathways for lymph to flow. Determine functionality and pain in passive range of motion and active range of motion. What is their joint integrity? Do they have hypermobile or hypomobile joints? Do they have functional muscle strength sufficient enough for performing their own self-manual lymph drainage and/or bandaging? Assess sensory integrity, dermatomes, myotomes, proprioception and kinesthesia. Screen for abnormal circulation and related pathologies. Is there healthy blood flow observed with a health skin color in the hands and feet? What is their integumentary tissue quality? Do they show inflammation, soft tissue swelling, signs of infection, trophic changes, and/or trigger points? Are there any regions of the body that are inadequately aligned, and would improve lymph flow if alignment were corrected? Assess their posture, balance and gait on a variety of surfaces. Do they require home care or an assistive device to ambulate? (Additionally, if the patient has balance impairment or gait abnormalities, they may require an alternative approach for bandaging to allow them to ambulate safely.) Are there any barriers they need to overcome in their

home, workplace, grocery store or other community related activity? In the home, can they step into their shower or tub?

In addition, have the patient complete an appropriate questionnaire. For example, the disabilities of the arm, shoulder and hand (DASH) questionnaire focuses on the upper extremities, asking questions like "can you open a tight jar, wash a wall, carry objects, wash your back and participate in sexual activities." Other questionnaires, like the Functional Assessment of Cancer Therapy (FACT), assess the effects of a particular condition on a variety of body regions.

Putting it Together

Contact the patient's physician if you'd recommend that the patient be referred to another practitioner. If not:

State the cause and onset of the patient's lymphedema, document any precautions or contraindications, and list their signs and symptoms. Note any other pertinent medical information you've gathered.

List the patient's goal(s).

Present the patient's plan of care – incorporating Current Procedural Terminology (CPT) codes – which may involve some or all of the following: Complete Decongestive Therapy (skin education and care, manual lymph drainage, limb clearance exercises, and multilayered compression bandaging and/or compression garments) diet, and breathing exercises. Specify if you also will be using any other type of therapy. State how the treatment program will help the patient, and thoroughly explain the procedures as well as the time commitment involved. List your short-term and long-term goals, and the recommended number of visits to achieve them. State your frequency and duration: the number of visits per week, and the number of weeks you plan to treat your patient. I further request up front that each patient commit to the treatment program, both by attending all their scheduled visits and by staying in compliance with their home program, and ask them to sign an informed consent for treatment.

Verify that the patient, and any caregivers, are aware of the medical urgency related to signs of infection (redness, heat, pain, and swelling), and know to contact the patient's physician immediately if any are present. Provide any other pertinent referrals and resources: garment fitters; instructions for caring for, donning, and doffing garments; post-op boots, walking devices, etc.; and/or patient support, among others.

Sign your evaluation. I leave space at the end of the evaluation for the physician to also sign, indicating that he/she has read the evaluation and agrees with the plan of care for the stated patient.

Having completed the evaluation, you will need to immediately order the necessary supplies: bandages, for example, must be on hand before beginning the intensive phase of treatment. Because of this, I keep bandages in the clinic so that I can order each patient's bandages, begin treatment using the office supply of bandages, and replenish my stock when the patient's bandages arrive.

You are ready to begin treatment!

Lymphedema Treatment

History

Records of lymphatic system discussion differentiating red blood and white blood date back to the ancient Babylonian and Greek civilizations.

In the 1600's, the first scientific description of lymph vessels in dogs was published. Olof Rudbeck, in 1650, demonstrated the flow of lymph fluid into the thoracic duct, proving it was part of the circulatory system. In the early 1800's, Pehr Henrik Ling developed Swedish massage as a rhythmic movement to increase lymph flow in the body; however, some of the heavy-pressure manual techniques developed by Ling are contraindicated in treatment for lymphedema today. In 1874, Andrew Still, MD, DO, developed a medical system that corrected anatomical deviations to improve the healing process in tissues related to blood and lymph. Building on the findings of Dr. Still, Elmer Barber, DO, published *Osteopathy Complete* in 1898, wherein he describes how to "free the lymphatic circulation." Likewise, in 1890, a German surgeon named Alexander Von Winiwater documented a lymphedema treatment program consisting of skin care, compression, massage and exercise (Chikly 2005).

In 1920, Earl Miller, DO, developed a technique to increase intrathoracic pressure changes on lymphatic flow for the entire body (Chikly 2005). Dr. Emil Vodder PhD, who was influenced by previous osteopathic manipulative techniques, developed manual lymph drainage (MLD) to treat skin conditions in 1936 (Kasseroller 1998).

Hungarian physicians Michael and Ethyl Foldi developed Complete Decongestive Therapy in 1970, consisting of skin care, manual lymph drainage, compression, and exercise. J.W. Measel conducted interesting research in 1982 to determine the effects of manual lymphatic pump stimulation on the B-cell and T-cell for immune support, and concluded that the subjects who received the lymphatic pump treatment had a greater immune response than the control group (Measel 1982, Chikly 2005). In the 1990's, Dr. Robert Lerner established the first Complete Decongestive Therapy Treatment Center in New York (Chasse 2015).

Since the 1990's, multiple lymphedema training programs have evolved in both North America and the United States. Some of the most prominent leaders include Guenter Klose and Steve Norton, who hold seminars educating their students about the lymphatic system and teaching the Vodder and Foldi techniques for

lymphedema treatment. Bruno Chickly teaches courses on a gentle osteopathic technique to assess and stimulate lymph flow, and also discusses lymphedema in the academic book *Silent Waves: Theory and Practice of Lymph Drainage Therapy* (Chikly 2011). Carol McMakin, DC, developed a lymphedema protocol using the influence of the Rife frequency pairing on her Frequency Specific Microcurrent device. **INSERT SIDEBAR** Dr. McMakin also teaches courses on how to use her device. Eric Franklin developed the Franklin Method, a therapeutic intervention based on a metaphor and image-based understanding of anatomy, allowing practitioners to make biomechanical changes in the body. Franklin also introduces awareness and movement in support of skin receptors and proprioceptors; increasing the body's alignment improves, among other things, lymph flow.

SIDEBAR: In the 1950's, Royal Raymond Rife (http://rifemachines.com) noted that every atom in the universe, including those in the body, has a frequency. He created a "beam ray" machine to induce resonance in the body to devitalize pathogens.

Training programs have gotten more specific, targeting new regions and conditions. For example, in 2013, the Herman Wallace training school (http://hermanwallace.com) offered a course on *Lymphatics and Pelvic Pain: New Strategies*. It was based on the work of Debora Chasse, DPT, who developed a treatment program to promote tissue healing and reduce pelvic pain in patients with pelvic floor dysfunction. Chasse's theory was that patients with pelvic floor dysfunction had a common theme of inflammation. The increase in histamine release in the capillaries caused increased fluid to leak into the interstitium, and these patients developed lymphedema. Chasse's clinical experience revealed a significant reduction in pelvic pain and an improvement in function. In 2012, she developed a specific protocol for pelvic pain patients using the concepts of manual lymph drainage on the female pelvic genitals after making a pathway to move lymph fluid.

Complete Decongestive Therapy

As we've seen, manual lymph drainage and Complete Decongestive Therapy have been used to reduce inflammation and support the immune system for hundreds of years. Improving blood flow to the tissues, and its return to the heart, also improves homeostasis in the health and function of the body (Chasse 2015, Vignes 2017).

Developed by Michael and Ethyl Foldi in 1970, Complete Decongestive Therapy is a two-phase treatment program: the Intensive phase and the Self-care phase. The Intensive phase consists of skin education, manual lymph drainage, limb clearance exercises, and multilayered compression bandaging. The Self-care phase is the maintenance program, and consists of the same four steps as above, except that manual lymph drainage is performed only when needed, and the bandaging system progresses to daily wear of compression garments, with foam-channeled compression during sleep if needed.

The frequency and duration of treatment is determined by the stage and severity of lymphedema. In terms of frequency, recent efficacy research by Vignes et al. reveals that, during the Intensive phase for recent onset upper limb lymphedema, 11 consecutive days of treatment decreased the limb more than or equal to 75%; those results were not obtainable in the 4 consecutive day intensive program for cancer related upper limb lymphedema. My clinical experience, combined with my studies, suggests that patients with stage 1 lymphedema require 1-2 weeks of 5 days per week. Stage 2 lymphedema requires 3 weeks of 5 days per week. Stage 3 lymphedema requires 4-5 weeks of 5 days per week. In terms of duration, the amount of time spent performing MLD and bandaging is determined by the severity of the lymphedema, and further based on upper limb versus lower limb swelling. In patients with upper limb lymphedema, I allow 45-60 minutes for manual lymph drainage and 20-30 minutes for bandaging. In lower extremity lymphedema I allow 60-75 minutes of manual lymph drainage and 30-40 minutes of bandaging.

I have observed that thorough clearing of the trunk during Complete Decongestive Therapy improves the effectiveness in reducing the volume in the limb. If the patient has bilateral limb lymphedema I will give treatment to the more severe side. I treat the other limb when we have achieved our desired results with the severe limb. In the meantime, the less severe side will benefit from treatment on the most severe side because the treatment will increase lymph flow throughout the body if performed effectively (Bozkurt et al 2017).

SKIN EDUCATION

Soon after I received my lymphedema certification, a patient arrived for her Complete Decongestive Therapy treatment stating she had body aches; redness was spreading up her arm. I immediately contacted her physician and sent her to the emergency room. By the time she was admitted, she had severe cellulitis, requiring hospitalization for one week. The culprit was a paper cut.

As you can see, skin care is an important part of lymphedema treatment!

Intact skin is the normal barrier that protects the body from the entry of pathogenic microorganisms. If that barrier is breached, and the lymphatic system is fully functioning, the immune system will destroy pathogens via inflammation, which causes an increase of white blood cells and histamines in the area. The histamines create gaps between the endothelial cells, causing the proteins to leak into the interstitial space. A **functional reserve** will cause the lymphatic vessels to contract more frequently, allowing the increased **lymphatic load** to be transported to the lymph nodes for phagocytosis.

In a person with a compromised lymphatic system, however, the **transport capacity** (the system's ability to transport an increased volume more frequently) is less than the lymphatic load. Lymphatic insufficiency, or **low output failure**, will result: the lymphatic precollectors and collectors are no longer able to transport the lymph fluid. Lymph fluid becomes stagnant in the interstitium, causing a decrease of

absorption which results in an increase in protein concentration, macrophage activity, fibroblasts and fibrosis. The patient will develop cellulitis and consequently lymphedema.

During the evaluation, I educate patients about skin care precautions using the following handout:

1. Avoid extreme temperatures. This includes hot baths, hot tubs, hot showers, and saunas. This also includes burns from cooking, smoking, and the sun, and travel in hot or cold climates.
2. Avoid manicures and pedicures, and do not cut the cuticles.
3. Avoid routine medical interventions on the affected limb. This includes blood samples, injections, vaccinations, blood pressure cuffs.
4. Avoid abrasions to the skin. Wear insect repellent to avoid insect bites, wear protective clothing, resist pet scratches and skin punctures, use an electric razor.
5. Avoid constricting clothing and other items that interfere with circulation. This includes jewelry, belts and heavy breast prostheses.
6. Avoid harsh chemicals and abrasive compounds.
7. Wear protective clothing when gardening or using strong chemicals.
8. Use a low ph hand lotion such as Eucerin on the affected limb.
9. Avoid lifting heavy objects. Restricting the weight depends on the person's strength and build. A person of average weight should limit lifting to 15 pounds; a smaller-framed person should limit lifting to 5 pounds.
10. If the skin is broken, promptly wash it and treat it with an antibacterial medicine, followed by a sterile dressing.
11. Report any signs of skin infection such as redness, soreness, fever, or body aches.

(I also educate about diet, especially reducing salt intake. If you find you're not getting the results you want in treatment, query your patient's intake of salt. While it may be easier to prepare a frozen dinner or eat out, due to lack of function, it is important to be aware that many restaurant foods and frozen foods are heavily salted, and their consumption can significantly increase swelling.)

MANUAL LYMPH DRAINAGE

NOTE: this section provides an overview of the manual lymph drainage process. I strongly urge you to take a hands-on training course if you plan to perform manual lymph drainage. Both Guenter Klose and Steven Norton have excellent lymphedema training programs; the Vodder Method is another more methodical, concrete option.

Manual lymph drainage (MLD) is a hands-on therapeutic treatment approach. It applies a gentle and rhythmical external pressure to the skin and fascia to influence the lymphatic vessels to contract, moving the lymphatic fluid from the capillary bed to the precollectors where the lymph flows from one lymph angion to the next and ultimately back to the circulatory system. Manual lymph drainage not only

stimulates the lymph nodes to release fluid from the efferent lymph vessels, but also decreases inflammation and reduces connective tissue adhesions.

The lymphatic fluid contains water, waste products, white blood cells, proteins and fats. Leaving the capillaries, the lymphatic fluid moves through lymph collecting vessels, to specific lymph node regions, to lymphatic trunks and ducts. If there are restrictions in the trunk that restrict the flow of lymph fluid in the lymphatic trunks or ducts, it will slow the flow of lymph fluid or cause stagnation in the extracellular spaces. Likewise, if there is damage to lymph nodes, it will slow the movement of lymph fluid from the interstitium to the lymph nodes. And if there are restrictions in the region of the terminus, it will reduce the flow of lymph fluid to the venous return via the subclavian and jugular veins.

The goals for MLD are to reduce the lymph blockages, re-route the lymph fluid to functional lymph node groups, stimulate lymph angion motoricity, and improve lymph transports. The effects on the body are to stimulate lymph vessel transport, reduce edema, reduce scarring in the connective tissue, remove waste products, relax the sympathetic nervous system, decrease pain, promote healing, and support the immune system.

Manual lymph drainage is indicated in people with lymphedema, edema, immobility, wounds, arthritis, chronic pain, complex regional pain syndrome, and toxicity from medications. It is contraindicated in people with active skin infections, acute deep vein thrombosis, recent abdominal surgery, radiation fibrosis, aortic aneurism, diverticulitis, and pregnancy. Use precautions and consult with the patient's physician when the patient has arterial disease, malnutrition, cardiac edema, kidney disease, hyperthyroidism, thyroid or liver disease, hypersensitivity of the carotid sinus, and unexplained pain. In cases of cancer, manual lymph drainage will not increase tumor size or cause any harm to the patient; however, the patient should be seeking additional medical care due to the malignancy. Palliative care using manual lymph drainage is also an option.

It is best to perform manual lymph drainage skin on skin. If either the patient or the practitioner is uncomfortable, gloves can be used, or a thin sheet can cover specific regions of the body.

Prior to performing manual lymph drainage, begin treatment with a breathing exercise emphasizing the abdomen. To begin, have the patient bend their knees and palpate the abdominal turgor. Assess how much abdominal pressure your patient can tolerate by observing discomfort signs in their expression, and be sure to stay within their comfort range. Apply pressure to their abdomen while asking them to give you a deep abdominal breath. Begin with your hand on their umbilicus. From there picture two triangles, one from the umbilicus to the ribs and the other from the umbilicus to their anterior superior iliac spine. After the umbilicus, move your hand inferior to the right ribs, next inferior to the left ribs. As their abdomen rises

into your hands, apply pressure to resist the movement. This action will increase the intra-thoracic pressure to create a suction of lymph fluid in the ducts.

Be aware that some patients have difficulty breathing deep into and expanding their abdomen. The most effective way to help them is to explain how that breathing anatomy and physiology works: show them a video of how the diaphragm moves during respirations, and make sure they understand what they're seeing. Do they know their diaphragm is their major breathing muscle and it is located under the lungs and above the liver, stomach, and spleen? When they breathe in does the diaphragm go up or down? Does it concentrically or eccentrically contract during inspiration? Feeling their lower rib angle, does it narrow or expand during inspiration? To strongly drive your point about abdominal expansion during inspiration, have them compare tightening their abdominal muscles and walking around the room to relaxing their abdominal muscles and walking around the room. They will quickly see how much more flexibility they have when they breathe into their abdomen during inhalation (http://franklinmethod.com).

Yoga, Reiki, and acupuncture may be additional beneficial tools for opening up breathing pathways. I have also used easy-to-obtain essential oils like peppermint, spearmint, or eucalyptus while teaching breathing exercises: the oils help to stimulate the limbic system, which makes the connection between smelling the oils and improved breathing. (We will discuss essential oils and aromatherapy further under Alternative Treatment Approaches.)

As we move into manual lymph drainage, remember that functioning lymph nodes receive fluid from the collecting lymph vessels via the afferent vessels, process it, and release it via the efferent vessels. So to begin, let's review Vodder Method strokes – manual techniques that are used to effectively stimulate the function of the lymph nodes.

Stationary circles are performed on lymph node groups and are used to empty lymph fluid from the lymph nodes. Perform by placing the palm of the hand and length of the fingers, if possible, flat on the lymph node groups. The hand moves in slow 4-second circles (the direction doesn't matter).

The **pump stroke**, or the pump, is used to move lymph fluid from one region to another. It is mostly used on the trunk and the lateral sides of the limb. To perform, place the web of your hand on the lateral side of the body with the palm facing the direction that you will transport fluid to. Compress your hand to the body and give a nudge towards the direction you'll be moving fluid to. Allow your hand to naturally recoil, and return your hand to the web position.

The **spiro-stroke** is used to move fluid from one region to another and is used on the lateral trunk from proximal to distal or distal to proximal. It can also be used to transport fluid from one side of the body to another, and on the extremities to move fluid from distal to proximal. To understand the concept of the spiro-stroke, recall

Spirograph, the children's toy that makes beautiful designs: imagine making these designs on the body. Glide your hand 3-10 cm on the tissue in the direction you are moving fluid to. Lift your hand off the skin and loop back around so that you are one third away from you last starting point. Remember, when you loop back around, your hand is *off the body*: fluid is never pushed backwards. You continue with this stroke until you've reached the region you are sending the fluid to.

The **rotary stroke** is used to move fluid from one side of the trunk to the other side. Place your fingertips of one hand on top of the anterior or posterior thorax or abdomen. Draw your thumb to your fingers, flatten your hand, and nudge your hand to the direction you are moving fluid to. Continue with the stroke from one side of the body to the other side of the body.

The last stroke is the **scoop stroke**. This stroke is used on the limbs. Contact the lower limb with your full hand and fingers. Rotate your hand clockwise as you glide your hand up the limb.

Each of these strokes should be performed smoothly, allowing the lymph nodes enough time to empty and fill. A healthy lymph system transports fluid every 4 seconds; an impaired system will be slower depending on the severity. The following osteopathic approach helps to establish a palpable baseline of lymph flow for each patient.

Lymph fluid moves from distal to proximal, so it is best to begin palpating lymph flow at the most proximal region of the body, just prior to the terminus (location where the lymphatic system ends). Gently place your fingers superior and lateral to the sternoclavicular joint. Imagine the gentle flow of fluid moving from the bronchomediastinal trunks to the thoracic duct. It may feel like a gentle "swoosh" under your fingers. Count how many seconds between each "swoosh." Ideally, the amplitude should be strong and the flow of lymph fluid should be felt every 4 seconds. In someone with lymphedema the amplitude will be weak and the frequency will be longer. Make a mental note of the time between each movement of lymph flow. Next, place a finger of one hand below the xyphoid process and the other gently above the sternal notch to palpate the flow of lymph fluid in the thoracic duct. Next, sitting at the head of your patient, gently place your fingers in the axilla palpating for the flow of lymph fluid from the efferent vessels of the axillary lymph nodes. Next, standing lateral to your patient, place your fingers medial to the anterior inferior iliac spine of the pelvis where you will be able to palpate the lymph fluid exiting the inguinal lymph nodes.

You can also palpate the flow of lymph fluid in the affected limb. For upper limb lymphedema, place your fingers of one hand on the axilla and your other hand on lymph vessels medial to the biceps muscle close to the median nerve to palpate the amplitude and frequency of lymph flow in the lymphatic vessels. Again, normal is a strong amplitude every 4 seconds. Move your fingers to the lymph vessels on the mid anterior surface of the patient's arm along the median nerve to the same lymph

vessel location medial to the biceps muscle. Palpate the amplitude and frequency of lymph flow in the vessels in the right lower arm. Repeat these same steps by placing your fingers between the thenar and hypothenar eminence. Compare your findings to the other side: if there is no swelling on the left side the amplitude and frequency will be stronger. The same procedure can be performed for the lower extremities. Lower extremity lymph vessels are located medial and posterior to the leg.

Training is available to help you improve your ability to palpitate lymph flow: Bruno Chikly, for example, offers a course.

Prior to treating the affected limb(s), manual lymph drainage begins by clearing the trunk. Think of a large warehouse store. Let's say there are 10 cashiers at 10 cash registers waiting to check out 50 people. But some of those lines have only 2 people in them, and others have 10 people in them. The people in the long rows are not able to see that there are short lines available. Now, add a person at the front of the lines re-directing traffic, assisting people in moving from the long lines to the shorter lines. Customers are able to flow through the checkouts much more efficiently! This is similar to relieving the lymphatic congestion in a limb. Making more space at the front of the line (the trunk) helps the back of the line (the limb) to move more quickly. This is why we clear the trunk prior to treating the limb. And the greater the lymphatic congestion, the more time and expertise is required to clear the trunk.

Some approaches to clearing the trunk work to decrease the strain on the immune system, lymphatic vessels, and lymph nodes, which improves function. In cases where patients have heart, lung, breathing, or digestive impairment, or scar tissue that causes lymphatic restriction, I use visceral manipulation to reduce fascial restriction and improve lymph flow around the affected organ and/or area. Donald Ingber researched cell function, and found that if you change the surface tension of a cell, you change the function of the cell (Ingber 2013). For our purposes, if there is tension from the surrounding tissue on the lymph vessel, it will impede its flow. Decreasing connective tissue adhesions and tension along pathways where the lymph travels can improve the movement of lymph fluid in the lymph vessels. Likewise, when I observe biomechanical and postural mal-alignment in a patient, I use Diane Lee's Integrative Systems Model or George Roth's Matrix Repatterning. I also use Dynamic Neurocognitive Imagery (DNI), a treatment approach that teaches relevant anatomy to patients so that they can better focus their attention on the region of the body they or the practitioner is working on. Research (Grecucci et al 2015) has shown that this increased awareness helps the brain and emotions trigger improved function, and my clinical experience backs these findings. To take a single example, I used DNI during a treatment session with a patient with scleroderma (an autoimmune connective tissue disorder that affects the immune system, vessels, and extracellular matrix, causing fibrosis in the skin and internal organs). I explained the process of the circulatory system and capillary physiology, using imagery to enhance her understanding. Palpation was used to assess lymph flow prior to treatment and following treatment; lymph flow increased significantly.

In fact lymph flow is increased, and therapy is more effective, following all these procedures.

Begin manual lymph drainage by using stationary circles on the lymph nodes closest to the terminus. The stationary circles at the neck are performed by placing the lengths of your fingers, not fingertips, between the base of the neck and clavicle. Slowly and gently move your hands in four-second circles until the fascia softens. You are working with the superficial lymph nodes, meaning you don't use a lot of pressures. As you're stimulating lymph nodes to empty in the neck region, the fascia in this region will soften. The decreased tension on the fascia allows the lymph nodes to improve their function and allow an increased flow of lymph back to the circulatory system via the right and left venous angle.

The abdominal and pelvic lymph nodes are deep. Some of them are located just anterior to the sacrum and many surround the colon, small intestines and pelvis organs. Your depth will depend on patient tolerance. Stationary circles will be performed over the descending, transverse, and ascending colon. Place your hand (one hand over the other if needed) over the descending colon with your hand medial to the pelvic bone. Move your hand in slow four-second circles until the fascia softens. When the fascia has softened move your hand to the transverse colon on the left, middle and right. Repeat the four-second circles until the tissue softens. Finally, place your hand over the ascending colon and repeat. NOTE: This region of the body may take as long as 20 minutes at the first treatment. Do not rush, or feel pressured to move on to the affected limb on the first day. It is important to release lymph fluid from the abdomen.

As you move on in the treatment, consider both the limb that is affected and where you want to transport lymph fluid to. Let's look at some specific examples.

PATIENT #1
The most common cause of lymphedema in North America is a result of cancer treatment (Liao et al 2004), so consider a patient with right upper extremity lymphedema who is status post lumpectomy, lymph node dissection, and radiation therapy. The right axillary lymph nodes have been removed and radiated and there is scar tissue in the right axilla. Also, there is scar tissue on the right breast and scarring of the connective tissue from the lymphedema in the arm.

In the case where the right axillary lymph nodes are not functional, you will transport fluid from the right limb, the left axillary lymph nodes, and the right inguinal lymph nodes where the lymph nodes are functional. The remaining manual lymph drainage will be stimulating the flow of lymph fluid from the subcutaneous lymph nodes and lymph vessels.

Begin with a breathing exercise, like the one discussed previously, to increase lymph flow in the thoracic duct. After that, place the palm of your hand on the left axilla and move your hand in four-second gentle stationary circles until the tissue softens.

Next move your hand to the right inguinal lymph nodes and repeat the same movement patterns. If the patient is not comfortable with your hand in their groin, you may place their hand in the location to be treated and place your hand on top.

Now you are ready to move onto clearing a pathway from the affected limb to the functional lymph nodes. Normally the lymph vessels are filling and contracting to send lymph fluid from the right quadrant into the lymph nodes. Since the lymph nodes are not functional, you will transport the lymph fluid from the right axilla to the left axilla. You will use begin by using the rotary stroke to increase lymph flow from the left upper quadrant to the left axilla by placing your fingertips at the sternum along ribs 2 & 3. Draw your thumb to the fingertips, flatten your hand and give a slight nudge toward the left axilla. Allow your hand to naturally recoil. Lift the center of your hand so that your fingertips are touching the rib cage, and repeat the sequence, progressing to the axilla. Apply the same sequence at ribs 4 & 5, 5 & 6, 6 & 7, and 7 & 8. The fascia will begin to soften between 5-8 repetitions. Once you palpate that the fascia has softened in this region, you are ready to move your fingertips to the right axilla and repeat the same sequence from the right axilla to the left axilla. When you have completed making pathways for lymph to flow on the anterior side of the body, you will also perform this on the posterior side of the body. You will find it particularly effective for patients that have scar tissue on the anterior side of the body.

Next you will make a pathway from the right axilla to the right inguinal lymph nodes: the most effective stroke here is the pump stroke. To perform the pump, place the web of your hand at the lateral side patient's waist. Flatten your hand and give a nudge towards the direction of the lymph nodes. Let your hand naturally recoil. Lift your hand with only the inner web touching the lateral side of the body. Continue with this movement toward the right inguinal lymph nodes. Perform this motion until you feel softening of the fascia, approximately 5-8 times. To help transport the lymph fluid from the upper right quadrant to the lower quadrant, place the web of your hand below the axilla. Repeat the same sequence from the right axilla to the right inguinal region. (Female patients can lift their breast tissue to reduce discomfort from the practitioner's hand.) Once you have completed this step, have the patient lie prone and repeat the sequence on the posterior side, moving lymph fluid from the right axilla to the left axilla and from the right axilla to the right inguinal region.

Once the trunk has been cleared, you can perform manual lymph drainage on the right upper limb.

Begin using the spiro-stroke on the proximal upper arm, beginning at the elbow to the top of the humerus. Using the palm of your right hand and fingers, glide along your patients' arm approximately 4 cm, lifting your hand up into a full circle so that your hand gently lands 2 cm proximal to the beginning of the last stroke. With the patient's arm by their side, use this stroke for the lateral, medial, anterior and

posterior surface of the arm. Notice when the tissue begins to soften – this will be after approximately 5-8 times.

Next move your hand to the wrist and repeat the same sequence for the lower arm to the top of the humerus. You'll use strokes on each surface of the arm; lateral, medial, anterior, and posterior. As you glide and lift, consider the subcutaneous lymphatic vessels, very fragile under the skin. Each time you place external pressure on the skin, you are stimulating the lymphatic vessels to contract, moving lymph fluid to the next lymphangion. You are also softening the epimysium that surrounds the muscle. Within the muscle is another fascial layer called the perimysium covering a bundle of muscle fascicles, and around each fascicle is another fascial layer called the endomysium. With each stroke consider how light pressure on each fascial layer will soften the muscle and decrease lymph congestion. Notice how the skin begins to be more pliable.

Repeat the same stroke on the dorsum of the hand (lymphoscintigraphy imaging reveals lymph fluid backup in the hand when a patient with a compromised lymph system exercises without external compression). When performing the spiro-stroke on the hand, use smaller strokes.

A good finishing technique for the arm is the scoop stroke. Holding the limb in one arm, use your other hand to create a corkscrew movement from the lower arm to the upper arm.

To summarize manual lymph drainage for a patient with right upper extremity lymphedema who has right axillary lymph nodes that are not functional: perform the breathing exercise, empty the bilateral neck lymph nodes, empty the abdominal lymph nodes around the colon, empty the left axillary and right inguinal lymph nodes, clear a pathway from the right axilla to the left axilla on both the anterior and posterior surface, clear a pathway from the right axilla to the right inguinal region, drain the lymph vessels in the right upper arm, drain the lymph vessels in the right lower arm, drain the lymph vessels in the right hand, and finish with an overall scoop of the right arm.

PATIENT #2

Now let's picture a male patient with primary lymphedema stage III, with severe swelling in both legs, but the right leg is larger than the left leg. As you may recall, primary lymphedema is a condition that is hereditary; usually something occurs in the patient's life to exacerbate the swelling. For example, in one patient, it was a weight gain from 200 to 230 pounds. In another patient, the swelling began after his time in the service, where he spent excessive time with his feet in a toxic chemical; in another, it occurred after an abrasion to the lower leg. Due to faulty lymph nodes, lymph vessels, or valves, the lymph fluid backs up and becomes stagnant. The lack of lymph transport and stagnant lymph fluid can cause connective tissue damage. This person will need manual therapy to move the lymph fluid out of the leg to the lymph nodes, lymph trunks, and lymph ducts.

Begin with a breathing exercise; next perform manual lymph drainage at the terminus, where the lymph system terminates. Perform stationary circles by placing the length of your fingers between the clavicle and the base of the neck. Gently and slowly, move your fingers in 4-second stationary circles on the neck lymph nodes until the tissue softens. This may require 20-30 strokes. You may either sit or stand behind the patient and perform stationary circles on both sides at once or stand on one side of the patient as you reach your hand across their body to the contralateral side.

Your next region of stationary circles will be around the colon, beginning first with the descending colon, second with the ascending colon, and third with the transverse colon. I spend an average of 20 minutes in the abdominal region during the first three days of treatment. Recall there are 100-200 lymph nodes in the abdominal region. Some of the lymph nodes are superficial, some surround the colon, and some are located deep in the pelvis. The abdominal and pelvic lymph fluid must be removed from the lymph nodes in order to receive more lymph fluid. If lymph fluid can't move from the legs to the abdominal or pelvic lymph nodes and lumbar lymph trunks, then fluid will continue to stay stagnant within the lower extremity tissues.

Next perform stationary circles on the right then left axillary lymph nodes followed by the right then left inguinal lymph nodes. Place the palm of your hand in the axilla as you move your hand in slow four-second circles. Notice the movement of the tissue during your stationary circles. The resistance in the tissues should soften as lymph flow increases. To perform stationary circles on the lymph nodes in the groin, place the palm of your hand in the groin with the hypothenar eminence (edge of your hand) close to the edge of the pubic bone. If a patient is uncomfortable with your hand close to their groin, place their hand or a bean bag on their inguinal lymph nodes and your hand on top of their hand as you move their hand in slow circles.

Next, you will use the pump or the spiro-stroke to move lymph fluid from the inguinal region to the axilla on both sides of the body.

Although you will clear all the lymph node groups for the right and left trunk, you will only perform manual lymph drainage on one limb: by stimulating lymph flow in one leg, you will also stimulate lymph flow on the contralateral side. I often choose the larger limb: the smaller limb will naturally decrease since you are increasing lymph flow throughout the entire body by moving fluid out of the larger limb. (Also, be aware that most patients have a difficult time staying on a treatment table for more than 90 minutes; in addition, the time it takes to clear both legs is more than what most third party and private payers will pay.)

You can use the pump stroke here: in standing, you will perform this stroke on the right side of the patient's body using your left hand and on the left side of the

patient's body using your right hand. Place the web of your right hand on the waist, compress the palm of your hand on the trunk and give a slight nudge towards the axilla. Allow your hand to naturally recoil as you lift your palm off the trunk. The web of your hand stays in contact with the trunk. Move your hand 3 cm distal from the beginning and repeat the same stroke. Continue with this stroke to the axilla and repeat at least 5 times. Next place the web of your hand at the greater trochanter and repeat the pump to the axilla. Repeat this stroke 10 times from the greater trochanter to the axilla with slow movements spaced closely together. The reason for this is that the lymph angions are placed closely together.

You may substitute the spiro-stroke for the pump: it is easier to do this stroke in a sitting position. The spiro-stroke begins at the waist where the natural anastomosis is and ends at the axilla. Picture a wheel rolling on the skin as the palm of your right hand glides 5 cm on the skin with a slight pressure, and lifts off in the direction of a wheel as the palm lands on the 3 cm mark of the skin. This process continues up to the axilla. Repeat the strokes from the waist to the axilla 5 times. Next place the palm of your hand on the greater trochanter and repeat the same stroke and process 10 times. Repeat these strokes on the contralateral side of the body. The procedure is meant to be slow, since lymph fluid pumps slowly between each lymph angion at approximately every four seconds.

As you address the lower extremities, if the lymph nodes are functional, you will direct lymph fluid to the inguinal lymph nodes. If they are not functional, such as in a case of someone who had cancer treatment where the lymph nodes were destroyed, you will direct the lymph fluid to the greater trochanter, sending the fluid to the axilla instead of the inguinal lymph nodes. Let's assume that Patient #2 has had post-operative cancer treatment, so we will focus on directing fluid to the greater trochanter.

Begin using the pump or the spiro-stroke on the right lateral leg. If you use the pump, perform the stroke with your left hand; if you use the spiro-stroke, take a sitting position and perform the stroke with your right hand. The pump is performed beginning with the web of your hand between your thumb and second finger. Flatten your hand and give a 3 cm nudge towards the axilla. Recoil as you lift your wrist off the tissue with the web of your hand still in contact with the skin. Repeat the sequence from the right knee to the right greater trochanter approximately 10-20 times. An indicator that lymph fluid is moving is the sense of softening of the tissues. Repeat the same sequence on the anterior thigh, moving the fluid from the anterior thigh angling up to the lateral thigh. Next place your hand on the inside of the right thigh and use the spiro-stroke from the inside of the thigh, over the anterior thigh, to the lateral thigh with an upward diagonal angle. Repeat 10-20 times or until the tissue softens.

To transport lymph from the right lower leg to the right upper leg, begin with your left hand on the lateral ankle, using the pump or spiro-stroke, moving lymph fluid to the lower thigh. Repeat the sequence 10-20 times. Next place your hand on the

medial ankle using the spiro-stroke from the ankle to above the medial knee, gliding from the medial knee to the lateral thigh. Place the length of your fingers or the palm of your hand just proximal to the toes. Use the spiro-stroke to glide your hand with small strokes to the ankle, repeating 10-20 times or until there is softening in the tissues. Using your fingers on each toe, move lymph from the distal to the proximal foot. Finish off the lower leg with the scoop stroke, corkscrewing from the lower leg to the lower thigh. (If the leg is too heavy to lift for the therapist then you may skip this step.)

Before turning the patient over to transport lymph flow on the back of the leg, make 5-10 stationary circles on the right axilla and right groin, to create the space to transport more fluid from the limb into the lymph node regions. Then have the patient lie prone; alternately, side-lying (on the non-treating side) is acceptable if the patient is unable to lie prone. Perform spiro-stroke or the pump technique from the right greater trochanter to the right axilla 5 times. Next use the spiro-stroke from the right ischial tuberosity over the buttocks to the lateral pelvis 10-20 times. Place the palm of your hand on the right posterior knee while using the spiro-stroke to transport fluid from knee to the buttocks. After repeating 10-20 times, repeat the same sequence from the right ankle to the posterior knee, and again from the distal foot to the ankle.

This procedure can take only 60 minutes if you don't wait until the tissue softens, especially in the abdomen. However, it's important to spend adequate time on the regions that are congested, otherwise fluid will not be able to pass through those regions. I take the time to clear each region – even though I may not finish the limb that day. To mitigate the time crunch, I often teach family members how to perform manual lymph drainage. A great time to give them instruction is when you are treating once side of the body: they can mirror you on the other side, allowing the patient to get double the treatment.

LIMB CLEARANCE EXERCISES

The lymph vessels and lymph nodes are surrounded by fascia. The fascial system interconnects the body to itself: it communicates force and movement from one place in the body to another distant place in the body through myofascial slings. When muscles move limbs, muscle contractions cause fascia to bulge around them and narrow again, moving the nearby fascia, resulting in an external stimulation of lymph vessels and lymph nodes.

In patients with lymphedema the fascia tightens and thickens as a result of the nearby inflammation. Patients can learn to decrease fascial tension by moving the yellow Franklin Method ball on their skin; although a full discussion of the method is beyond the scope of this course, interested readers can learn more about fascia, mindfulness, and movement through the Franklin Method Workshops (http://franklinmethod.com).

Gentle stretching and strengthening exercises with a therapeutic band, such as the following, stretch the fascia (Chikly 2005) and stimulate lymph flow in the subcutaneous tissues. 1) Place each foot on the ends of an eleven foot therapeutic moderate resistance band. With your hands holding the middle of the band, reach up to the sky, gently stretching the band. Keep your hands up and bend your torso to the right as you stretch the fascial fibers and the subcutaneous lymph vessels on the left, and repeat on the left. 2) Place the center of the band around your back and hold the ends of the band in your hands. Stretch your arms out to each side like wings. Feel a slight stretch on the band as you flex and extend your spine and shift your spine from right to left. 3) Place a foot on each end of the band and place the middle of the band on your head. Next position one hand on the top of your head with your fingers over the band, and the other hand on your back with your fingers touching the tailbone. With your hands in place and the band connecting your feet to your head, curl your spine forward and back like a standing "cat cow" movement. This exercise in particular will stimulate the fascia around the spinal cord and will encourage lymph flow.

As we've seen, the lymph vessels and nodes rely on the nearby muscles and joints to contract and relax, stimulating lymph flow. To continue to stimulate lymph flow, give your patients exercises that increase functional activities and active range of motion.

You have already learned there are 160 lymph nodes around the neck region, and the right lymphatic duct travels along the medial border of the anterior scalenes muscle. The scalenes muscle originates at the transverse processes of C2-7 and anchors to the first and second rib. The action of the scalenes muscle is to side bend your head; also, during inhalation, the scalenes muscles lift the top ribs towards the neck. First, notice how it feels to side bend your neck. Then place your fingers on the scalenes muscle. Slide your fingers up along the muscle on inhalation. Simultaneously, imagine you are pulling up the top ring of the ribcage through the scalenes to make more space in the ribcage. When you exhale allow your hand to relax. Repeat this 5 times. Notice if the exercise changed your breathing, and how it now feels to side bend your head.

There are 33 lymph nodes in the axilla; if lymph nodes have been removed it is more likely that the tight fascia will limit lymph movement. First lift your shoulder blades up and down and move them forward and back. Notice how the movement feels. Now use a metaphor such as imagining your shoulder blades are slippery bars of soap: when you lift them up they glide smoothly; when you lower them they descend with ease. Repeat the original movement 5 more times, and notice how it compares to the first time. Next, place a rolled up wash cloth or a soft purple plush Franklin Ball under each arm. Repeat the same movement up, down, forward, and back 5 times. Again compare this movement to the original. Finally, lift your arms above your head and notice the flexibility in your shoulders.

The inguinal region has approximately 11 lymph nodes. The pectineus muscle, which functions as an adductor and also assists the iliopsoas muscle in hip flexion, is located close to the lymph nodes. The origination of the pectineus muscle is along the superior ramus of the pubis, and it inserts along the inner aspect of the thigh. While standing, place your finger tips on the pubic ramus and feel the pectineus muscle engage as you flex the hip. Tap along the muscle as you lift your leg up and down. Do this 5 times. Stand and compare the two sides. Repeat on the other side.

The iliopsoas muscle is a strong hip flexor; when the muscle contracts, the fascia around it bulges. While standing, flex your hip and knee then extend it again. Think about the fascia bulging outwards as you lift your leg and narrowing as you lower your leg. Repeat this 5 times. Stand and notice the difference between the two legs. Repeat on the other side. Perform the same exercise, and this time imagine that the movement is hugging the lymph nodes found in the groin, whispering to the body that it can release the lymph fluid in the lymph nodes and allow more fluid to enter. Repeat this exercise 5 times.

In addition to simple movement exercises, aerobic activity increases lymph flow tenfold; however, some patients have functional restrictions causing them to be sedentary, so always consult with the physician regarding the amount of aerobic activity that is desired. Swimming is not only a full body aerobic activity, but the water compression can also stimulate lymphatic flow. Rebounding is another way to stimulate lymph flow: jumping on a trampoline for 20-30 minutes moves the lymph while stimulating blood circulation through the body (Downey et al 2008).

Finally, increase the patient's sense of body awareness through proprioception activities. One of the proprioceptive properties is the sense of heaviness (Aman et al 2015). Other proprioceptor sensors are muscle spindles in the stretch receptors, golgi tendon organs located in the tendon that sense tension on a muscle, and pacinian corpuscles that detect changes of movement and pressure. Tapping on the thorax and affected limbs will stimulate proprioception, just as moving your joint during active range of motion increases your proprioception (Franklin 2013).

NOTE: To prevent a backup of fluid into the limbs, all exercises are performed with compression bandages or garments on.

COMPRESSION BANDAGING & COMPRESSION GARMENTS

Compression is used for all three stages of lymphedema. Compression bandaging, foam channeled garments, and compression garments provide the skin with the amount of tissue compression required to stimulate lymph movement. Bandages and garments must be worn with more compression distally than proximally. This is a skill that comes with training and practice.

Contraindications for layered bandaging and garments are: arterial disease (signs include a diminished pulse, and impaired skin integrity consisting of pale, blue,

smooth, shiny, and clammy skin, with a possibility of arterial ulcers.), arterial ulcers (normally found in the lower leg, they are classified as small round non-deep ulcers with very little drainage, and are painful with the limb elevated), signs of infection, or wounds. Both arterial disease and arterial ulcers are a red flag in general, and can be confirmed with an arterial Doppler or perfusion test (Brigham and Women's Hospital Inc. 2007).

We will begin with a discussion of bandaging, and move on to garments afterwards.

COMPRESSION BANDAGING

Layered short stretch compression bandages are used during the day and night for the intensive phase of treatment, and at night during the self-care phase of treatment. The layered bandaging is necessary because the skin has been overstretched by chronic protein rich edema, and the fascia has become tight, preventing healthy movement of lymph flow. It increases lymph transport during functional activities, and prevents re-accumulation of the pre-evacuated fluid.

The layering consists of a closed meshed tubular stockinette, finger bandages, thick cotton non-woven padding and/or medical grade grey foam, and short stretch compression bandages. The thick cotton filler between the tubular stockinette and the short stretch non-elastic bandaging applies pressure to help evacuate stagnant lymph fluid, and continues to add pressure when the limb gets smaller by filling up the space between the limb and the short stretch bandaging. Often the bandages become loose because the limb circumference is decreasing. As lymph fluid is transported to the lymph nodes, the filler takes up more space and continues to add compression.

Bandaging is applied following manual lymph drainage and should be worn during exercise. It needs to be removed and re-applied daily*. If there is any numbing, or the fingers or toes turn blue or purple, the bandages should be removed immediately.*

If the patient's insurance company pays for the bandages, you will need to coordinate with the third party payer to obtain them.

The therapist is the person who determines the types and number of bandages that will be used, depending on the size of the affected limb(s) and the duration of the treatment program. I personally have settled into Molelast, Tricofix for the tubular gauze, Artiflex for the filler, gray foam in addition to or in place of the Artiflex for the more excessively fibrotic tissues, and Comprilan for the short stretch bandages. I will be using these names as I discuss the specifics of bandaging. However, it is wise to test a range of compression bandages, to identify your personal favorites.

For the upper extremity, I suggest 1-2 boxes of Tricofix, (9) 10cm rolls of Artiflex, (6) 15 cm rolls of Artiflex, (3) 6 cm rolls of Comprilan, (6) 8 cm rolls of Comprilan, and (6) 10 cm rolls of Comprilan. For the lower extremity, I recommend 2-3 boxes of

Tricofix, (6) rolls of 10 cm Artiflex, (12) rolls of 12 cm Artiflex, (3) rolls of 8 cm Comprilan, (9) rolls of 10 cm Comprilan, and (9) rolls of 12 cm Comprilan. I keep a roll of ¼", 1/2" and ¾" sheets of lymphedema grade grey foam on hand, and use as needed. I also keep a roll of painters tape on hand (to hold the Comprilan in place). Some companies offer pre-prepared lymphedema kits for the upper extremity and lower extremity. I find that these kits don't have enough bandages, so the patient sometimes doesn't get their bandages washed in time or brings them to you still wet. If you order a kit, it is wise to have extra bandages on hand.

It's beneficial to begin instructing patients in self-bandaging at the beginning of treatment, so they will learn how to bandage themselves on the two days each week they are not receiving treatment.

Alternatives are available for those who are unable to self-bandage. Juzo sells Solaris products with foam channeled non-custom garments for the extremities that are easier to manage: they still require applying the short stretch bandage over the garment, but that does not take as much precision. Another option is a custom foam channeled garment with a jacket that is applied on top. Both Solaris (Juzo) and JoviPak (Jobst) have this option. The garment by Solaris is easier to apply but may not fit as precisely as does the JoviPak. Examine both versions: many use one company for one type of a patient and another company for the other. If the patient has the financial means (and does not require a customized garment), my personal preference is non-custom foam channeled garments followed by Comprilan. Many patients shy away from the initial cost, which is triple that of bandages alone. Realistically, though, the bandages lose their elasticity in 2-3 weeks and need to be replaced, making the cost similar in the end. Also, the non-custom foam channeled garments can be used for night-time compression when the patient is ready for the self care phase of treatment.

NOTE: Bandaging is an art, and is best if learned in a lymphedema-bandaging course. That said, let's talk through the process of bandaging a limb.

Prior to applying the bandaging, the skin should be moist: a low ph lotion can be used to prevent drying and cracking. Also, patients with stage 2 or 3 lymphedema most likely already have fungus on their toes; in any case, an antifungal cream should be applied to the toes. (I request that patients do both at home after showering; I also keep a low ph lotion in the office.)

The first layer applied in the multilayered bandaging is the closed meshed tubular stockinette, which is soft on the skin, protects the skin, wicks away moisture, and provides adherence for the next layer. Begin by choosing the correct size stockinette: the manufacturer will have a recommendation. In brief, though, the closed meshed netting can be lengthened four times by pulling on it; as it lengthens it will also narrow. Similarly, as you widen the tubular stocking, it will shorten. Since the lower leg is normally much narrower than the upper leg, choose the size that won't be too loose for the lower leg, and that will widen enough to fit the upper leg.

The stockinette I use is Tricofix, which is available in X-small (6cm x 20m), Small (8cm x 20m), Medium (10cm x 20m) and Large (12cm x 20m). The Tricofix will stretch both in width and length. When applying it to a limb with increased circumference the length will shorten. Therefore, it requires additional length than anticipated to accommodate for the increase in circumference. When measuring the amount of to use, the length of the Tricofix should be two and a half times the length of the leg, with enough to overlap 3 inches at the top. Do the same for the upper limb. Begin by placing the Tricofix on the limb from distal foot to upper thigh, close to the groin. Leave enough space to bandage the toes distally, and enough room that patients can void without getting their bandages wet. For the arm, make a small hole for the thumb, place the hand into the stockinette and pull it up to the axilla. The thumb will be placed through the hole.

Next apply bandages on the fingers or toes: open all the bandages with the outside layer on the skin as though you are unpeeling the roll. I use Mollelast (4cm x 4m). Anchor the Mollelast on the distal foot, or on the wrist, by wrapping it around the limb once. Take the Mollelast to the distal end of the digit and wrap the fifth finger two times without completely overlapping and without creating any type of a tourniquet effect. For the foot, begin with the fourth digit. Return to the dorsum of the hand so that you come in one direction and exit in the opposite direction. Take the Mollelast to the fourth digit and wrap the finger or toes one time from the distal to proximal digit, entering from one direction and exiting another direction over the dorsum of the limb. Continue with this process until each toe or finger is bandaged at least one time. There will be spaces showing skin at the web between each digit. Anchor a second bandage at the wrist and wrap around the proximal end of each digit. If you skip this step, there will be swelling in the web spaces.

IMAGE: mollelast

The next layer is the thick cotton non-woven padding, which provides comfort and protection, allows for a more even distribution of pressure, and is good for conforming to odd shapes such as elbow, wrist, knee, and heel. It takes up the space between the stockinette and the short stretch compression bandages. I use Artiflex, which is available in 15cm x 3m and 10cm x 3m. Open the roll with the outside of the bandage on the skin. Wrap from distal to proximal overlapping one third of the bandage. When bandaging joints, use the figure eight method with the "x" crossing on the cubital fossa or popliteal fossa for the greatest comfort. Create a thickness in this layer, since it helps make the increased tension from the compression bandages more comfortable. There is no need to tape these bandages, as they adhere to the tubular stockinette. These bandages are normally washed after each use.

IMAGE: artiflex

Grey foam not always used – when used, it is placed under padding to soften the indurated tissue. It is also used to decrease pressure over sensitive areas. It

provides a more uniform sense of surface compression. It is available in sheets and cut to fit.

IMAGE: grey foam

The final layer is the short stretch compression bandages. Made from 100% cotton, without elastic fibers, these bandages resist stretching and provide compression and high resistance to increase venous and lymphatic return. I use Comprilan, which is available in 6cm x 5m, 8cm x 5m, 10cm x 5m and 12cm x 5m. Use the smaller bandages first, and finish with the larger bandages. While bandaging, give a pull on the bandages to increase the tension on them. Follow bandaging protocol so as to avoid a tourniquet effect. The distal end of the bandaging will have more compression than the proximal end, but should not turn fingers or toes blue.

IMAGE: comprilan

The first bandage on the lower extremity is the 8 cm bandage. Place the foot in a dorsi-flexed position. Begin application at the distal foot to the malleoli. Anchor the bandage by wrapping around the foot once. Continue more proximal wrapping at a 30-degree angle to the ankle with overlapping on the last 1/3 of the bandage. At the ankle use a figure eight style wrapping. Next, wrap over your figure eight to the malleoli. Secure with painters tape only on the Comprilan, and discard the clip, which has sharp edges and is contraindicated in the skin care protocol. Use the 10 cm bandage from the malleoli up the midline of the leg, using the 30-degree angle and overlapping on the last 1/3 of the bandage. Omit wrinkles in the bandages. Secure with painters tape only on the Comprilan. When you run out of the bandage roll, add another 10 cm bandage and continue to the knee. At the knee use the figure eight pattern with the knee slightly bent 30 degrees. Bring the bandage back down the knee to fill in the uncovered spaces. Secure with painters tape only on the Comprilan. It's a matter of preference to use the 12 cm bandage in place of the 10 cm bandage at the knee. Following bandaging the knee, use the 12 cm bandage from above the knee up the thigh keeping the bandage at a 30 degree angle and overlapping the last 1/3 of each layer. Secure with painters tape only on the Comprilan. Repeat until you get to the top of the thigh. You can use a herringbone style of wrapping to improve the support. When you have completed bandaging, feel the bandages to verify they are tighter distally than proximally. (Remember, as the limb circumference decreases, the bandages become loose. Some patients like wearing bike shorts to help keep the bandages in place.)

Begin bandaging on the hand and wrist with a 6 cm bandage. Anchor the bandage at the wrist to the palm using a 30-degree, angle contouring the wrist without creating a tourniquet effect. Continue to bandage up the forearm. Similar to the leg, the bandage has increased tension distally. Secure with painters tape. Next apply the 8 cm bandage wrapping up the midline of the arm. When you get to the elbow, use a figure 8 wrap and fill in the spaces with the 30-degree angle. Omit any wrinkles and pull on the bandages to create tension without turning the fingers blue or causing

numbness. Next use the 10 cm bandage for the rest of the arm. You may need a second 10 cm bandage to get to the top of the arm (Protz et al 2017).

The bandages are worn throughout the intensive phase of treatment day and night; patients remove the bandages to shower just before their appointment time to minimize increase in lymph fluid. During the self-care phase, bandages are also worn at night if needed (recommended for anyone with stage 2 or 3 lymphedema).

During the intensive phase of treatment there should be ongoing training with the patient and caregivers to prepare the patient to manage self-care. Despite training, I have never had a patient or caregiver who could manage this care entirely independently; I aim for them to confidently manage the care in between three visits per week. This should be planned into your treatment program.

COMPRESSION GARMENTS

Compression garments are primarily worn during the self-care phase, which begins when the patient, therapist, doctor, and third party payers have reached the target reduction.

Maintaining limb reduction is crucial in this phase of treatment. The garment has a gradient compression with increased tension distally to assist in lymph transport and return to the circulatory system. In addition, the compression in the garment assists lymph transport by reducing the blood volume and the diameter of the superficial veins, preventing back flow of the lymph fluid and decreasing lymph and blood from pooling. It accomplishes this by increasing the pressure in the interstital fluid compartment and decreasing the spaces in the interstitium that allows fluid to leak out into the capillary beds. This improves the microcirculation in the blood by increasing the availability of oxygen and nutrients to the nearby tissues (Chasse 2015).

Depending on the size and severity of the limb, the patient will need either a custom made or non-custom made garment. The non-custom garment is determined by the size and length of the limb, whereas custom garments are precisely measured by a "fitter" to contour to the size and shape of the limb and to provide the most accurate amount of compression from distal to proximal. There are many compression garment companies: I recommend you meet with all of them so that you can choose the ones that have the best fit for each patient.

IMAGE: compression garments

I have the patient contact the fitter at the Durable Medical Equipment facility provided by their insurance at the beginning of treatment to determine how much lead time they need to set up an appointment and order the garment. Remember, the patient has to have reached the desired results in order to be measured for the garment, and then must wait for the garment to be made. This may take 2-3 weeks.

If the patient is not compliant with the interim phase of treatment in the meantime, the limb will get bigger and the newly measured garment will not fit.

A standard rule to follow for the amount of compression is: mild lymphedema of the arm should wear a class I garment with 20 mm Hg to 30 mm Hg, moderate lymphedema of the arm or mild lymphedema of the leg should wear a class II garment with 30 mm Hg to 40 mm Hg, severe lymphedema of the arm or moderate lymphedema of the leg should wear a class III garment with 40 mm Hg to 50 mm Hg and severe lymphedema of the leg should wear a class IV garment greater than 50 mm. Patients tolerate a lower amount of compression to begin with; as they continue to wear the garment, they find they can tolerate more compression. If you begin with more compression than they can tolerate, they may resist wearing the garment.

Patients should learn to put on and take off (don and doff) their garment from their fitter. It is recommended to wear dishwashing gloves that have a grip on the fingertips to put the garments on, and to avoid nails that may snag the garment. Garments should be washed daily in ordinary laundry soap without bleach or fabric softener. The garments will last longer if they are line dried. The garments should be replaced every 3-6 months due to the damage caused by wash and wear. Patients will require a minimum of two pairs of garments so that while one is being worn the previously worn garment is being washed. Research shows that patient whom are compliant with this phase of the program prevent their symptoms from worsening and continue to show improvement (Jones, Mansour 2017).

In addition to the compression garment, an intermittent compression pump can be beneficial during the self-care phase of treatment, giving abdominal and limb lymph stimulation. The pump has chambers that sequentially inflate and deflate in a gentle wavelike movement to assist in directing lymph fluid from the affected limb towards the circulatory system at the neck. Contraindications for the pump are: an acute infection such as cellulitis, deep vein thrombosis, congestive heart failure or respiratory insufficiency, when the limb is extremely painful, or in any case where increasing lymph flow to a region of the body is contraindicated (Karaca-Mandic et al 2015).

Contact the patient's insurance provider to clarify the criteria outline for adding a pump to the self-care program; also, contact the sequential compression pump companies for cash rate costs. Choose a pump that is gentle on the lymph vessels, and instruct the patient in breathing exercises to increase lymph flow in the thoracic duct and clear the selected lymph node groups that the pump may not stimulate (Mayrovitz 2015).

Alternative Treatment Approaches

In addition to Complete Decongestive Therapy, alternative treatment approaches can be used to support lymphatic flow. "Alternative treatment" refers to therapeutic interventions that are believed to have an influence on lymph flow in the body, but may not yet have extensive research verifying the results. Does that mean they shouldn't be used? Not necessarily. Remember, peer-reviewed research is only one element of evidence based medicine; the others are patients' goals and clinicians' professional experience.

So how do you know which alternative treatment approaches to use?

As we've seen, the keys to lymph flow are blood circulation, breathing, fascial flexibility, proprioception, the parasympathetic nervous system, and skin health. Consider some alternative approaches that you have studied. Do these approaches address these needs: do they release fascial restriction, improve microcirculation, decrease inflammation, stimulate the parasympathetic nervous system, improve breathing, and align the body to improve overall cellular function? In addition, are there any relevant contraindications: would any element of these approaches worsen a person with lymphedema?

Given these considerations, the alternative treatment approaches I'll share with you are hands-on techniques, therapeutic movement, electrical therapy, and proprioception stimulating techniques. In my experience, these procedures create more space to increase circulation, increase fascial movement, and increase space between organs.

Hands-on Techniques

VISCERAL MANIPULATION

The parasympathetic nervous system, when relaxed, stimulates lymph flow in the body. You can stimulate the parasympathetic nervous system through deep abdominal breathing – we discussed this technique in the context of CDT.

The respiratory system – which consists of the mouth, nose, pharynx, larynx, trachea, bronchi, bronchioles, aveoli, pleura, and the diaphragm – replenishes the blood with oxygen and removes waste products from the blood, eliminating them from the body. However, if there are any fascial restrictions around the organs, this can cause them to not function properly, impacting the oxygen/carbon dioxide balance in the body.

Visceral manipulation, developed by Jean-Pierre Barral (http://barralinstitute.com), is a hands-on osteopathic treatment approach that incorporates gentle movement of organs, membranes, fascia and ligaments. Fascia is found beneath the skin and is located around the nervous system, muscles, bones, organs, and vessels. The ligaments are comprised of the muscles' deep fascial tissue as it joins to epimysium to then be connected to the bone. A healthy fascial system provides communication and proprioceptive input within the body. Manipulating the viscera and deep connective tissue structures releases restrictions, improving energy and the flow of

fluids in the body, including lymphatic fluid. The visceral organs ought to be suspended, with each organ sliding over the organ above and below. Visceral manipulation creates space and increases circulation to improve the health and function of the organ.

Both a direct approach, direction of the tension, and an indirect approach, direction of ease, can be used during treatment, depending on which the patient responds more favorably to. For example, during a scalenes muscle contraction, the scalenes muscles in the neck rotate the head to the same side. The scalenes muscle will stretch when rotating to the opposite side (Buford et al 2002). A direct approach to release myofascial tension on the left scalenes is to place one hand on the cervical spine and another on the first and second ribs as you rotate the head to the right. To provide an indirect approach, with the same hand position, rotate the head to the left (Holey, Dixon 2014).

As previously discussed, the abdomen has 100-200 lymph nodes. Lymph nodes empty the processed lymph fluid into the lymph trunks to return to circulation. Physiologically, more lymph fluid from the afferent lymph vessels enters into the lymph node for processing and emptying. Lymph nodes are found around the abdominal and pelvic organs and are surrounded by fascia. Releasing fascial tension between the visceral structures and within the fascia supports the processing and emptying of lymph fluid and supports lymph transport back to the circulatory system.

IMAGE: visceral manipulation

In my professional opinion, patients who have secondary lymphedema due to cancer treatment would significantly benefit from this treatment prior to receiving Complete Decongestive Therapy. That said, nearly all patients, in my experience, would benefit from visceral manipulation. For example, a patient of mine had a history of congestive heart failure and stage III bilateral lower extremity lymphedema. On his third treatment session, as I was performing visceral manipulation around his thoracic organs, he told me he was very disappointed with his treatment session each time he left because I hadn't yet treated his legs. I re-explained to him that I needed lymph to flow through the thoracic duct to move the lymph fluid from his leg back to the circulatory system. Moments later, as I was releasing the restrictions in his liver, he was able to take a big breath. I then asked him to evaluate the tightness in his most involved leg, the left leg. He was so pleased at the progress, he told me when he died he wanted me to go to heaven with him!

MATRIX REPATTERNING

Matrix Repatterning is another hands-on treatment approach that targets the primary restriction found in fluid filled organs, the skeletal framework, and dense fascial tissues associated with the core structures of the body. Areas of injury and strain in the body may cause alterations within the tissues, which may further have an effect on the lymphatic vessels. A trained practitioner locates the primary

restrictions and applies a gentle pressure on the tissue to release the tension, which can facilitate improved muscle tone, connective tissue flexibility, joint mobility, and biomechanical function (http://MatrixRepatterning.com).

IMAGE: matrix repatterning

Dr. Norman Doidge MD, author of *The Brain's Way of Healing: Remarkable Discoveries and Recoveries from the Frontiers of Neuroplasticity*, addresses Matrix Repatterning in his discussion of treatment approaches, recommending it as the first form of intervention in the treatment of concussions and traumatic brain injuries. Matrix Repatterning is a whole body treatment approach using biotensegrity concepts in the extracellular matrix. In my clinical experience, patients who first receive Matrix Repatterning begin to show signs of increased lymph flow even prior to undergoing Complete Decongestive Therapy. I hypothesize that by decreasing the tension within the tissues and improving biomechanical function within the body the lymph vessels have less strain and can transport fluid more effectively. Additionally, this form of treatment supports the autonomic nervous system, and a health parasympathetic nervous system improves lymph flow within the body (Tadeo et al 2014, Doidge 2015, Levin et al 2017, Urner et al 2018).

INTEGRATIVE SYSTEMS MODEL

In optimal movement, the body is aligned over each structure and all the tissues are strong and flexible. Healthy tone in the muscles supports the muscle joint pump. The fascia moves easily with the body. The Integrative Systems Model works to bring the patient closer to this ideal by listening to the patient's complaints, testing the postural alignment, and performing corrections. In other words, what the patient is actively doing will determine the functional task to test.

For example, a patient with stage two lymphedema secondary to lipedema complained about increased pressure in her head due to the swelling. Using the Chikly method of testing lymph flow in the body, I determined which key regions revealed slower than four seconds lymph flow. Since her complaints were worse in a standing position, I assessed her posture and determined the position of the right and left side of her cranium, evaluated the cervical vertebra to determine any of the vertebrae were shifted, palpated the ribs relative to the thoracic vertebrae and sternum feeling for rib compression or shifts to the right or left, assessed correct alignment of the lumbar spine and pelvis during a simple hip and knee flexion test, and observed pronation and supination during foot dorsiflexion. Biomechanics that were incorrectly aligned were temporarily corrected, and the patient was asked if the adjustments decreased the pressure in her head. Once the best corrections were determined, the patient was placed on the treatment table and they were performed: cranial sphenoid alignment, dural release (the dural tube is the tough fascia around the spinal cord from the base of the cranium to the sacrum; an indirect approach is to place the fingers in the patient's suboccipital space, and with a slight directional pull towards their head, allow the dura to lengthen as the fascial tension is released) and thoracic ring (ribs, sternum and vertebra) mobilizations. The

patient was very pleased with the immediate decrease in head pressure from the lymphedema, as well as improved ease of breathing. In addition, a comparison of the initial baseline lymph flow test to the new baseline lymph flow revealed a significant change and improvement in lymph flow. Using the Integrative Systems Model approach significantly improved lymph transport in the patient's head and the rest of her body.

In my professional experience, aligning the biomechanics in this manner decreases stress on the lymphatic structures. However, using this treatment approach does not negate the need for Complete Decongestive Therapy.

Therapeutic Movement & Proprioception Stimulating Techniques

DYNAMIC NEUROCOGNITIVE IMAGERY

Dynamic Neurocognitive Imagery is an imagery-based systematic method for movement and postural control retraining.

Dynamic imagery (anatomical, metaphorical, and/or positive self-talk) boosts our ability to make bodily changes by using vivid and emotional pictures to stimulate the neurons.

Tapping, brushing, and vibration are activities that can increase proprioception (the body's sense of movement, position, balance, gravity, and effort) and kinesthetic awareness (the body's sense of where it is in time and space) by activating the body's mechanoreceptors. The mechanoreceptors then send a signal to the brain, which recognizes the improved movement.

IMAGE: DNI

Dynamic Neurocognitive Imagery, developed by Eric Franklin, activates the mind-body connection through the use of imagery and movement. The principles of dynamic imagery are to notice your own body for one minute to obtain a status quo; give yourself feedback with movement; set a goal to create change; implement the change; and compare the movement with the initial movement. The goal is to increase proprioception and improve efficiency in movement (as we've seen, the two are interrelated). Making permanent changes requires practice, focused attention, and challenging the body over a long period of time.

Dynamic Neurocognitive Imagery combines mindfulness and movement, and can be adjusted to suit the needs of each specific patient. For example, it has many movement patterns that stimulate proprioception and kinesthetic awareness to improve lymph flow in the body. Let's examine one such sequence.

Stand and notice your body for one minute. Do you feel more weight on one side? Does your body feel rotated? Does one side feel heavier than the other? Choose the heavier limb and tap the quadrant of the body for two to three minutes using a flexible wrist. Go back and recheck your flexibility, alignment and heaviness. Were

there changes? Compare one side to the other side. Has your kinesthetic awareness changed? Raise your right arm, then the left arm. Does the limb you tapped have more range of motion? Does it feel lighter as you lift it? Next, lift your shoulders up and down. Lift your right arm overhead and then your left arm overhead and notice what it feels like.

Then, place the palm of your hand in the contralateral axilla. "Sponging" is a term used by Eric Franklin to denote squeezing the muscle as though you're releasing fluid from the muscle (Franklin 2013). With your hand sponging the pectoralis major in the periaxilla, swing the contralateral limb forward and back 10 times. Think of the image of squeezing water out of a sponge (the pectoralis major muscle) as you do this movement. Also, consider the lymph nodes that are embedded in the fascia near this muscle. As you squeeze, you're creating more space around the lymph nodes to improve their function.

Consider other anatomical and metaphorical images to use with this same movement. Also, compare the impact of using negative words such as "I'm so tired today and don't feel like doing this activity" to positive words like "My lymph nodes are happy that I am giving them some loving kindness today by hugging them (Abraham 2014, 2016)."

Lymph nodes are found both under the skin and surrounding the abdominal organs. Abdominal muscle contraction creates a gentle hug on the abdominal visceral lymph nodes. During trunk movement abdominal muscles are used to stabilize, rotate, sidebend, protect, breathe, and cough, as well as hold the organs in place. Vectors on the lymph nodes are stimulated via the type of movement that occurs. Strap the center of a therapeutic band around your back and wrap the ends of the band around your hands so there is a little stretch when you move your arms. Reach each arm diagonally across your body. Add in the opposite leg forward to the arm that is reaching. As you perform these movements, imagine the external oblique muscle sliding over the fascia of the internal oblique muscle. In the same way, you can picture the internal oblique muscle sliding over the transversus abdominus muscle. The contraction of the muscles and the sliding and gliding of the fascia stimulate the lymph nodes to release the fluid and make room for more fluid to enter the lymph node for processing.

Proprioception Stimulating Techniques

KINESIOLOGY TAPE

Kinesiology tape, or kinesio tape was developed by Dr. Kenzo Kase in the 1970's as an alternative to restrictive sports tape (KTAI, 2014). Made of close to 100% cotton fibers, it has a similar elasticity to human skin: it can stretch to nearly 150% of its original length (Gomez-Soriano et al 2013).

Kinesio taping is used to support connective tissue movement, relaxation, stability, and lymphatic fluid circulation (Huang et al 2011). When kinesio tape is stretched over the skin it causes a toning effect on the deep muscle fibers, stimulating the

proprioceptors in the body. To increase muscle activation the tape is applied from origin to insertion with a 20% stretch. When relaxing the muscle the tape is applied without stretch on a stretch muscle. Ligament support requires a maximum stretch to give the best support. To support lymph drainage, kineso tape lifts the skin to increase blood flow and oxygen to the tissues, and also increase removal of toxins.

It's been suggested that kinesio tape could be used during CDT in place of bandaging. As compared to bandaging, kinesio tape is convenient (it's waterproof, allowing patients to shower with it on), easier to use, and patients are more compliant using it. In a study by Jan-Ju Tsai et al., circumference reduction was greater in the bandaging group compared to the taping group – nevertheless, both groups showed improvement (Jan-Ju Tsai et al 2009). However, the adhesive in kinesio tape causes more wounds during application and removal than bandaging alone – and avoiding wounds is part of the skin care phase in a Complete Decongestive Therapy treatment program (Kase et al 2003, Taradaj et al 2016).

If a particular patient's skin is not susceptible to tearing, then kinesio tape could potentially be used. I have successfully used kinesio tape in bilateral lower extremity lymphedema on the non-bandaged leg. Patients are not able to tolerate bandaging both legs simultaneously. However, they are compliant with bandaging the more involved leg and taping the less involved leg for improved results.

IMAGE: kinesio tape

Electrical Therapy

FREQUENCY SPECIFIC MICROCURRENT

The body has its own biological semiconductor: the connective tissue matrix within it. In addition, each tissue in the body has a specific frequency at which it resonates during healthy function. For example, 142 Hz is the frequency for fascia and 13 Hz is the frequency for lymphatic tissues. Illness and disease, however, alter the body's ability to resonate at the correct frequency.

Frequency specific microcurrent (FSM) uses a small amount of electrical current to correct the frequency and improve the function of the tissue, increasing the body's ability to heal and repair itself. Research shows that FSM decreases inflammation while increasing mitochondrial adenosine triphosphate (ATP – a coenzyme that each cell uses to store energy), amino acid transport, protein synthesis, and waste product removal required for healing at the cellular level. Contraindications are pregnancy, malignancy, and/or pacemakers (http://precisiondistributing.com).

FSM is applied to the body via a device that delivers a micro-amperage current. While the rule of thumb is 100 micro-amps for a smaller person and 150 micro-amps for a larger person, I prefer to palpate a muscle and set the unit at 80, 100, 120 and 150 micro amps respectively, testing muscle softening as I go, to determine the best intensity – the micro-amperage that softens the tissue the best.

IMAGE: FSM

FSM uses graphite gloves worn by the therapist – either with a direct contact on the patient to manipulate connective tissue, or wrapped in wet towels and applied to specific regions of the body (the manual gives suggestions on placement).

Two frequencies are used at the same time, one from each channel, and the frequencies work together to produce specific effects on the connective tissue matrix. Commonly-used frequencies for channel B are 13 and 142. On channel A, you may see 40 (the frequency to decrease inflammation), 3 (the frequency for scar tissue) and 81 (the frequency for increasing secretions), as well as 970, 321, 296, 9, 284, 13, and 49. Additionally, using 58 on channel A and 00, 02, and 32 on channel B are very beneficial: pairing the frequencies for lymph and fascia with decreasing inflammation and reducing scar tissue improves lymph fluid movement through the lymph vessels, decreasing limb swelling.

While training is required to become proficient in FSM, it can be used in conjunction with many conditions such as fibromyalgia, myofascial pain, women's health issues, chronic pain conditions, and degenerative nerve conditions. I have used FSM on the extremity of patients with non-cancer related lymphedema while I perform manual lymph drainage on their core. My clinical experience is that combining these two treatment modalities yields significant improvements. The FSM unit softens the indurated connective tissue in the limb as I'm releasing the lymphatic congestion in the core, which allows lymph fluid to move more quickly to the lymph node groups (McMakin et al 2007).

LOW LEVEL LASER
Low level laser (light) therapy, or LLLT, applies light emitting diodes (LEDs) to the surface of the body. It increases ATP), emits no heat, and has no contraindications.

In a recent study, low level laser was found to slow nerve conduction velocity, decrease the amplitude of compound action potential, and suppress noxiously evoked action potentials including pro-inflammatory mediators (Chow et al 2011). In other words, it improves connective tissue healing, reduces inflammation, and decreases pain.

In lymphedema treatment, LLLT softens tissue, creating open pathways and allowing lymph flow to move through fibrotic areas to reduce edema volume and fibrosis (Carati et al 1998). While I have never used LLLT as a stand-alone therapy for lymphedema, I have successfully used it in conjunction with Complete Decongestive Therapy.

Complementary Therapies
In addition to the approaches to alternative treatment that we've discussed, patients receiving cancer treatment often use complementary and integrative therapies as a form of support during their cancer treatment and to decrease the unpleasant side

effects from the medical intervention. Some of the known therapies are mind body therapies such as meditation, relaxation, yoga, massage, music therapy, acupressure, acupuncture, and supplements (Greenlee et al 2017).

AROMATHERAPY

Aromatherapy is the therapeutic use of essential oils from flowers, herbs or trees for physical, emotional and spiritual support. The U.S. Food and Drug Administration does not require approval to use aromatherapy unless a person makes a claim that it is used for treatment of a specific disease. However, the words "supports, maintains, or promotes" can be used without violating the FDA.

Oils are only considered true essential oils if a chemical solvent was not used to extract the oils. Essential oils are extracted from plants by steam distillation or with physical expression. The chemical components in essential oils are monoterpenes, esters, aldehydes, ketones, alcohols, phenols, and oxides. It is the variety of these compounds that gives each essential oil its specific fragrance and therapeutic quality. The efficacy of the oil is determined by its purity, number of distillations, and transport time from distillation to bottling.

Essential oils have a low toxicity profile when inhaled or topically applied. Young Living Essential Oils is the only company with a line of oils that is GRAS, "generally recognized as safe for ingestion," by the FDA. In the United States, essential oils are primarily available for inhalation and topical treatment. The essential oil binds to the receptors in the olfactory bulb affecting the limbic system, the brain's emotional center. Topical application of the oils may have an antibacterial, anti-inflammatory and analgesic effect.

The Aromatherapy and Essential Oils Physician Data Query provides peer reviewed, evidence-based information to health professionals. It discusses the use of aromatherapy to improve the quality of life for cancer patients, and includes a review of clinical trials and possible side effects. It's a good resource to determine which essential oils would be useful for patients with specific diagnoses (PDQ 2018).

Ho et al. conducted a study to determine the benefits of aromatherapy in women with cancer. The study found that aromatherapy massage provided both physical and psychological benefits, including improved overall comfort, increased relaxation, reduced pain, decreased muscular tension, reduced lymphedema, decreased numbness, improved sleep, increased energy level, improved appetite, and enhanced mood. The study also suggests that nurses should increase their knowledge of the basic essential oil pharmacology (Ho et al 2017).

I apply essential oil blends to stimulate lymph transport: lemongrass, rosemary, basil, peppermint mixed with a carrier oil such as coconut oil for lymph transport; lemon, lime, orange or grapefruit in a carrier oil or in a glass of water for lymph stimulation. At home, patients can also take 2-3 drops of cypress or any of the

previously-mentioned oils and diffuse them in a diffuser. For skin and nail care, I've used lavender, frankincense and helicrysum, any of which can be applied in an oil blend or directly on the skin.

CVAC TREATMENT
Cyclic Variation in Adaptive Conditioning ™ (CVAC) treatment is delivered in a pod-like device where the person is in a semi-reclined position.

IMAGE: open pod

The CVAC process creates variable changes in temperature (warm air and cooler air), pressure (air density) and hypoxic stress so that the participant can naturally adapt. This type of conditioning improves cellular and endocrine system functions in a manner that is correlative to those improvements gained from short term and moderate exercise. The CVAC also assists in the removal of waste products produced during the treatment session. (Ear clearing techniques are taught beforehand to reduce the risk of ear pain or discomfort.)

The CVAC process is different from hyperbaric oxygen therapy treatment, where a static high-pressure environment infused with a high oxygen content is used. The CVAC teaches the body to use available oxygen, which, in turn, drives better overall performance of the body's organs and tissues (Hetzler et al 2009). We know that lymphatic mobilization decreases inflammation, improves the immune system response, increases endocrine function efficiency, increases nutrient delivery and supports effective breathing strategies (Herbst, Rutledge 2010) (http://cvacsystem.com).

Conclusion

This course has led you through a great deal of basic information about lymphedema and lymphedema treatment. We've considered the lymphatic system, the characteristics and etiology of lymphedema, evaluation, treatment, and alternative treatment approaches.

Should you wish to continue your study, one option is to become certified in lymphedema by completing and passing a lymphedema training course and meeting all related requirements. For example, to become LANA (Lymphology Association of North America) certified, you must possess a current and unrestricted U.S. state professional medical license, complete an accredited 135 hour lymphedema certification course including practical lab work, provide proof of completion of basic science requirements (anatomy, physiology, and pathology) from an accredited college or university, pay a fee, and pass a 120 question exam.

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Lymphedema Treatment in Physical Therapy

(4 CE Hours)

FINAL EXAM

1. The flow of lymph fluid is intrinsically controlled by _____.
    a. Contracting the skeletal muscles with movement and exercise
    b. Respiratory pressure changes
    c. The stretch receptor causing a stretch reflex and contractions of the smooth muscle
    d. All of the above

2. The lymph vessels constitute _____ of the lymphatic system and are made of three layers.
    a. 15%
    b. 20%
    c. 45%
    d. 60%

3. The lymph node is made up of the lymphatic sinuses, blood vessels and parenchyma. The parenchyma is divided into the cortex, paracortex and medulla. B cells are located mostly in the _____.
    a. Cortex
    b. Medulla
    c. Paracortex
    d. None of the above

4. The intestinal lymph trunk has its own lymphoid follicles, known as _____, in the ileum of the small intestines. They monitor and prevent growth of bacteria in the intestine.
    a. Fulbright's follicles
    b. Intestinal nodes
    c. Peyer’s patches
    d. Trunk dendrites

5. _____ is the movement of water across a semipermeable membrane from an area of high water concentration to an area of low water concentration.
    a. Circulation
    b. Drainage
    c. Osmosis
    d. Transference

6. The most common cases of lymphedema in the world are due to _____.
    a. Cancer treatments
    b. Filariasis
    c. High altitudes
    d. Medical procedures

7. Cellulitis is a localized skin infection that can develop into _____, a skin infection of the entire limb. Often, these skin infections can lead to lymphedema.

a. Ascaris
b. Lymphangitis
c. Septicemia
d. Yersinia

8. Which of the following is NOT true of primary lymphedema?

a. It is caused by lymphangiodysplasia, a genetic anomaly of the lymph vessels and/or lymph nodes during the first trimester of fetal development
b. It is divided into Type I and Type II
c. It normally occurs in the lower extremities
d. Its distribution is higher in males

9. Type II primary lymphedema that appears after the age of 35 is known as _____.

a. Beesley's disease
b. Lymphedema praecox
c. Lymphedema tarda
d. Milroy’s disease

10. Considering secondary lymphedema, Norman et al. observed 433 breast cancer survivors for three years following medical treatment. _____ reported moderate to severe lymphedema.

a. 2%
b. 12%
c. 23%
d. 42%

11. In staging lymphedema, stage _____ is characterized as "when lobular folds of skin are present with a presentation of elephantiasis and trophic changes in the skin are occurring."

a. 0
b. 1
c. 2
d. 3

12. The amount of edema in a limb is quantified as minimal, moderate and severe. _____ is a 20-40% increase in limb size compared to the contralateral limb.

a. Minimal lymphedema
b. Moderate lymphedema
c. Severe lymphedema
d. None of the above

13. _____ is characterized by growths of subcutaneous fat found anywhere on the body from the head to the feet. The benign fat tumors are unencapsulated. They can be small or

large nodules or diffuse nodules. In addition to an association with metabolic disorders, it is also an autoimmune disorder.

a. Dercum disease
b. Madelung's disease
c. Meige's disease
d. Milroy's disease

14. Knowledge of the TNM cancer staging system, which describes the extent of cancer in a patient's body, may prove helpful in the course of lymphedema evaluation. It classifies the size and extension of the primary tumor (T) as well as its lymphatic involvement (N), and also _____ (M).

a. Indicates the presence of metastasis
b. Lists ongoing medical treatment
c. Signifies treatment-related decreased mobility
d. None of the above

15. _____ developed Complete Decongestive Therapy in 1970, consisting of skin care, manual lymph drainage, compression, and exercise.

a. Earl Miller, DO
b. German surgeon Alexander Von Winiwater
c. Hungarian physicians Michael and Ethyl Foldi
d. Pehr Henrik Ling

16. Which of the following is NOT a skin care precaution related to Complete Decongestive Therapy?

a. Avoid manicures and pedicures, and do not cut the cuticles
b. Report any signs of skin infection such as redness, soreness, fever, or body aches
c. Use a high ph hand lotion on the affected limb
d. Wear protective clothing when gardening or using strong chemicals

17. Contraindications for manual lymph drainage (MLD) include _____.

a. Active skin infections
b. Arthritis and/or chronic pain
c. Complex regional pain syndrome
d. Immobility

18. Which of the Vodder Method strokes is described by the following? "Used to move fluid from one region to another. Used on the lateral trunk from proximal to distal or distal to proximal. It can also be used to transport fluid from one side of the body to another, and on the extremities to move fluid from distal to proximal."

a. Stationary circles
b. The pump stroke
c. The rotary stroke
d. The spiro-stroke

19. Prior to treating the affected limb(s), manual lymph drainage begins by _____.
    a. Clearing the trunk
    b. Manipulating the contralateral limb
    c. Performing stationary circles
    d. None of the above

20. Per Chikly (2005), gentle stretching and strengthening exercises with a therapeutic band _____.
    a. Are contraindicated in patients with lymphedema
    b. Are less effective than aerobic activity and proprioception activities
    c. Should be performed with compression bandages or garments removed
    d. Stretch the fascia and stimulate lymph flow in the subcutaneous tissues

21. Compression (bandaging and/or garments) is used for _____ of lymphedema.
    a. All three stages
    b. Stage 3
    c. Stages 1-2
    d. Stages 2-3

22. Compression bandages and garments must be worn _____.
    a. Except during exercise
    b. With more compression distally than proximally
    c. With more compression proximally than distally
    d. With the same compression distally and proximally

23. The first layer applied in multilayered compression bandaging is the _____, which is soft on the skin, protects the skin, wicks away moisture, and provides adherence for the next layer.
    a. Closed meshed tubular stockinette
    b. Grey foam
    c. Short stretch compression bandages
    d. Thick cotton non-woven padding

24. _____ is a hands-on treatment approach that targets the primary restriction found in fluid filled organs, the skeletal framework, and dense fascial tissues associated with the core structures of the body.
    a. Dynamic Neurocognitive Imagery
    b. Matrix Repatterning
    c. The Integrative Systems Model
    d. Visceral manipulation

25. _____ uses a small amount of electrical current to improve the function of the tissue, increasing the body's ability to heal and repair itself.
    a. Cyclic Variation in Adaptive Conditioning (CVAC) treatment
    b. Dynamic Neurocognitive Imagery (DNI)
    c. Frequency specific microcurrent (FSM)

d. Low level laser (light) therapy (LLLT)