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Arm Lymphedema as a Consequence of Breast Cancer Therapy

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1. Introduction

Lymphedema is the result of an abnormality of the lymphatic system. It is caused by an excessive accumulation of lymphatic fluid, known as interstitial fluid, in the interstitial tissue, particularly in the subcutaneous fat. Ultimately, this leads to swelling of affected tissues due to a build up of and inadequate lymph drainage, known as lymphedema (Farrow, 2010a) [Figure 1].



Fig. 1. Right arm lymphedema

Primary lymphedema occurs when people are born with abnormalities in the lymphatic system, such as missing or impaired lymphatic vessels (Farrow, 2010b). The severity of the

condition is able to assess whether swelling is present at birth or develops at the onset of puberty or in adulthood. It can affect from one up to four limbs and/or body parts (Farrow, 2010a). Secondary lymphedema is more common and occurs from damage to the lymphatic system that occurs as a result of cancer and its treatment, due to the resection of lymph nodes. Trauma to the skin, such as burns or infections, can also cause secondary lymphedema (Gordon, 2007; Piller, 2009).

Signs and symptoms of progressive lymphedema include discomfort and pain associated with full sensation in the limb(s) and the skin feeling tight, as well as difficulty with daily tasks due to a decreased flexibility in the hand, wrist, or ankle and the inability to fit into clothing and jewelry in a certain area. Progressive lymphedema is complicated by recurrent infections, non-healing wounds, as well as emotional and social distress (Ridner, 2009; Ahmed, 2008; Shih, 2009).

Lymphedema is prevalent and most often studied as a consequence of breast cancer. However, it has been studied in cases of melanoma, gynecological cancer, head and neck cancer as well as sarcoma (Lewin et al., 2010; Murphy et al., 2010; Smith et al., 2010; Cormier et al., 2010; Lacomba, 2010). Research shows that there is a lifelong risk of developing lymphedema due to cancer and the overall risk has been reported to be 15.5% (Chang et al., 2010) [Figure 2].

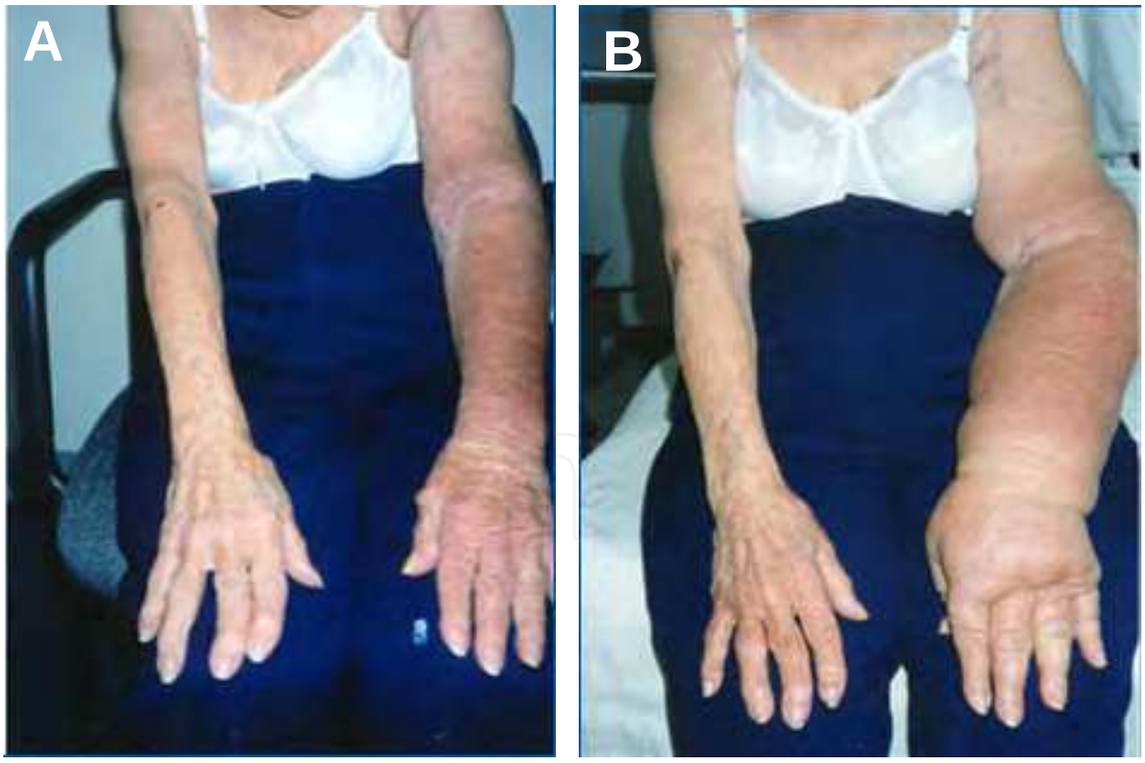


Fig. 2. A woman with locally advanced breast cancer status post left modified radical mastectomy and lymph node dissection and radiotherapy to the left chest wall, supraclavicular area and axillary lymph nodes. **A.** Left arm at 3 months after treatment. **B.** Left arm demonstrates marked lymphedema at 3 years after treatment.

Both primary and secondary lymphedemas possess characteristic features that can be distinguished over time. History should include information such as age of onset, location(s) of swelling, pain and other symptoms of discomfort, medications that instigate swelling, the course of progression of swelling, and factors prompting swelling such as cancer, injury, or infection. Family history is important to diagnose inherited forms of lymphedema (Gupta, 2006). A physical examination assesses the vascular system, the soft tissue and skin surrounding the swollen body parts, palpation of lymph nodes, and looks for changes in the body systems in accordance with inherited lymphedemas (Wang, 2005; Moseley et al., 2008). Further diagnostic tests and imagining coupled with history, family history, and physical examination are used to correctly diagnose a patient (Lewin et al., 2010; Smith et al., 2010).

Lympehedema is a type of side effect requiring attention to diagnosis and management by a number of specialists taking care of a patient with breast cancer. It is critical for each discipline to pay particular attention to the patients' subjective reporting of their symptoms suggestive of lymphedema. Therefore, a multidisciplinary approach to diagnosis and management of lympehedema is essential for the routine surveillance after treatment by all the involved physicians, including the surgeon, radiation oncologist, and medical oncologist. A lymphedema specialist's consultation is often necessary, especially when the patient is at risk for developing lymphedema or has an evidence of this diagnosis on physical examination.

2. Diagnosis of lymphedema

Physical examination includes placing hands on location of lymphedema and feeling palpation as well as the surrounding area of the affected limb. This procedure is called subjective palpation. Upon physical examination, the standard way of detecting lymphedema is by taking measures of limb volume (Chen et al., 2008; Cheville et al., 2003; Hayes et al., 2005). An enlargement, or increase in volume, of the limb is the result of fluid build up in the tissues. Volume is measured by 3 methods including tape measurements, perometry, and water displacement. These measurements of volume illustrate the presence and severity of the condition (Unno et al., 2008). Tape measurements are most accurate when done at precisely defined intervals and when taken by the same individual, ultimately using geometric formulas to determine the total volume.

Perometry uses an infra-red optical electronic scanner to calculate volume by precisely positioning the body part exactly the same each time and calibrating the machine (Rockson et al., 2007). This method can detect volume changes in breast cancer survivors as little as 3% (Czerneic et al., 2010). Water displacement measurements are taken by immersing the limb in a large cylinder and determining the volume of water displaced, or pushed out of the cylinder. However, measuring volume cannot differentiate lymphedema from other types of edema and is a technique best used as follow up for treatment of lymphedema rather then diagnosis (Unno et al., 2008).

A radiological technique, that detects slow or absent lymph flow and areas of reflux or backup of lymph node and lymph vessel imaging due to lymphedema is called a lymphoscintigraphy. Normally, technetium labeled sulfur is the radio-labeled particle of protein injected directly under the skin to detect and image the affected area (Piller, 2009; Szuba et al., 2003; Hayes et al., 2008; Bellini et al., 2005). The procedure identifies lymphatic

problems at late stages of lymphedema and shows the basics of the peripheral lymphatic system and larger more prominent lymph nodes and vessels. Radiology dpartments are apt at performing lymphoscintigraphy studies aimed at identifying the sentinel lymph node for cancers of the breast and ultimately further studies for the diagnosis of lymphedema Cornish et al., 2007; Szuba et al., 2000, 2003, 2007)

A more recent technique of lymph vessel imaging uses indocyanine green (ICG) injections into the skin and an infrared fluorescence camera to detect the function of even the smallest lymphatic vessels. This is called Near Infra-Red Florescence Imaging (NIR). NIR-ICG can pick up early stages of lymphedema and diagnose diseased non-contracting lymphatics even before swelling occurs (Farrow, 2010; Adams et al.; Rasmussen et al., 2009, 2010; Unno et al., 2010; Maus, 2010)

There is a variety of diagnostic tests that can be performed in order to classify and detect lymphedema. These include soft tissue imaging, bioimpedance spectroscopy, tonometry, genetic testing, various forms of vascular imaging, as well as blood tests (Farrow, 2010).

Soft tissue imaging like MRIs (magnetic resonance imaging), CTs (computed tomography scans, and US (ultrasounds) detect excess fluid in the tissues. Since lymphedema is the result of interstitial fluid build up these imaging techniques are often used to determine the cause of the condition as well as lymphedema that is a result of an untreated cancer (Astrom et al., 2001; Deltombe et al., 2007; Unno et al., 2008)

Bioimpedance Spectroscopy (BIS) measures water content in tissues by passing a small, harmless, electrical current through the limb in order to measure the impedance to current flow. The higher the water content in the area the lower the resistance. BIS assesses the condition by comparing the resistance of electrical flow in the intracellular and interstitial fluid of a whole limb, because calculations are performed to the length of the body part (Gergich et al., 2008; Ward, 2006; Rockson et al., 2007).

Lymphedema is graded according to increased size as well as staging of the progression in the change of the skin texture. As a consequence lymphedema the skin and subcutaneous tissue become harder and denser (Executive Committee of International Society of Lymphology, 2009). Upon physical examination, tissue texture, pitting, larger skin folds, wounds or papillomas are noted. Current examinations to determine skin texture and resistance are tissue dielectric constant and tonometry. The tissue dielectric constant measures tissue water content and uses a specific frequency of an electrical current to measure the reflected return wave in order to indicate how much water is present in the tissue (Mayrovitz, 2009; Corica et al., 2006; Mirnajafi et al., 2004; Ridner et al., 2007). Tonometry determines how firm a tissue is by measuring how much force is needed to indent the tissue sample (Mayrovitz, 2009) [Figure 3].

Young patients diagnosed with primary lymphedema should undergo genetic testing and counseling and have a karyotype test performed in order to detect abnormalities. Turner's syndrome has been linked to lymphedema and can be determined from a karyotype. Specific genes are also associated with lymphedema (Ferrell, 2008). These include FOXC2 an SOX18 (Connell et al., 2009; Brice et al, 2002). However, inherited lymphedema is not detectible on gene or chromosome tests and genetic testing for late-onset lymphedema does not prove to have benefits (Farrow, 2010b).



Fig. 3. A tonometer is used to assess the firmness of a tissue by measuring how much force is needed to indent the tissue sample.

Cardiovascular diseases or abnormalities may also serve as a trigger for many forms of edema (Schumacher et al., 2008). For those given a diagnosis of primary lymphedema, it is important to determine if congestive heart failure, deep venous thrombosis, damaged valves in the vein or any arterial conditions account for the swelling or are an adjunct to existent lymphedema (Szuba, 2000; Bellini, 2005). Secondary lymphedema, as a result of cancer, can be studied by taking images of the heart, veins and valves to determine the case, severity, and treatment options of the edema. Cardiovascular studies usually ordered for edema studies include echocardiogram, venous ultrasound, and arterial ultrasound with ankle brachial index (ABI). It is best to do ultrasounds in a standing up position to test for incompetency of the valves. More advanced forms of imaging for insufficiency of blood vessels is by means of a computed tomography, venogram, and arteiogram. These are normally used to assess conditions in the chest, abdomen, or pelvis (Farrow, 2010).

Blood tests are unavailable for diagnosis of lymphedema. However, conditions that mimic lymphedema's symptoms such as hypothyroidism or hypoproteinemia may cause swelling and need to be assessed by means of a blood test. For some lymphedemas that are genetically inherited x-rays are important to detect orthopedic abnormalities (Bellini et al., 2009; Gupta et al., 2006).

3. Lymphedema as a long-term sequelae of breast cancer therapy

There are recommended guidelines to follow for optimal prevention, screening and measurement for early detection of breast cancer related lymphedema (Farrow, 2010c). There should be a pro-active approach pre-operatively and post-operatively for arm measurements taken by patients and physicians. Patients should receive risk-reduction strategies prior to treatment (NLN Position Paper, 2011; Fu et al., 2010). Weight and height should be accurately measured during each visit to a specialist in order to

determine body mass index (BMI). A BMI greater than or equal to 25 warrants a consultation with a dietician and a BMI greater or equal to 30 warrants a consultation with a dietician and a weight reduction (Ridner et al., 2011; Helyer et al., 2010; Centers for Disease Control, 2011).

Patients that have been diagnosed with breast cancer should have baseline pre and post-treatment arm measurements taken on both arms and should be given this information to share with other healthcare providers. Lymphedema warrants active surveillance post-treatment for such symptoms as swelling, heaviness or tightness in the affected arm(s), and at-risk chest and truncal areas. If there appears to be an increase of 1 cm in any of the circumference measurements when compared to the contralateral limb, the patient should schedule a follow-up visit in 1 month. A 2 cm change in any of the circumferential measurements or a 5% volume change in an at-risk limb warrant immediate referral for further evaluation by a professional trained in lymphedema assessment and management. Subjective symptom reports should be taken seriously and may include perceived swelling, tightness, tingling, and heaviness (Farrow, 2010c).

Surgical techniques of managing breast cancer and long-term morbidity include radical mastectomy, modified radical mastectomy, and lumpectomy. Surgical approaches to axillary treatment include sentinel lymph node dissection (SLND) and axillary lymph node dissection (ALND). The number of lymph nodes that defines ALND is 10, and the standard ALND involved at least dissection of levels I-II axillary lymph nodes, based on the arbitrarily set anatomic Berg principles (Berg, 1955). Identification of a sentinel lymph node for SLND is typically done by either an injection of the isosulfan blue dye, the technetium (99mTc)-sulphur colloid, or both. All blue-stained nodes and/or nodes with radioactive counts, as measured with the gamma probe, are defined as sentinel lymph nodes. Typically, the number of nodes sample as a result of a SLND is small, with a median number of 2 nodes (Wernicke, 2010).

A number of efforts have been employed to minimize the risk of lymphedema (Figure 2B), as it is associated with the dissection of a large number of axillary lymph nodes. Various studies have determined the incidence of lymphedema depending on the type of lymph node dissection, ALND versus SLND. Table I summarizes the incidence of lymphedema based on the type of axillary lymph node surgery – SLND or ALND – from a number of published studies for both node negative and node positive patients. The Milan trial, the Sentinella/GIVOM trial, The ALMANAC-UK trial, and the NSABP B-32 trial all showcase node negative patients in the varying prospective randomized trials (Veronesi et al., 2003, 1997; Land et al., 2010; Mclaughlin et al., 2008; Ashikaga et al., 2008; Mansel et al., 2006). In the Milan Trial, at the median follow up of 3 years lymphedema, as assessed by a medical professional, was detectable in 7/100 (7%) of patients in the SLND group in contrast with 75/100 (75%) of cases of lymphedema in the ALND group (Veronesi et al., 2003, 1997). In the Sentinella/GIVOM trial, it was found that the odds ratio of sentinel lymph node to axillary lymph node was 0.52 at their median follow up of 4.6 years (Land et al., 2010). In the ALMANAC-UK trial, with a short median follow up of 1 year lymphedema was assessed by a patient and was reported in 20/412 (4.9%) of patients in the SLND group in contrast with 53/403 (13%) of cases of lymphedema in the ALND group (Mclaughlin et al., 2008).

Published studies	Median follow up (years)	N	Inclusion Criteria	Lymphedema by medical professionals (%)	Lymphedema by patients (%)
MILAN (Veronesi et al., 1997, 2003) (negative SLN in 341patients (167SLN +174ALND) (1998-1999)	3	516	<2cm, L only (wide excision or quadran-tectomy)	* 7/100 (7) # 75/100 (75)	N/A
Sentinella/ GIVOM (Land et al., 2010) (1999-2004)	4.6	749	<3cm, L,MRM	0.52[2]	N/A
ALMANAC-UK (Mclaughlin et al., 2008) (1999-2003)	1	1031	<2, 2-5,>5cm, L, MRM, axillary RT	N/A	* 20/412 (5)[1] # 53/403 (13)[1]
ACOSZOG Z0011 Trial (Aareleid et al., 2002) (1999-2004)	3	891	<2cm, L, with 1-2 +SLN	* 14/226 (6) # 26/242 (11)	* 14/253 (5) # 52/272 (19)
NSABP B-32 Morbidty results (Ashikaga et al., 2010) (1999-2004)	3	5611	≤2.0, 2.1-4.0, >4.0 cm, L or M	*303/1459 (20.8) # 431/1421 (30.3)	N/A
NSABP B-32 Outcome study (Mansel et al., 2006) (2001-2004)	3	749	≤2.0, 2.1-4.0, ≥4.1 cm, L or M	N/A	*10/320 (3) # 25/307 (8)
Wernicke et al. (Wernicke et al., 2010, 2011)	10	265	<5.0cm, L	*6/111 (5.4) #21/115 (18.3)	* 10/111 (10.0) # 39/115 (33.9)

L=lumpectomy
MRM=modified radical mastectomy
RT=radiotherapy
*SLND=Sentinel Lymph Node
SLN +ALN=Sentinel Lymph Node+Axillary Lymph Node
[1] Summation of patients with mild and severe symptoms.
[2] Odds ratio (SLN/ALN)

Table 1. A summary of incidence of lymphedema from the published studies.

In the NSABP B-32 trial, at a 3-year follow-up lymphedema was assessed by both medical professionals and by patients themselves. When assessed by the former, the incidence of lymphedema was 303/1459 (20.8%) of patients in the SLND group in contrast with 431/1421 (30.3%) of cases of lymphedema in the ALND group. However, the patient self-assessment group demonstrated the rate of lymphedema as 10/320 (3.1%) in the SLND cohort and occurred in 25/307 (8.1%) of women in the ALND group (Ashikaga et al., 2008; Mansel et al., 2006). One of the largest retrospective reviews of a mature 10-year follow-up of experience from Thomas Jefferson University Hospital conducted by Wernicke et al, also assessed lymphedema by two methodologies. It was evident that regardless of whether the assessment was performed by a medical professional or a patient, there was statistically significant difference in the rates of this complication between the two cohorts as experienced by patients. When assessed by a medical professional, lymphedema was detectable in 6/111 (5.4%) of patients in the SLND group in contrast with 21/115 (18.3%) of cases of lymphedema in the ALND group, respectively ($p<0.0001$). The patient self-assessment groups demonstrated the lymphedema in 10/111 (10.0%) of patients in the SLND cohort and 39/115 (33.9%) of women reporting this complication in the ALND group ($p<0.0001$). This difference appears to be sustainable even a decade after the surgery, and the percentage of patients that experienced chronic lymphedema is significantly greater in the ALND cohort as compared with the SLND one (Wernicke et al., 2010) [Table 1].

The ACOSOG Z001 trial assessed patients with clinically positive axillary nodes (Aareleid et al. 2002). In this study, lymphedema was also assessed by the dual methodologies of a medical professional and a patient self-assessment. At a median follow-up age of 3 years, when assessed by a medical professional, lymphedema was detected in 14/226 (6%) of patients in the SLND group in contrast with 26/242 (11%) of cases of lymphedema in the ALND group. The patient self-assessment groups demonstrated the incidence of lymphedema in 14/253 (5%) of patients in the SLND cohort and 52/272 (19%) of women reporting this complication in the ALND group [Table I].

Could radiotherapy be a contributing factor to the complications of axillary surgery? If a low incidence of ALN failures lies in sterilization of the occult metastases in the axillary lymph nodes with the conventional breast tangential ports delivering RT to a patient in a supine position (Wernicke et al., 2010), radiotherapy may be at least in part responsible for the morbidity attributable to surgery. Goodman et al reported that with the standard radiation tangents, 90% of the Berg level I axilla and up to 70% of level II axillary lymph nodes received 95% of the prescribed dose to the breast (Smitt et al., 1999). Figure 4 demonstrates a typical patient treated with 3-D radiotherapy in the supine position with the standard tangential radiation fields targeting the breast tissue and inadvertently providing at least partial coverage for at least two of the Berg axillary levels. The vast majority of literature, with only a few negative studies, supports the fact that the modern 3-D tangential radiation port of the breast, administered in supine position, will at least partially irradiate the undissected axillary lymph nodes stations (Smitt et al., 1999; Takeda et al., 2000, 2004; Krasin et al., 2000; Aristei et al., 2001; Schlembach et al., 2001; **Orecchia et al., 2005;** Wong et al., 2008; Rabinovitch et al., 2008). This phenomenon may explain why even patients with SLND experience lymphedema as a long-term toxicity [Wernicke et al., 2010].

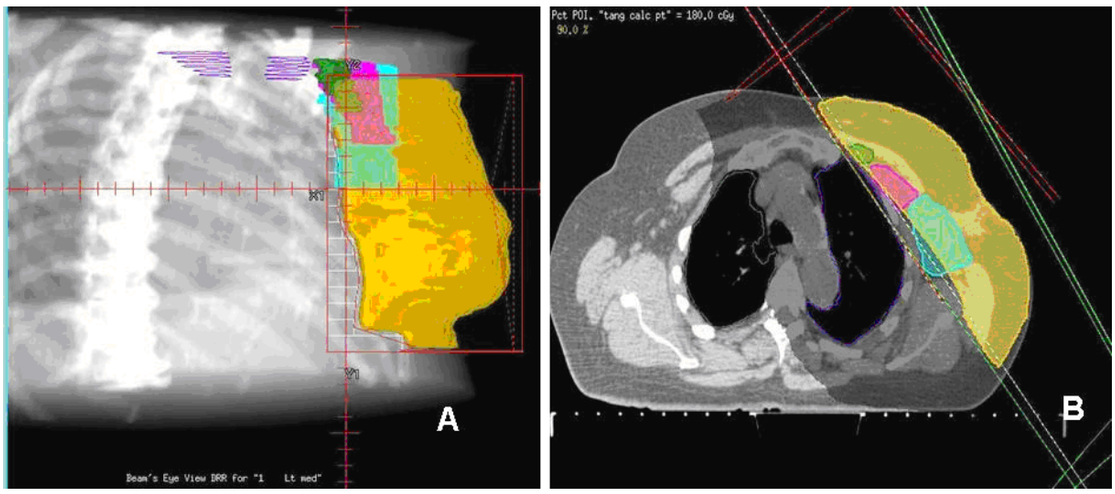


Fig. 4. **A.** A relationship between local breast tangent radiation field and regional lymph nodes as depicted in the lateral beam's eye view with a tangential portal, where the superior border of the radiation portal is set below the heads of the clavicles (navy). **B.** The axial image through the dissected axilla demonstrates Level I (blue), Level II (purple), and Level III (dark green) axillary lymph nodal stations which are partially covered by the 90% isodose area covering the breast tissue (orange).

Does lymphedema have any risks associated with the use of systemic therapy? No significantly increased risk of incidence of lymphedema was observed in the literature with systemic therapy using hormonal treatment (Norman et al., 2010). Chemotherapy has been reported in some series to increase the complication rate associated with breast RT, including arm edema (Meek, 1998). However, no formal studies report any concrete data, which can predict such outcomes.

4. Treatment of lymphedema

4.1 Non-invasive management techniques

The main, "gold standard" of treatment for lymphedema is Combined, Complex or Comprehensive Decongestive Therapy (CDT) (Mayrovitz, 2009). The initial reductive phase of CDT treatment is known as Phase I. The main goals are to reduce the size of the affected location and to improve the skin. Phase II is known as the maintenance phase, where the patient self-manages to keep the effects of phase I treatment long term (Szuba, 2000; Hinrichs et al., 2004; Lasinski, 2002; Thomas et al., 2007; Koul et al., 2007). The effects of CDT include decreases in swelling, an increase in lymph drainage from the congested areas, a reduction in skin fibrosis and improvements in the skin conditions, an enhancement in the patient's functional status and quality of life as well as a relief in discomfort, and a reduced risk of cellulitis and Steward-Treves-Syndrome (a rare form of angiosarcoma) (Hammer et al., 2007; Mondry et al., 2004; Ferrandez, 1996; Franzcek et al., 1997; Hayes et al., 2008; Ahmed, 2008; Weiss, 2002; Kim et al., 2007; Cormier et al., 2009; Hormes et al., 2010; Fu et al., 2009; Vignes, 2006).

Components of Combined, Complex or Comprehensive Decongestive Therapy include manual lymph drainage (MLD), multi-layer, short-stretch compression bandaging, lymphatic exercise, skin care, and education in lymphedema management as well as elastic

compression garments (Didem et al., 2005; Ko, 1998). There are to phases of CDT: Phase I (Reductive) and Phase II (Maintenance). The first phase's frequency and duration should be altered as to produce the best possible outcome of improvements in skin and reduction in swelling of the affected area in the shortest time period. Normally, CDT is completed within 3 to 8 weeks and administered daily, or 5 days per week (Mayrovitz, 2009; Ko, 1998; Yamamoto et al., 2008). The second phase of CDT is a self-management program is set up directly following completion of phase I. It includes self-lymph drainage, home lymphatic exercises, a skin regimen, and self-application of compression garments or bandages (Yamamoto, 2008). Phase II must be monitored and changed periodically to ensure effectiveness. This includes changing compression garments every 4-6 months and equipment replacements and maintenance. Monitoring by a medical profession is, also, essential to the long-term success for lymphedema treatment (Ko, 1998; Hafner et al., 2005; Boris et al., 1994; Johnstone et al., 2006; Lasinski, 2002).

Therapists providing CDT care are recommended by the Lymphology Association of North America® (LANA®) to have a minimum of 135 hours of training. Additional training may be required for specialists treating facial, truncal, and genital lymphedema and patients with complex diseases or illnesses (Farrow, 2010b; Czerneic et al., 2010).

Manual lymph drainage is a manual, hands-on, part of CDT care that prompts superficial lymphatic vessels to remove excess interstitial fluid which is then moved through the subepidermal fluid channels formed as a result of damage of the lymphatics (Williams et al., 2002). Certified Lymphedema therapists use the MLD technique to stimulate fluid removal from areas where the lymphatics are not working properly into working lymph vessels and nodes (McNeely, 2004).

Compression bandaging creates gradient compression by effectively utilizing multiple layers of several materials. Components of compression bandaging include tubular bandage lining, digit bandages, polyester, cotton, or foam under-cast padding, and multiple layers of short-stretch bandages with 50% overlap and 50% stretch to cover the entire limb. Short-stretch bandages stretch to 40-60% from resting length and long-stretch bandages stretch to greater than 140% of resting length. Short-stretch bandages are applied with low to moderate tension and are more prominent at the ends of extremities, reduce tissue hardening, also known as fibrosis (Farrow, 2010b; Brice et al., 2002; King, 2001; Williams, 2005; Lerner, 2000; Foldi et al., 2005)

Exercise, including lymphatic "Remedial Exercise", has been shown to have increased beneficial effects for patients with lymphedema. Patients are encouraged to create individualized exercise programs with a lymphedema specialist (Schmitz et al., 2009; Johansson et al., 2005; Mustian et al., 2009). Exercise must be done while wearing a compression garment or bandage to alleviate the build up of interstitial fluid (Gultig, 2005).

Hygiene is an important factor in lymphedema treatment which aides in reducing the amount of fungus and bacteria present on the skin. Cracks and dry skin are entry points for these pathogens and it is recommended that patients use low pH moisturizers to hydrate the skin and alleviate drying and cracking, which can lead to infections and wounds (Vaillant, 2002; Mallon, 1994). Typical infection of the skin is known as cellulitis and, ultimately, requires antibiotic treatment in people with lymphedema (Czerneic et al., 2010; Al Niaimi et al., 2009; Cooper et al., 2009; Godoy et al., 2007).

After maximal volume reduction in Phase I CDT, patients will be fitted to any one of the following compression garments, depending on the affected body part: sleeves, stockings, bras, compression shorts, or face and neck compression wear. The patient will receive two compression garments one to wear and one to wash and dry. This is done to prevent wearing dirty or wet compression wear, which will promote growth of fungus and bacteria. Garments should be washed daily and replaced every 4-6 months to maintain the same compression strength. It is important the garment be properly fitted to the proper garment style and compression strength to maintain long-term control of the lymphedema in terms of volume control and skin health. Custom garments are made for those patients who cannot fit into ready-made garments and allow for special options such as reduction of risk of breakdown of skin or fastening devices for easier removal or putting on of the garment. There are both day and night or advanced day garments (Yasuhara, 1996; Badger et al., 2000; Cornu-Thenard et al., 2007). The latter come in specialized varieties that better help to maintain the results of Phase I CDT, throughout Phase II. These include Velcro closure and specialized foam compression garments (Lund, 2000; Hafner et al., 2005; Lawrence, 2008).

Seeing that lymphedema is a life-long condition, maintenance is very important (Fu et al., 2008). Self-care includes education on risk-reduction practices, self-lymph drainage, skin care, signs and symptoms of infection, proper fit and care of garments, and the importance of good nutrition, as well as healthy regiments of exercise and weight control (Farrow, 2010b). The risk of getting lymphedema increases with obesity. Therefore, it is important to maintain or lose to be at a normal, healthy weight (Gur et al., 2009; Petrek, 2001; Soran et al., 2006; Helyer et al., 2010). It has been proven that the arm volume of post-mastectomy lymphedema patients decreases in overweight patients with weight loss (Shaw et al., 2007). Other patient conditions, such as scars, musculoskeletal ailments, palliative care necessities, post-radiation fibrosis, may require alterations in the CDT program. Adaptations are additions to CDT and include therapy, scar massage or myofacial therapy (Lund, 2000; Mallon, 1994; Yamamoto et al., 2008)

Compression pump therapy or Intermittent Pneumatic Compression Therapy (IPC) can be used as either an adjunct to Phase I CDT or as a component of Phase II CDT. These pumps should have a individualized pattern of a multi-chamber system that stimulates lymph flow in a single direction based on the pattern and diagnosis of lymphedema. Since lymphedema is a result of a condition in a quadrant of the body as well as the limb, the pump must work to treat the condition as a whole (Shaw et al., 2007; Miranda et al., 2001; Yamazaki, 1988; Dini, 1998; Partsch, 1980; Hammond et al., 2009; Ridner et al., 2008; Szolnoky et al., 2009). Normal pump pressures range between 30-60 mmHg (Olszewski, 2009). Recent studies show possible false correlations between the skin and device interface pressure patterns. This may have an ultimate effect on therapy (Mayrovitz, 2007). Higher pressures are more dangerous because they may do harm to superficial structures (Segers et al., 2002). The length of treatment is normally 1 hour (Hammond et al., 2009; Ridner et al., 2008).

Patients considered for IPC therapy need to be evaluated by a physician with medical knowledge of lymphedema. The evaluation provides level of pain and skin sensitivity as well as pressure for application to fibrotic areas. With trunk, chest or genital swelling is present, the physician must determine whether a pump that provides appliances to treat those areas is necessary or if the patient can manage the trunk swelling through self-MLD or

garments. If a pump with only extremity attachments used, monitoring of a condition known as fibroscelerotic ring should be a must, to detect an increase in hardening of the tissue or edema above the device sleeve (Boris, 1998). If this occurs both the extremities and the trunk should be treated (Olszewski, 2009, Brice et al. 2002).

IPC should not be administered with the following conditions: acute infection, severe arterial vascular disease, acute superficial or deep vein phlebitis (inflammation or clot), recurrent cancer in the affected area, or uncompensated congestive heart failure (Farrow, 2010b).

5. Invasive management techniques

Surgical treatment for lymphedema is performed under special circumstances, when the condition's severity supersedes all possible treatment options to control it, and in unison with CDT. Surgery has been used to reduce the weight of that part of the body that suffers from the condition, minimize the recurring inflammatory attacks, improve aesthetics, and to fit the limb into garments (Gloviczki, 1999; Vignes, 2002). Several surgical options have proven to work on lymphedema patients including debulking and liposuction, tissue transfers and microsurgical lymphatic reconstruction. Debulking surgery aims at removing hard connective tissue as well as large folds of fatty tissue that presents as a consequence of the condition. After this operation patients must wear compression garments to maintain the after effects of surgery, which include lymphatic scarring and lymphatic insufficiency. However, prolonged hospitalizations, poor healing of wounds, nerve damage or loss, intense scarring, negative effects on lymphatic vessels in that limb's area, aesthetically displeasing results, and even loss of function in the limb may occur (Farrow, 2010b; Miller, 1998; Salgado et al., 20009; Kim, 2004).

Liposuction, performed under general anesthesia, is the removal of fatty tissue deposits and the creation of many small incisions in the affected body part withstanding a long history with the lymphedema condition. The fat is suctioned out by means of tubular suction devices which breaks up and liquefies it. Tight bandaging is necessary post surgery to stop bleeding and compression garments are worn life-long to prevent lymphedema recurrence due to possible scarring of the lymph vessels during the procedure. Bleeding, infection, skin loss, unordinary sensations, and recurrence may occur post-operatively (Brorson, 2003; Brorson et al., 2006; Fazhi et al., 2009). Tissue grafts, or tissue transfers, are less well known forms of surgery for effectively treating lymphedema. Their overall goal is to bring lymph vessels into congested areas for better removal of excess interstitial fluid (Fazhi et al., 2009; Slavin et al., 1999)

Microsurgical and supramicrosurgical treatments, similarly aim at draining excess lymphatic fluid by means of shuttling lymph vessels to more congested areas. Although no long-term studies have been conducted on the effectiveness of this surgery, there have been limb volume reductions and successful connections of lymph vessels and veins, lymph nodes and veins, and multiple lymph vessels (Weiss et al., 2003; Becker et al., 2006; Baumeister, 2003a, 2003b; Koshima, 2000; Chang, 2010; Campisi et al., 2006). Surgical treatment of affected lymphedema sights is risky and very rarely a necessary consideration. If surgical treatment is considered, CDT is still a necessary adjunct and compression garments and Phase II maintenance is crucial (Warren et al., 2007).

6. Pharmacological, complementary integrative and alternative management

Pharmaceutical approaches to lymphedema have shown that treatment with drugs, such as Diosmin and Coumarin, or dietary supplements alone is ineffective. Diuretics cannot effectively remove interstitial fluid from the tissues, but may ultimately result in dehydration, electrolyte imbalance, or tissue damage. However patients with a history of hypertension and cardiovascular disease should speak to a healthcare provider or doctor before stopping use of diuretics (Farrow, 2010b; Loprinzi, 1999; Taylor, 1993; Cotonat, 1989).

Little research from studies has proved that all natural supplements are beneficial for lymphedema patients. Selenium has been proven to aide in lymphedema as a consequence of head and neck cancers. However, bromelain and American horse chestnut have not been studied for lymphedema related specific cases. Any natural supplements should be discussed with a physician prior to ingestion (Siebert et al., 2002; Micke et al., 2003; Bruns et al., 2004; Cirelli, 1962; Kelly, 1996; Gaby, 1995).

Ongoing research has been presented in treatments such as cold laser, electrical stimulation, vibratory therapy, oscillation therapy, endermologie and aqualymphatic therapy and are done in combination with portions of CDT (Piller et al., 2010; Carati et al., 2003; Hafner et al., 2005; Lawrence, 2008; Tidhar et al., 201; Omar et al., 2010; Jahr, et al., 2008). Acupuncture is shown to ease some cancer and treatment related symptoms such as fatigue, hot flashes, nausea, neuropathy, and muscular or joint pain, but no formal treatment has been devised from acupuncture (Farrow, 2010b).

7. Conclusions

Overall, lymphedema is a serious condition that requires timely intervention and appropriate therapy. The multidisciplinary approach is important to a patient at risk for lymphedema. It is important that early education on lymphedema be a standard of management and care for all patients. Prevention, screening, and measurement are all important for early detection of breast cancer related lymphedema. The conservative surgical approach minimizes a breast cancer patient's long-term risk of lymphedema, as does hormonal therapy. Chemotherapy, on the other hand, may have risks associated with developing lymphedema after breast cancer.

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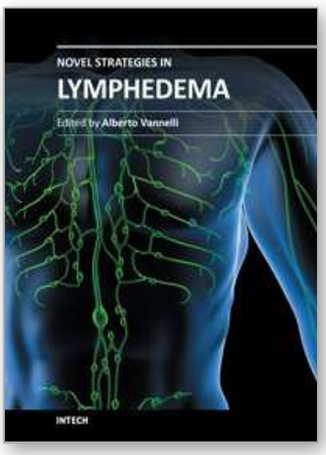
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Lymphedema is a swelling caused by the abnormal accumulation of lymphatic fluid in the skin. Lymphedema can be caused by burns, injury, surgery, radiation therapy or cancer treatment that cancer survivors undergo. Risk of developing lymphedema is high especially in those with breast or prostate cancer. It is hereditary and can appear without warning at any time of life and is related to obesity and circulatory problems. If not treated, lymphedema can be painful and lead to life-threatening infections. This book will help physicians who deal with lymphedema. It will help you understand how the lymphatic system works, how lymphedema is diagnosed, how to cope with the challenges of lymphedema, how to find treatment, and how to deal with insurance issues. Novel Strategies in Lymphedema is for those with, or at risk of, developing lymphedema, and the healthcare professionals who care for them.

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