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Feasibility of liposuction for treatment of arm lymphedema from breast cancer: A prospective study and review of the literature

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Abstract

Lymphedema is a dreaded complication of breast cancer treatment affecting 20% of women having axillary node dissection. We explored the feasibility of liposuction to reduce volume and thus arm lymphedema. A prospective trial of women with unilateral arm lymphedema from breast cancer treatment was conducted. Arm measurements, volumes (water displacement and geometric calculation), muscle strength differences and quality of life/functionality were measured pre-operatively and post-operatively at 6 weeks, 6 months and yearly up to 5 years.

Six patients had liposuction. Average age was 52.8 yrs. Average percent volume reductions at 6 weeks, 6 months and 1 year were 70%, 47%, 71% mls geometrically and 63%, 18%, 54% by water displacement. 1 patient had cellulitis at 4 months and had no other adverse events. Quality of life and functionality were not statistically significant. Pain decreased. Mean grip strength improved.

Liposuction can safely reduce volume of arm lymphedema and may improve functionality/quality of life. Larger studies with longer follow-up are required to validate the durability of these early results.

Introduction

Lymphedema is a dreaded complication of breast cancer treatment that affects approximately 20% of women having axillary lymph node dissection [1]. It is defined as an abnormal regional accumulation of protein-rich interstitial fluid, resulting in edema formation and eventual chronic inflammation with or without fibrosis [2]. Risk factors for the development of lymphedema after axillary lymph node dissection are advanced age, radiation, obesity, metastasis to lymph nodes and post-surgical complications like seroma [2]. Handley in 1908 was the first to describe the "brawn arm" associated with untreated advanced breast cancer [3]. In 1921 Halsted reported on "Elephantiasis Chirurgica, its cause and prevention" occurring after radical mastectomy [4]. Patients with lymphedema often have difficulty with activities of daily living caused by: limitations in range of motion, pain, numbness and weakness in the affected extremity [5]. Psychological morbidity including a decline in emotional and social well-being has also been documented in patients suffering from lymphedema [6,7].

The goal of lymphedema treatment is to decrease swelling, restore function and improve discomfort in and cosmesis of the affected limb. Conservative and surgical methods have been used with often less than optimal success. Current conservative treatment modalities include; arm elevation, exercise, lymphatic drainage techniques and controlled compression. Manual lymphatic drainage was introduced by Vodder in 1936; this technique uses massage to improve lymph flow [8]. Complete decongestive physiotherapy was developed by Foeldi in 1985 and consists of manual lymphatic drainage, compressive bandaging and exercise [9]. Pneumatic compression devices are another popular technique to improve lymphatic drainage, using an air compressor unit that attaches to a garment sequentially inflating and deflating creating a treatment effect [10].

Surgical therapy for lymphedema was first described by Charles, who in performed a wide excision of scrotal edema with skin grafting [11]. This excisional technique was applied by others to arm lymphedema, which is still used today but largely limited by its number of complications. O'Brien *et al.* reported on microlymphatic ovenous anastomoses for the treatment of obstructive lymphedema [12]. A decade later, in 1988, Nava published the first case of a patient treated with liposuction for an edematous arm [13]. The most noted advocate for liposuction as a treatment for lymphedema is Brorson, who started to use liposuction for arm lymphedema in 1987 [14]. Brorson reported his experience with liposuction extensively starting with a study of 28 women who after 12 months had an average reduction in arm volume

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of 106% [15]. In 2003 Brorson updated his results: with 48 patients treated with liposuction, after 48 months (n=12), an average reduction in volume of edema of 100% was found, showing the longevity of results [14]. Liposuction has similarly been used with success for the treatment of lower-extremity lymphedema [16-18].

To date there are a select number of publications addressing the feasibility of liposuction for the treatment of chronic arm lymphedema, resulting from the treatment of breast cancer. Brorson's group as well as a few others document its successful use, however experience reported in the U.S. literature is scarce [17,19,20]. Our objective was to explore the feasibility of liposuction to reduce fat volume and thus arm lymphedema, restoring function and improving cosmesis of the limb in an American study population. We report our protocol and review our early results with this technique.

Methods and materials

Pre-operative assessment and inclusion criteria

An IRB-approved prospective trial was conducted of women having non-pitting chronic unilateral arm lymphedema resulting from breast cancer treatment. Informed consent was obtained from all patients. Patients included in this study had mild to severe lymphedema; classification was based on the difference in volume of the affected arm compared to the unaffected arm: slight (<150 ml), mild (150-400 ml), moderate (400-800 ml), severe (>800).

At the time of enrollment no patients had evidence of active cancer, arm cellulitis, open wounds or pitting edema. All patients had undergone multiple previous conservative therapies, but none had surgical treatment for lymphedema.

Data collection

Data was collected at each patient visit starting at the pre-operative visit, then post-operatively at 2 weeks, 6 weeks, 6 months, 1 year and yearly afterwards for a planned five years. Patient independent variables included; age, height and weight, type of breast cancer surgery, reconstruction, number of lymph nodes removed, number of nodes with cancer, radiation treatment, chemotherapy, hormone therapy, previous arm infections, previous therapy for lymphedema and garment use.

The functional assessment of cancer therapy breast scale (FACT-B + 4, version 4) was used to assess patient quality of life measures [21]. This questionnaire follows a Likert scale of 0-4. We have arranged the data so that 0 represents the most negative value and 4 the most positive. The questionnaire has been previously validated and assesses physical well-being, social/family well-being, emotional well-being, functional well-being, and breast surgery related concerns.

Dependent variables recorded post-operatively included; arm measurements (circumferential), arm volume (water displacement and geometric methods), muscle strength differences between the affected and unaffected arms and quality of life/functionality. Water displacement was calculated by weighing displaced water to the nearest 5 g, corresponding to 5 mL. Both arms are always measured at each visit, and the difference in arm volumes is designated as the edema volume. The geometric calculation of volume was achieved using the Frustum method (Figure 1) [22]. Hand grip strength was quantified by measuring the amount of static force that the hand can squeeze around a dynamometer and measured in pounds. The patient's grip strength post-operatively of the involved verses the uninvolved arm was measured at each visit.

$$V_{frustum} = \frac{1}{12\pi} \sum_{i-1}^{n} L(C_i^2 + C_i C_{i-1} + C_{i-1}^2)$$

Figure 1. Geometric formula used to calculate the volume of the arm.
C: Circumference of arm
C_{i-1}: Circumference of arm at more proximal measurement
L: length of arm segment between C and C_{i-1}

Liposuction technique

The surgical procedure was performed by a single surgeon at our institution and a routine protocol was followed. All patients received a pre-operative antibiotic. A series of small incisions ~3-4 mm in size were made in the affected arm, forearm, and/or hand. A Hunstead needle was used to inject a "wetting solution" containing 1 liter of Lactated Ringer's solution with 50 cc of 1% xylocaine and 1 ampule of Epinephrine. 3 and 4 mm liposuction catheters were then used to circumferentially remove edematous fat as completely as possible. Ace compression wraps were placed from the fingertips to the shoulder in the operating room to provide hemostasis.

Post-operative care

On post-operative day 2, all patients had their operative bandage removed by the surgeon and the skin was inspected. Then a physical therapist re-wrapped the arm using a lymphedema bandage. Post-operatively patients were required to remove the dressing for bathing and skincare of the operative arm. After showering they were instructed to reapply the lymphedema compression wraps for 2 weeks. At 2 weeks, each patient was fitted for a compression sleeve that was worn during the day and removed at night in exchange for the multi-layered bandage, for a total of 6 weeks. Thereafter, the garment could be taken off only at night, as the patients were instructed pre-operatively that expected continued garment use would be life-long.

As aforementioned, skin inspection, edema volume measurements, arm functionality assessment and quality of life were re-assessed at 6 weeks, 6 months, one year and yearly thereafter until year 5. Due to anticipated changes in arm measurements during the first year post-operatively, new compression sleeves would be fitted at 6 months and one year.

Statistical analysis

Data is described as percentages, means or median with ranges as appropriate. A t-test was used to compare the difference in pre-operative and post-operative arm volume by geometric and water displacement. T-test was also used to compare the quality of life scores pre-operatively and post-operatively.

Results

Six patients were enrolled and underwent the liposuction procedure from 12/2008- 4/2011. The average age was 52.8 years with a range of 43-60 years. The time patients were living with lymphedema prior to participation in this study was 1.6-6.5 years. Of the six patients, one patient did not return after the two-week post-operative visit for her arm measurements. The remaining patients have been followed from 1-5 years. The average volume difference between the affected and unaffected arms at baseline was 562.6 mls (range 176-868 mls) by geometric calculation and 567 mls (range 219-770 mls) by water

displacement. Patients had mild to severe lymphedema, most falling into the moderate category (400-800 ml). Three patients had total mastectomy with axillary lymph node dissection and three had partial mastectomy with axillary lymph node dissection. Descriptive statistics can be found in Table 1.

Median volume of fat aspirated from the arm by liposuction was 700 mls (range 350-700 mls). No immediate surgical complications (within 30 days) occurred. One patient developed cellulitis requiring antibiotics at four months post-operatively which resulted in an increase in lymphedema volume. This accounted for a temporary increase in the median calculated arm edema for the entire study cohort at the six-month data point. By one year, the transient rise in lymphedema volume was no longer evident.

The average percent volume reductions for 5 of the 6 women at 6 weeks, 6 months, 1 yearpost-operatively were 70%, 47%, 71% mls geometrically and 63%, 18%, 54% by water displacement respectively (Figure 2a and 2b). Two patients have now been followed for 5 years with one having a 153%/121% reduction at five years, by geometrically and water displacement respectively, while the other patient has had recurrence of edema with a -165%/-110% change in volume. Although there is a trend toward decreasing arm volumes at 1 year, the population size was too small for statistical significance. A t-test

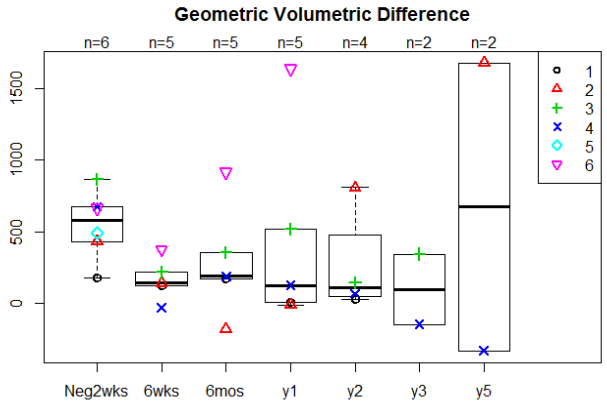

Figure 2a. Median arm volume reductions by geometric calculation in mls.

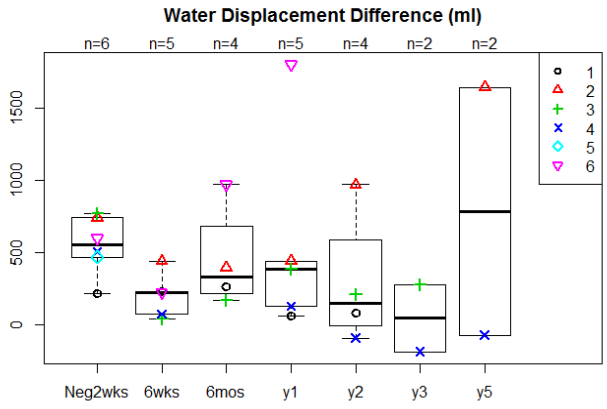

Figure 2b. Median arm volume reductions by water displacement in ml.

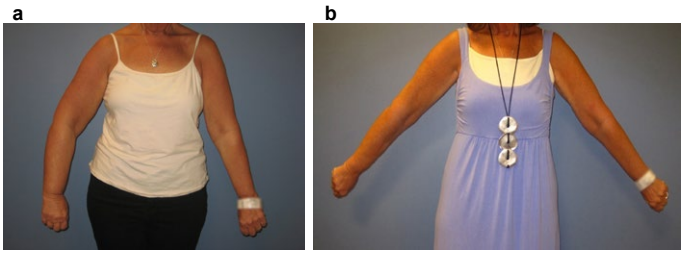

Figure 3. Pre-operative (a) and post-operative (b) photos demonstrating utility of liposuction for right arm lymphedema.

comparing the pre-operative difference in arm volume to the six month post-operative difference in arm volume by geometric and water displacement calculations respectively revealed the following p-values, p=0.181 and p=0.58. When comparing the pre-operative to 1 year post-operative results using geometric and water displacement, p-values were, p=0.722 and p=0.993 respectively.

Quality of life and functionality scores were calculated as total per patient, on a Likert scale 0-4, 4 being most positive. As sample size was small, no statistical significance was found in regards to quality of life change over time, p-values range from 0.181-1.100% of patients reported no pain at the 1-year follow up. Grip strength improved dramatically for one patient with 4/6 displaying minimal change at 1 year. The mean grip strength of the involved arm at baseline was 26.33lbs, at 6 weeks 25.83lbs, 6 months 33.8lbs, and 1-year32.5lbs. A t-test comparing the pre-operative arm strength to the 6 month and 1 year post-operative strength revealed no statistical significance, p=0.167 and p=0.202 respectively. Pre-operative and post-operative photos in Figure 3 demonstrate the clinical utility of liposuction for reduction of arm lymphedema.

Discussion

Lymphedema is a complication of breast cancer treatment that is commonly treated with conservative, non-surgical measures. The pathophysiology of lymphedema is such that the removal of axillary lymph nodes interferes with normal lymph drainage from the arm. The accumulation of interstitial fluid increases tissue pressure and this in turn reduces micro-vascular blood flow. The inter-relationship between microvascular blood flow and subcutaneous fat is not completely understood, however slow flow rate is a condition that spurs lipogenesis and deposition of fat, then adipose hypertrophy occurs [23]. Brorson *et al.* showed in a study using dual energy x-ray absorptiometry that the lymphedematous arm has a significant increase in soft tissue, 73% more fat, 47% more muscle and 7% more bone by volume then the unaffected arm [24]. Conservative measures and lymphovenous bypass may improve lymphatic flow in the early stages of pitting lymphedema when predominantly fluid remains in the tissues. Once non-pitting edema occurs, the overall accumulation of fat in the tissue can only effectively be removed by liposuction or excisional techniques [25].

The technique of liposuction was first developed in the 1970s and widely popularized in the early 1980s by a French surgeon Illouz [26]. Since then liposuction has proven to be a safe and reliable method to treat lipodystrophy. Brorson *et al.* investigated the effect of liposuction on lymph transport to disprove the theory that liposuction may impair the already impaired lymph transport. Using indirect lymphoscintigraphy in 20 patients with arm lymphedema before and after liposuction, they found that the already decreased lymph transport was not further reduced after liposuction, it was essentially

unchanged [27,28]. Based on these findings we consider liposuction a safe procedure for the treatment of lymphedema.

Although it did not reach statistical significance, our study demonstrates a noted decrease in volume of the affected arm at 6 weeks, 6 months and 1 year after treatment with liposuction. Reduction in volume was noted by geometric calculation as well as by volume displacement. These measurements have been shown to correlate strongly but are not mutually exclusive and therefore both are used to assess changes in arm volume [22]. The overall reduction in volume at the six month mark (18-47%) is decreased compared to the other values as it has been skewed by a single patient who had cellulitis increasing arm edema at four months. As expected percent decrease in volume trends back up at the 1-year mark with only one patient followed up to five years showing significant improvement.

Brorson proposes that chronic non pitting arm lymphedema of up to 4L in excess can be treated with liposuction [17]. His long-term results show significant decreases in arm volume, 104% at 1 year, 106% at 4 years, without recurrence [27]. Our reduction in arm volumes did not reach the 100% reductions, found in Brorson's studies. As our mean excess arm volumes were moderate (562.6 and 567mls by geometric and water displacement) and liposuction aspirate uniformly lower (700mls), this may have contributed to our decreased reduction in arm volumes. We may need to be more aggressive with our liposuction technique and thus achieve more volume reduction in the future. Other investigators performing liposuction found similarly positive results using Brorson's liposuction method. Schaverien *et al.* reported reduction in arm volume over a 5 year time period, with 101% reduction reported at 1 year in 12 patients [19]. Continued reduction in volume has been attributed to the continued use of compression garments. Damstra *et al.* show similar findings with a reduction in volume of 118% at 1 year in 37 patients [20].

How do these findings compare to conservative therapies? Exact measure of outcomes of conservative modalities varies from study to study. Most studies have shown reductions in volume or circumference of arm lymphedema, but no total corrections and often these results trail off at the 1 year mark [29]. In a randomized controlled trial, evaluating pneumatic compression for treatment of postmastectomy lymphedema, they found no significant improvement compared to the control group [30]. In a randomized study comparing manual lymphatic drainage to pneumatic compression devices, they found 15% reduction in arm volume in the manual lymphatic drainage group and a 7% reduction in the pneumatic compression group, with no significant difference between groups [31]. Brorson *et al.* evaluated liposuction with compression therapy verses compression therapy alone in 28 patients [27,32]. They found in the compression therapy alone group a 47% reduction of volume at 1 year, and in the liposuction group a 113% volume reduction at 1 year [27]. They additionally showed that removal of the compression garment at 1 year for 1 week, in patients treated with liposuction, increased the volume on average by 370 ml, reversed by re-compression [27,32]. Therefore life-long use of compression therapy is imperative.

Others have proposed a multi-modality approach using liposuction with myocutaneous flaps and lymph-fascia grafts for treatment of lymphedema and found significant decrease in arm circumference in a study of 11 patients [33]. Microsurgical techniques for lymphovenous bypass have varying results. In a prospective study by Damstra *et al.* 10 patients underwent lymphatic venous anastomosis, they found only a 2% reduction in arm volume at 1 year and minimal improvement in quality of life [34]. In1990 O'Brien reported a series of 52 patients treated with lymphatic-venous anastomoses [35]. They showed an average volume reduction of the treated extremity of 44% with some having 4-year follow up showing a reduction of 26% [35]. Other authors experience with lymphatic-venous anastomoses has shown modest improvements in arm volume of 30-50% [36]. Lymphovenous bypass may have efficacy for early stage lymphedema but is less likely to affect late-stage disease, as tissues have extensive fibrosis [36].

Aside from arm volume reduction, benefits of liposuction procedure also include increased quality of life and functionality. We assessed quality of life by survey, but were unable to achieve statistical significance, as our sample size was small. Schaverien *et al.* found significant reduction in patient reported anxiety and depression scores [19]. Brorson *et al.* found that in the liposuction group compared to compression therapy alone, the sensation of swelling, heaviness, fatigue and pain decreased after treatment, but for more physiological related factors and social life, there were few effects of treatment [37]. In addition reduction of volume likely decreases the incidence of cellulitis as total blood flow in the lymphedematous arm has been shown to increase significantly after liposuction [27]. We had only 1 of 6 patients that reported a post-operative cellulitis.

Conclusion

Liposuction is one of many modalities available to treat arm lymphedema from the treatment of breast cancer. It has been shown to safely reduce arm volume and may improve functionality and quality of life. Those who should be considered for this procedure have chronic secondary non-pitting lymphedema, have failed conservative measures, and are willing to continue with compression therapy post-operatively. In order for this treatment to reach optimal success an interdisciplinary team should be in place. The use of compression garments continues to be life long as it helps decrease the rate of recurrence. Larger studies with longer follow up are required to validate our early results.

Conflicts of interest

The authors of this article do not have any conflicts of interest in the manuscript, including financial, consultative, institutional, or other relationships that might lead to bias. This study was conducted under the approval of the Institutional Review Board (IRB) at Moffitt Cancer Center where the study was conducted.

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