

Original Research

Outcome of Liposuction for Limb Lymphedema in Men Compared with Women

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Abstract

Objectives: Liposuction effectively reduces limb volume in cases of advanced fat-dominant lymphedema. This study compares surgical outcomes between men and women using Brorson's liposuction for lymphedema protocol.

Methods: A total of 11 men and 11 women with unilateral limb lymphedema who underwent liposuction were matched based on preoperative volume difference (Vol Diff) and percentage volume difference (%Vol Diff) between the affected and unaffected limbs. Individuals were secondarily matched for age, body mass index, and lymphedema duration. The volume of fat aspirated was compared to preoperative Vol Diff to calculate a percentage (%) aspirate volume. The preoperative %Vol Diff and postoperative %Vol Diff at two-time intervals over 12 months were recorded. Differences between the groups were assessed for significance.

Results: Preoperative male group mean %Vol Diff of 35.1% matched the female group mean %Vol Diff of 34.8% ($p = 0.928$). The surgical male mean %aspiration volume of 80.4% was significantly less than the female group of 119% ($p = 0.004$). The reduction in male mean %Vol Diff was significantly less at the two postoperative time intervals. At 3-6 months, the mean %Vol Diff for men was 20.7% and 3.8% for women ($p = 0.009$). At the 9-12 months, the mean %Vol Diff was 13.2% for men and 4.2% for women ($p = 0.006$).

Conclusions: The male group matched for preoperative volume with a female group had a lower %aspiration volume and higher postoperative %Vol Diff which was most likely due to sex-based fat differences.

Keywords

liposuction, advanced lymphoedema, men, debulking

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Introduction

Lymphedema is a disorder characterized by impaired lymphatic drainage. Lymphatic fluid stasis and accumulation triggers a local chronic inflammatory state, leading to tissue remodeling, fibrosis, adipose cell hypertrophy, and fat deposition^{1,2)}. Conservative therapies such as compression, manual lymphatic drainage, skin care, and exercise remain the mainstay of lymphedema management. However, if this therapy is optimized and a significant limb volume difference remains, then surgical debulking may be appropriate if confirmed to be due to fat accumulation. Liposuction for debulking of excess subcutaneous fat aims to equalize the limb volume between the affected and unaffected limbs. This pro-

cedure has also shown positive health related quality of life scores and patient satisfaction³⁾.

Liposuction for the treatment of both primary and secondary fat-dominant lymphedema has emerged as an effective technique since its advocacy by Brorson⁴⁾ and has been implemented worldwide. The Brorson's liposuction method³⁾ using a tourniquet and dry liposuction with immediate compression has been reported to be more efficient and minimizes blood loss compared to tumescent technique^{5,6)}.

The goal volume of fat aspiration is calculated as the difference between the calculated volume of the lymphedema affected limb and the volume of the unaffected limb. This aspiration volume must be achieved within the limited time available under tourniquet. A rigorous postoperative routine

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of continuous compression therapy with customized compression garments and general care managed by a multidisciplinary lymphedema team is vital in maintaining a long-term positive outcome^{2-4,7,8}.

Publications of overall liposuction outcomes have indicated excellent long-term limb volume reduction^{1,2,4}. However, it has been our clinical impression that while the number of male patients undergoing this procedure is small, the surgical outcome for men in terms of volume reduction was worse than that for women. We identified limited published literature that compared the difference in outcomes following tumescent liposuction between men and women^{9,10}.

This study aims to compare the surgical and outcome data from a group of men with a group of selected case-matched women undergoing a standardized liposuction surgery for fat-dominant lymphedema of the extremity. We aim to identify any sex-based differences in the outcome of liposuction for lymphedema, in particular if this is due to body shape or muscle volume causing measurement variations or operative fat aspiration differences. If there is a sex-based difference in outcome of liposuction using a standardized non-sex-based surgical protocol, we will consider if a change in technique or protocol is necessary to improve the outcome for men.

Methods

This retrospective audit used a matched group analysis to explore any statistically or clinically significant differences in outcomes over a 12-month period between men and women with lymphedema treated with Brorson's liposuction technique for fat-dominant limb lymphedema^{3,4}. As a protocol of continued compression garment circumference reduction is undertaken to a stable garment measure over the first 12 months, it was believed that this 12-month period would best reflect surgical outcomes. The following years more likely reflect adherence to compression protocols or intervening health incidents.

Patient cohorts and matching criteria

All data analyzed was extracted from the electronic medical records of consented patients who had undergone liposuction for unilateral limb lymphedema between 2015 and 2022. All patients were required to have consented to clinical data retention for analysis and have at least two postoperative measures taken over a 12-month postoperative period. All patients were assessed to be ISL Stage 2b. Each male patient was matched with several female patients with similar preoperative limb Vol Diff and %Vol Diff, and then from that group of females, a single female was selected who was closest by age, body mass index (BMI), duration, and/or cause. Matching was undertaken by two independent assessors (HM, RR).

Liposuction protocol

Liposuction was performed following Brorson's protocol^{3,4} utilizing a dry technique with tourniquet at the upper

thigh or upper arm. The tourniquet was then removed after application of leg wraps or arm sleeve below it to compress the treated areas prior to performing routine tumescent liposuction from the upper thigh or upper arm tissue. Commercially available (Microaire®, Virginia, USA) 3 mm standard liposuction cannulas were used around the ankle or wrist, and 4 mm spiral cannulas were used for the remainder of the limb. Intraoperative compression was applied immediately prior to release of the tourniquet. In the leg, we applied compression wraps for the foot, calf, and knee. For the arm, we used a class 2 flat knit custom sleeve measured to the non-affected arm circumferences and a glove. Following completion of tumescent liposuction of the area above the tourniquet, the thigh wrap component was added in the leg, or the compression sleeve was pulled up with a shoulder strap in the arm. The leg wraps were replaced by customized flat knit compression garments measured using the non-affected limb 4-7 days postoperative. The garments were then replaced on a 3-monthly basis for the first 12 months using the controlled compression technique outlined by Brorson^{3,4}. The compression regimen was the same for men and women. Our previous research has demonstrated our liposuction complications to be minimal; less than 1% require blood transfusion as there is virtually no blood loss below the tourniquet. Other complications include skin injury (less than 5%), seroma formation (less than 1%), and prolonged pain (less than 3%) and do not appear to be associated with sex¹¹.

Limb measurements

Limb measurements data at the preoperative and two postoperative time points, 3-6 months and 9-12 months, were collected for each patient. Limb volume was determined using 4 cm truncated cone circumferential measurement method described in previous publications². In this study, limb Vol Diff and %Vol Diff were used:

- *Vol Diff in milliliters* = volume of affected limb – volume of unaffected limb
- *%Vol Diff* = [(volume of affected limb – volume of unaffected limb) / volume of unaffected limb] × 100

Aspirate volume

The volume of fat aspirated was calculated at the completion of surgery by the addition of fat volume observed in each of the individual liposuction canisters collected from below the knee, above the knee to tourniquet, and above the tourniquet minus the volume of separated blood or tumescent fluid visible below the floating aspirated fat. To confirm this volume, two study members (TL, HM) separately reviewed the medical and surgical records and photographs taken of the canisters at the end of the surgery. A percentage aspirate was then calculated.

- *Percentage of aspirate (% aspirate)* = (volume of aspiration / pre-op Vol Diff) × 100

Statistical analysis

Statistical analysis was conducted using IBM SPSS Statis-

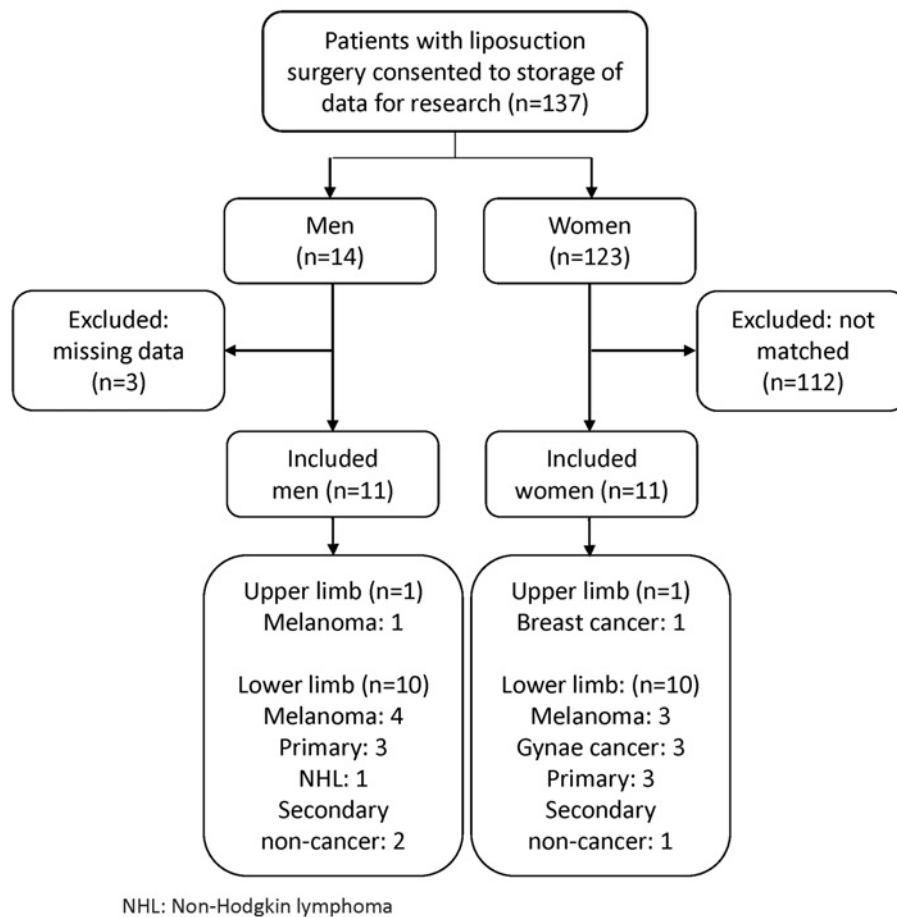


Figure 1. Flow diagram.

tics Version 27.0 for Windows (Armonk, NY: IBM Corp) and Microsoft Excel (Redmond, WA: Microsoft Corporation). Data scores were tested for normality using the Shapiro-Wilk test. Limb volume was compared between baseline and follow-up time points using two-sided independent sample t-tests. The Mann-Whitney U test was utilized for non-normally distributed data. All statistical tests were considered significant if $p < 0.05$.

Ethics approval

Written informed consent was obtained from all patients for the storing of clinical and operative data for further analysis. Ethical approval was granted by the Macquarie University Human Research Ethics Committee (reference number: 52020613914268).

Results

The data of all 14 consented men who had undertaken liposuction from 2015 to 2022 was reviewed and 3 men removed from analysis due to inadequate postoperative follow-up data (1 had died, 1 moved overseas, and 1 was unable to attend due to COVID-19 border lockdowns) (Figure 1). This resulted in a male group of 11 (arm = 1, leg = 10). Each man was then matched with a female patient (arm = 1, leg = 10). The preoperative median limb Vol Diff in the male group was 2151.1 mls compared to the female group me-

dian Vol Diff of 2331.2 mls ($p = 0.898$). Preoperatively the mean %Vol Diff in the male group was 41.3% and in the matched female group was 40.4% ($p = 0.928$). The men and women were then matched secondarily by age ($p = 0.652$), BMI ($p = 0.515$), and lymphedema duration ($p = 0.438$) (Table 1). The causes of the lymphedema in each group were similar.

The mean operative %aspirate in the male group was 80.7% and was significantly less when compared to the female group of 119.4% ($p = 0.004$). The surgical outcome as indicated by reduction in mean %Vol Diff was greater in women at both postoperative time intervals. At review between 3 and 6 months postoperatively, the male group had a mean %Vol Diff of 20.7% and the female group of 3.8% ($p = 0.009$), and at the second review between 9 and 12 months, the mean %Vol Diff in the male group was 14.1% and female group was 3.4% ($p = 0.006$).

A review was undertaken of the compliance of the male and female cohorts with the postoperative compression garment wear regimen of 24 hour/day wear and replacement of garments on a third monthly basis customized using controlled compression technique¹². This demonstrated consistent and equal compliance in both groups over the first 12 months following liposuction. Using a score of 0-3 (0 = noncompliance to 3 = full compliance) at each postoperative visit at 3, 6, 9, and 12 months, the male cohort scored 11.0/12 and the female cohort scored 10.8/12.

Table 1. Demographics, Measurement, and Outcome Data.

| Characteristics | Men (n = 11) | Women (n = 11) | p-value |
|--|-------------------------|-------------------------|---------|
| Age (years): median (IQR) | 57 (39.5, 62.0) | 57 (53.5, 63.5) | 0.652 |
| BMI (kg/m ²): mean (SD) | 28.1 (3.3) | 27.0 (4.1) | 0.515 |
| Duration of lymphedema (years): median (IQR) | 10 (8.7, 15.4) | 8.2 (5.2, 14.3) | 0.438 |
| Pre-op volume difference (ml): median (IQR) | 2151.1 (1729.4, 4777.1) | 2331.2 (1778.8, 3960.9) | 0.898 |
| Pre-op % volume difference: mean (SD) | 41.3% (23.0) | 40.4% (24.6) | 0.928 |
| Aspirate volume (ml): median (IQR) | 1700 (1462, 3400) | 3600 (2200, 4600) | 0.193 |
| % aspirate volume: mean (SD) | 80.7% (26.7) | 119.4% (29.6) | 0.004* |
| Post-op % volume difference: mean (SD) | | | |
| 3–6 months | 20.7% (18.7) | 3.8% (4.1) | 0.009* |
| 7–12 months | 14.1% (10.3) | 3.4% (5.5) | 0.006* |

*Significant: $p < 0.05$. BMI: body mass index; IQR: interquartile range; kg: kilograms; m: meters; ml: milliliters; op: operative;

%: percentage; SD: standard deviation

Discussion

The aim of this study was to compare the surgical and outcome data from men with case-matched women undergoing a standardized liposuction surgery for advanced fat-dominant lymphedema of the extremity. The protocol for this surgery is not currently sex modified. The results of this study demonstrated a statistically significant difference in the %aspirate volume and the %Vol Diff outcome between matched groups of men and women suggesting that men may have poorer volume reductions than women following liposuction for fat-dominant limb lymphedema.

While there are studies evaluating the efficacy of liposuction for lymphedema using other liposuction techniques^{2,13}, there is little data on the effect of sex on outcome. As the majority of patients are treated for lymphoedema secondary to breast and gynecological cancers³, the patient cohort is female dominated, making sex-based studies difficult to conduct due to the small male patient population. Men may also be more tolerant to limb volume increase and less likely to present for surgical intervention.

Our findings do concur with two studies that have noted that their male patient group had larger persistent post tumescent liposuction volume differences compared to a female patient group; however, these male patients were more likely to have a primary lymphedema diagnosis and greater preoperative volume difference^{6,14}. A Chinese publication using a tumescent liposuction technique similarly reported a poorer outcome in men due to greater difficulty in extracting fat in men compared with women¹⁵. It is suggested this may be the effect of different hormone levels in men and women on the composition of subcutaneous tissue¹⁶. There are also recognized physiological and hormonal variations by sex that lead to differences in the distribution and fibrotic component of subcutaneous tissue^{17,18}. There are physiological differences in tissue from areas of lymphedema in the composition of certain molecules compared to normal adipose tissue related to altered adipocyte metabolism¹⁹. Several publications have also noted that compliance with postoperative compression protocols were generally lower among men compared with women although they were more satisfied

with their results^{9,10}.

There were possible sex-based effects of the different body shape of men when compared to women on measured aspirate volume and %aspirate volume. This was particularly apparent in the volume of fat aspirated from the above torniquet segment in the lateral upper thigh of the women. Additional fat was aspirated from this segment using a tumescent solution to achieve a smooth thigh contour. This area is not included in the preoperative estimated limb volume where the upper circumference measured may be below the high upper thigh and therefore may result in an increase in the mean %aspirate volume in women. However, in relation to %Vol Diff outcomes, we note that the pre- and postoperative calculated volumes are measured at the same recorded distance from the heel to the upper inner thigh levels.

The known muscle volume differences between men and women had no impact on limb volume difference measurements. This is because we are comparing the volume difference between the affected and unaffected limb in the individual patient. This accords with previously published studies that found no difference in muscle size between the lymphedema affected and unaffected limbs when measuring section thickness of the calves²⁰.

The outcomes of post liposuction volume reduction show a similar difference between male and female patients. Men had a larger postoperative %Vol Diff at each time point of measurement over the first 12 months. This appears to confirm our clinical observations and is consistent with other studies that have also described that male patients have a lower fat aspiration volume than predicted and thus higher persisting volume differences^{5,14,21} using other liposuction surgical techniques. Even though there may be some question of the overvaluation of the operative aspirate volume in women due to the gynoid shaping of the upper thigh, outcome %Vol Diff measures of leg volume were calculated to a consistent level in the limb at each of the measurement time points and therefore are not affected by possible additional fat aspiration above the measurement level in women.

Study limitations

This study has several limitations, in particular the small

sample size. The number of male patients who present for this procedure is limited. The period of follow-up was set to 12 months as this was seen as the time frame for stabilization of the compression garment measurements postoperatively. Nevertheless, the 2020-2021 COVID-19 pandemic lockdown period made clinic attendance and measurement challenging for some patients, and there was some loss of outcome data intervals.

Accurate measurement of the aspirated fat volume proved difficult at the above tourniquet thigh area where tumescent liposuction was performed. This was because the gynoid fat distribution in women meant that the liposuction area in upper thigh tended to be higher than in men and was often above the preoperative upper circumferential measurement level for predicted limb volume. A careful review of the operative photograph taken of the aspirate canister and contemporaneous surgical description was undertaken to limit this error. In addition, we have not attempted to identify specific levels of patient satisfaction with the outcome and therefore cannot make any judgment on sex difference in this area.

Significance of this study and future directions

Given the significant difference in the results of this study between men and women, it is important to focus on enhancing outcomes for male patients. Liposuction for lymphedema as well as long-term conservative management is an expensive, time-consuming, and effort-consuming process for both sexes. While quality of life improvements postoperatively should not be measured on volume reduction alone¹⁾, clinicians may need to advise male patients of lower expectations in the time frame it takes for their limb circumference to normalize. Surgical techniques for men may enhance the overall experience of male patients and promote compliance.

It is known that liposuction in men is generally a more difficult procedure due to tissue architecture differences - men have thicker skin, and their fat tends to be denser and more fibrous^{3,10,14)} and therefore more difficult to aspirate. The results of this study demonstrate that a lower aspirate volume is a major contributor to the sex-based outcome differences. In addition, Microaire® 4 mm spiral cannulas were utilized for the limb in this study. As the Microaire® spiral cannula is currently the “sharpest” available, the results of this study suggest that trial of the slightly larger 5 mm spiral cannula for men may be warranted.

Repeating the procedure or modified liposuction methods may be considered, including ultrasound-assisted liposuction and laser-assisted liposuction³⁾. Although not yet used for lymphedema treatment, there have been speculations on the benefits of these alternative approaches in tumescent liposuction for HIV-associated lipodystrophy²²⁾ and Madelung’s disease²³⁾. It has been proposed that these methods may enhance skin laxity and tone and result in better preservation of neurovascular structures, as well as reducing surgeon fatigue during the procedure^{23,24)}. However, they generally increase surgical time, which is a critical factor in this lipo-

suction technique and may cause unfavorable effects such as skin retraction. All our liposuction surgeries are performed under tourniquet control as per Brorson’s protocol, and the larger limbs typically need a complete 2-hour tourniquet (ischemic) period. If a slower method is used, the total surgery time may need to be increased significantly to allow for reperfusion time following tourniquet removal before re-application. Furthermore, there is no evidence that more fat can be extracted using these alternative methods.

Research has suggested that men are potentially less compliant^{8,10,15)} with compression use due to a variety of factors such as higher result satisfaction and higher tolerance toward flaws. Our research confirmed that our patients did continue to adhere to their prescribed compression garment wear regimen, however, over a longer trial period, patients may become exhausted. Compliance with long-term compression garment wear needs to be supported and encouraged to maintain the treated limb volume.

Conclusions

Overall, this study supported our observation that men have poorer surgical outcomes in relation to volume reduction after liposuction for fat-dominant limb lymphedema compared to women. This appears to be primarily due to the smaller aspirate volume achievable in men. Further studies are required, and consideration for modified gender-based techniques of liposuction may provide an outcome benefit for men.

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Conflicts of Interest: There are no conflicts of interest.

Ethical Approval: The study involving human participants was examined and approved by Macquarie University Human Research Ethics Committee reference no. 52020613914268 and Macquarie University Clinical Innovation and Audit Committee reference no. MQCIAC2018017 A.

Consent to Participate: The patients gave their written informed consent to participate in this research.

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