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Breast

Power-assisted Liposuction for Lymphedema: A Cost-utility Analysis

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Background: Lymphedema is a chronic, debilitating disease that has been described as the largest breast cancer survivorship burden. Debulking surgery has been shown to improve extremity volume, improve patient quality of life, and decrease the incidence of cellulitis in the literature. This procedure is routinely covered in numerous other developed countries, yet it is still inconsistently covered in the United States.

Methods: Extremity volumes from all patients who underwent debulking surgery of the upper extremity at two institutions between December 2017 and January 2020 with at least 12 months follow-up were included. Procedural costs were calculated using Medicare reimbursement data. Average utility scores were obtained for each health state using a visual analog scale, then converted to quality-adjusted life years. A decision tree was generated, and incremental cost-utility ratios were calculated. Sensitivity analyses were performed to evaluate our findings.

Results: Debulking surgery is associated with a higher clinical effectiveness (quality-adjusted life year) of 27.05 compared to conservative management (23.34), with a relative cost reduction of $74,487. Rollback analysis favored debulking surgery as the cost-effective option compared to conservative management. The resulting negative incremental cost-utility ratio of −20,115.07 favored debulking surgery and indicated a dominant strategy.

Conclusion: Our study supports the use of debulking surgery for the treatment of chronic lymphedema of the upper extremity. *(Plast Reconstr Surg Glob Open 2022;10:e4671; doi: 10.1097/GOX.0000000000004671; Published online 18 November 2022.)*

INTRODUCTION

Although lymphedema is chronic and progressive, recent surgical advances have allowed for greatly improved quality of life and function for people living with this incurable disease. While microsurgical interventions including lymphovenous bypass and vascularized lymph node transfer have received the most attention in the United States, debulking surgery via power-assisted liposuction is an effective option that does not require microsurgical training and is the standard treatment in many other developed countries.[1] Debulking surgery has been shown to consistently and dramatically improve extremity volume, patient quality of life, and patient function.[2–7] From a cost-effectiveness perspective, the outcomes are so consistently positive that the cost of the procedure is almost irrelevant. However, this surgery is still not consistently covered by insurance in the United States. Although there is a clear clinical benefit, the surgical community is duty-bound to assess value because with every additional surgical option, there is additional cost, and there are only so many resources available in our healthcare system. Therefore, we are obligated to assess the value of this intervention and promote value-based surgical options and their coverage by insurance companies.

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Although healthcare systems differ dramatically by country, it is worth noting that other developed countries fully cover this procedure. In the United Kingdom, for example, the evidence-based recommendation is to perform liposuction for chronic lymphedema after conservative management with manual lymphatic drainage and decongestive lymphatic therapy are optimized.[8] Of note, the policy emphasizes that care must be delivered as part of a multidisciplinary effort similar to our prior description of debulking procedures at the Boston Lymphatic Center.[1] Brorson,[9] who initially described the technique most widely used today, notes that all patients with lymphedema whose conservative management has been optimized to the point of no pitting edema and who agree to compliance with compression therapy are good candidates for debulking surgery. Of note, surgery, conservative therapy and compression therapy are consistently covered by insurance in Sweden.[10] In Australia, Medicare, which is the universal health insurance scheme, covers liposuction for the treatment of lymphedema as long as clinical details are documented with photographic evidence. In the United States, Blue Cross Blue Shield Massachusetts, working alongside the Boston Lymphatic Center, passed the first policy in the United States for coverage of lymphatic surgery procedures including liposuction for lymphedema in June, 2019.[11] However, there is no consistent coverage available for patients nationwide.

In this study, we perform a cost-utility analysis in the hopes of raising awareness to the extreme utility and cost-effectiveness of this procedure, so that it may be consistently covered by insurance, affording our lymphedema patients an important surgical option in their care.

Takeaways

Question: Is debulking surgery for the treatment of chronic lymphedema of the upper extremity in breast cancer patients cost-effective compared to conservative management?

Findings: A decision tree was generated, and incremental cost-utility ratios were calculated. Debulking surgery is more effective and costs less when compared to conservative management. Rollback analysis favored debulking surgery as the cost-effective option compared to conservative management.

Meaning: Debulking surgery is cost-effective for the treatment of chronic lymphedema of the upper extremity in breast cancer patients.

METHODS

Reference Case

In this cost-utility model, a hypothetical cohort of lymphedema patients with upper extremity fat-dominant lymphedema, defined by MRI imaging criteria with circumferential subcutaneous fat hypertrophy, were included. The base case was defined as a 45-year-old female patient with upper extremity fat-dominant lymphedema of her dominant extremity. In this hypothetical scenario, the patient could either undergo conservative management with compression garments and physical therapy or debulking surgery with postoperative compression. Patients did not undergo any other prior surgical intervention for their lymphedema. Life expectancy of patients in this cohort from time of surgery is estimated to be 36.1 years.[12]

Decision Model and Probabilities

We used TreeAge Software Pro Version 2020 (TreeAge Software, Inc., Williamstown, Mass.) to construct the decision model and compare both treatment modalities (Fig. 1). In this model, under each arm of the decision tree, the probability of health states was incorporated as well as the associated costs and their utilities. This approach has been previously described.[12,13] Both interventions (conservative management and debulking surgery) have the same categories of postoperative outcomes: successful (within 25% volume of unaffected arm) or unsuccessful (more than 25% larger than unaffected arm) with different probabilities. These event pathways and probabilities were obtained from a prospective institutional database. (**See figure, Supplemental Digital Content 1**, which shows the postoperative debulking surgery outcomes at 1 year, **http://links.lww.com/PRSGO/C279**.) (**See figure, Supplemental Digital Content 2**, which shows conservative management

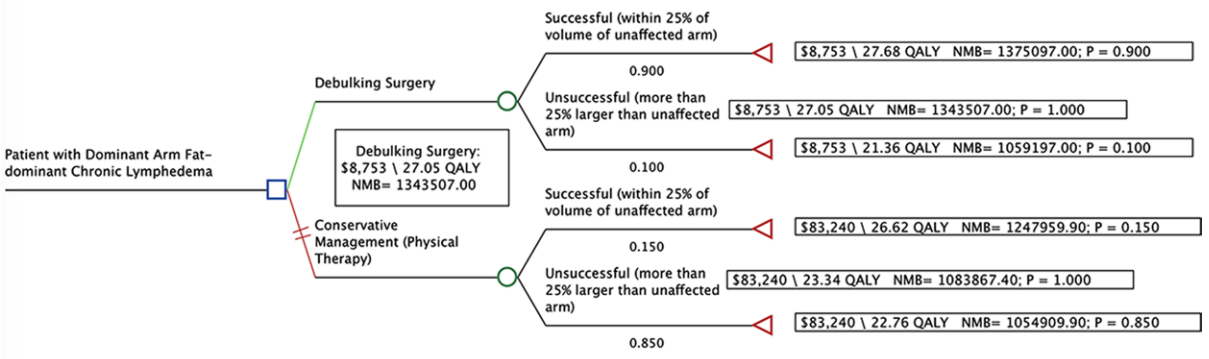

Fig. 1. Decision tree. The top green line represents the cost-effective strategy.

Table 1. Utilities, Costs, and QALY

Health State	Utility Score	Cost ($USD)	QALY
Debulking surgery—successful	0.77	$8753	27.68
Debulking surgery—unsuccessful	0.59	$8753	21.36
Conservative management—successful	0.74	$83,240	26.62
Conservative management—unsuccessful	0.63	$83,240	22.76

Baseline utility score with lymphedema is 0.65.

outcomes at 1 year, **http://links.lww.com/PRSGO/C280**.) In our practice, the overwhelming majority of patients present as fat-dominant lymphedema and most have stage 2 lymphedema. Of note, the probability of successful debulking surgery was defined as 0.9, despite our data demonstrating a 100% success rate, in order to allow for sensitivity analyses (SAs).

Costs and Perspective

Direct costs of both arms, as well as associated costs of each health state, were reported in 2020 US dollars (Table 1). Debulking surgery payment data were based on 2020 Medicare current procedure terminology (CPT) code 38999, whereas conservative management cost was based upon annual out of pocket costs propagated over the course of a lifetime.[12,14] Of note, this model did not include any indirect costs such as those for loss of productivity, waiting time, transportation, and absence from work. Additionally, given that both arms were prescribed compression, the costs of the compression garments were excluded from the analysis. Custom high-grade compression garments are worn in both arms of this analysis and must be replaced every 3–6 months as per standard of care due to garment loosening. The perspective of the third-party payer was adopted in order to provide well-balanced cost burden to each treatment modality, which is a well-accepted and established perspective in the literature.[15,16]

Utilities

Utility scores of all health states were obtained from a visual analogue scale (VAS) survey administered to breast tumor board members. (**See figure, Supplemental Digital Content 3**, which shows the assessment of lymphedema treatments on quality of life, **http://links.lww.com/PRSGO/C281**.) The health states of the questionnaire represented health states ranging from 0 (death) to 1 (healthy). These utility scores (Table 1) were converted to quality-adjusted life years (QALYs) to measure the effectiveness of our model. Patients were estimated to reach a stable outcome at 1 year after treatment.[12] The example below illustrates how QALY was obtained for a 45-year-old male patient who was expected to live up to age 81.1 years. A similar example was published in our previous works.

Life expectancy for a patient with upper extremity fat-dominant lymphedema is 81.1 years.[1] For a 45-year-old patient, life expectancy is 36.1 years. The baseline utility of a patient with fat-dominant lymphedema of their dominant extremity is 0.65. A patient with a successful outcome after debulking surgery is expected to have a utility of 0.77 and reach this outcome within 1 year.

$$\text{Number of health years remaining} = \text{average life expectancy} - \text{average age of patient}$$

81.1 – 45 years = 36.1 years.[12]
Duration of health state:

$$52 \text{ weeks}/52 \text{ weeks} = 1.0 \text{ year}$$

QALY: (utility of health state) × (duration of health state) + (utility of successful procedure) × (remaining life years).

$$(0.65)\ (1) + (0.77)\ (36.1 - 1.0) = 27.68 \text{ QALYs}$$

Incremental Cost-utility Ratio

Using the QALYs and costs in the decision tree, the incremental cost-utility ratio (ICUR) was then calculated using the formula below:

$$\text{ICUR} = \frac{(\text{Expected cost of debulking surgery} - \text{Expected cost of conservative management})}{(\text{Expected QALY of debulking surgery} - \text{Expected QALY of conservative management})}$$

An ICUR of less than $50,000 was used to deem an approach cost-effective.[12]

Deterministic SA

To further evaluate the robustness of our model, we conducted SAs. One-way deterministic SA was conducted for each variable, which was varied from the lowest to the highest values (from institutional data) to determine the impact on our result. Specifically, one-way SA was performed for the cost of debulking surgery using a range of costs from the Medicare CPT database to account for variation among hospitals around the country and for the utility scores for each health state. Tornado analysis was performed to identify the greatest variables of uncertainty.

Probabilistic SA

The second form of SA was probabilistic SA using Monte Carlo simulation, in which the effect of simultaneously changing the values of variables is based on the SD obtained from institutional data. Variables included in this probabilistic SA were cost of physical therapy (gamma distribution), cost of debulking surgery (gamma distribution), utility of physical therapy (beta distribution), utility of debulking surgery (beta distribution), probability of success with physical therapy (beta distribution), and probability of success with debulking surgery (beta distribution).

Decision Analysis Quality Assessment

The cost-utility and decision analysis design followed value analysis consensus guideline recommendations described by the CHEERS criteria.[17]

Institutional review board approval was obtained, and this study was done in accordance with the principles outlined in the Declaration of Helsinki of 1964, and its most recent revision 2013.

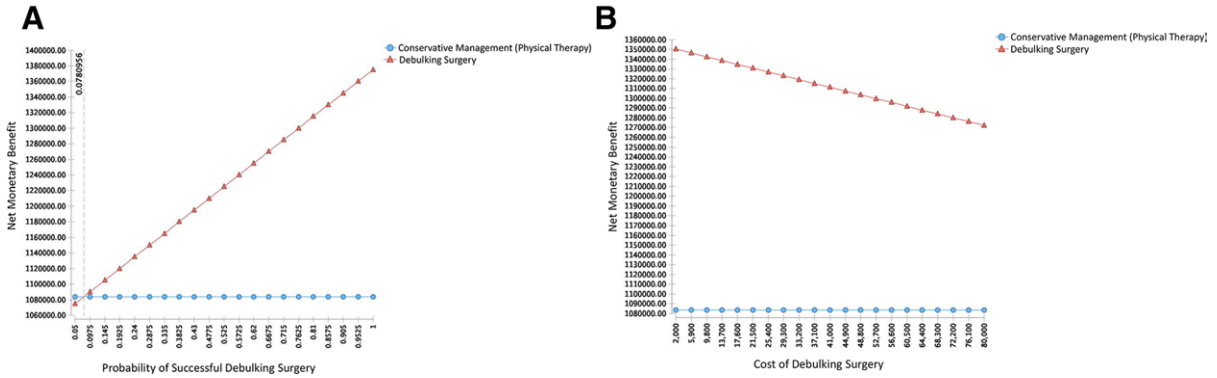

Fig. 2. One-way SA. A, At WTP of $50,000, debulking surgery remained the more cost-effective strategy if the probability of successful surgery is greater than 7.8%. B, At WTP of $50,000, the cost of debulking surgery did not reach a threshold point over a range of values from $2000 to $80,000.

RESULTS

The decision tree analysis (Fig. 1) demonstrated that debulking surgery is associated with a higher clinical effectiveness (QALY) of 27.05 compared to conservative management (23.34), with a higher increment of clinical effectiveness of 3.70 and relative cost reduction of $74,487. Rollback analysis favored debulking surgery as the cost-effective option compared to conservative management. The resulting negative ICUR of –20,115.07 favored debulking surgery and indicated a dominant strategy. Probabilities present in the decision tree (Fig. 1) were notable for a higher success rate for debulking surgery (90%) compared to conservative management (15%).

Deterministic SA

Debulking surgery remained the cost-effective strategy if the probability of successful surgery was greater than 7.8% (Fig. 2A). On the other hand, there was no threshold point for the cost of debulking surgery that would allow for conservative management to become the more cost-effective strategy, including the range of costs from the Medicare CPT database to account for variation among hospitals around the country (Fig. 2B). A Tornado diagram analysis (Fig. 3), with uncertainty around the mean value for each of the variables studied, identified the utility of successful debulking surgery as the greatest variable of uncertainty. This also did not identify a value in the utility scores that would change our conclusion.

Probabilistic SA

With probabilistic SA, we used Monte Carlo simulation to show a confidence of 92.7% in favor of debulking surgery (Fig. 4).

DISCUSSION

Debulking surgery is widely recognized as a clinically effective treatment to reduce extremity volume, and although reports differ regarding the extent of volume reduction achieved, the effectiveness of this technique is not controversial. The effectiveness of this technique has been reported over the long term, without the need for repeat surgery.[9] Although the initial cost of debulking surgery is higher than that of conservative treatment alone, this procedure is cost-effective. However, in this study, we go beyond cost-effectiveness and evaluate value. A procedure with good value is one that has clinical benefits at a *reasonable* cost. Reasonable is defined by context. In the United States, it is generally accepted as an ICUR less than 50,000/QALY, whereas in the United Kingdom, it is less than 30,000/QALY. In this study, we show that debulking surgery has an ICUR of –20,115.07/QALY.

To complete this analysis in a methodologically sound way, we had to define a successful surgery as the affected extremity coming within 25% of the unaffected extremity. In our clinic, we define success as the affected extremity coming within 10% of the unaffected extremity, but by this stricter definition, no patients who underwent

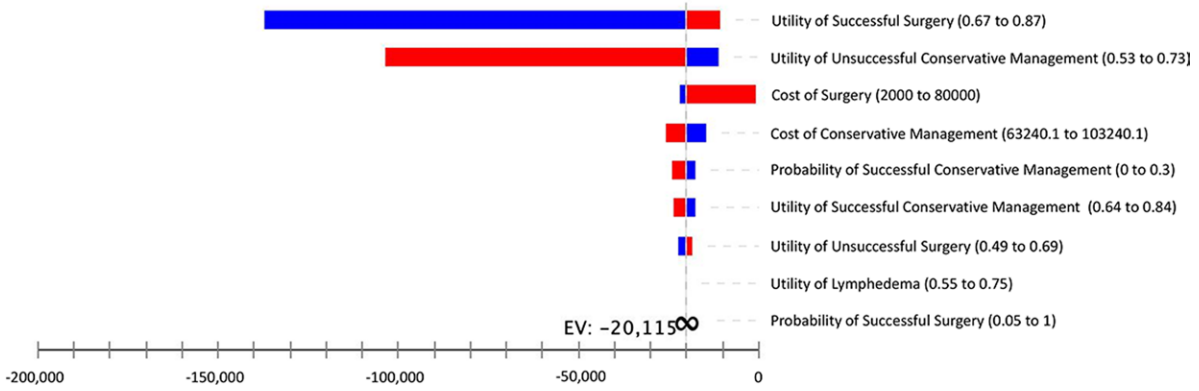

Fig. 3. Tornado diagram (ICER) identifying the greatest variable of uncertainty as utility of successful debulking surgery.

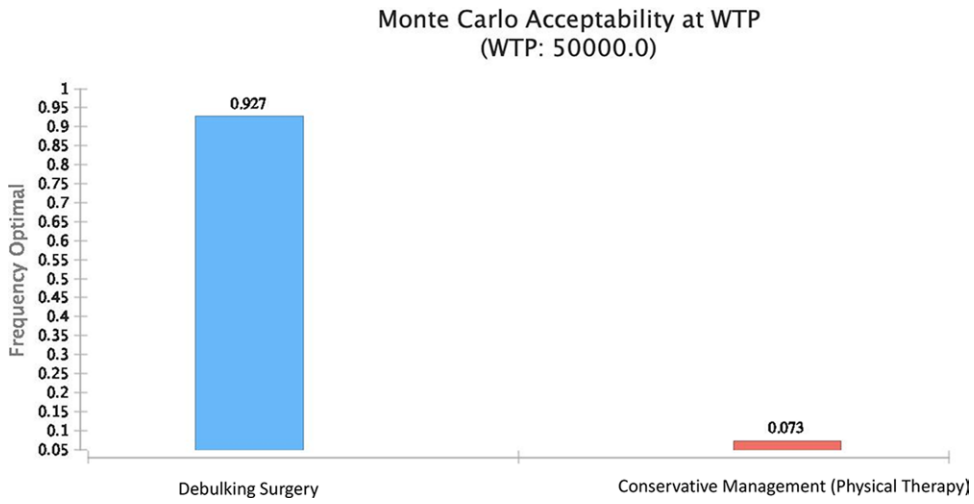

Fig. 4. Probabilistic SA Monte Carlo acceptability at WTP $50,000. A confidence of 92.7% that our conclusion, debulking surgery, was the more cost-effective strategy.

conservative treatment would have been classified as successful, and the analysis could not have been performed. This highlights the enormous advantage of debulking surgery over conservative management. In addition, for the analysis, we had to falsely lower our success rate of surgery to 90%, even though 100% of our patients achieved volume reductions of 90% or greater.

Even with these lowered standards for the definition and rate of success, this procedure is cost-effective and has an excellent value. Without question, it should be consistently covered by insurance, as it is in many other developed countries, including the United Kingdom, Australia, Denmark, Finland, Norway, and Sweden. The US healthcare system is not perfect, but it does emphasize value-based care. The field of cost-utility analysis is gaining more attention because it addresses this core principle of value-based care.[14] It is important that surgeons lead these studies as we advocate for what we know is working for our patients.

This study is unique in that it is multi-institutional and multicontinental, drawing patient outcomes data from two major multidisciplinary lymphedema institutions that have been designated as centers of excellence. In addition, it is the first cost-utility analysis to evaluate debulking surgery for the treatment of lymphedema. We acknowledge the enormous body of evidence for this procedure and internal cost review that has been conducted internationally that has led to insurance coverage abroad.

The limitation of this study is that utility scores were provided by physicians, and the number of surveys we were able to administer was limited by the COVID-19 pandemic. Patient-reported utility scores would be preferable for future studies. However, deterministic SA across a range of values did not show a utility score that would change our conclusion. In addition, another limitation of this study is that this article does not address a societal cost perspective. However, the third-party payer perspective is an accepted and important addition to the literature, as it allows the surgeon to provide evidence for insurance coverage and policy change supporting the value of power-assisted liposuction.[15,16] Moreover, given that the cost of power-assisted liposuction can vary between institutions and around the country, a one-way SA was performed that did not change our conclusion, making the results more generalizable. Given that many insurances do not presently cover this technique in the treatment of lymphedema, the results from a third-party payer perspective justifies why insurance plans need to reimburse these operations which will likely increase technique adoption and expand access for this intervention in lymphedema treatment.

Overall, a central goal of this article was to identify the cost-effectiveness of liposuction in fat-dominant lymphedema by reviewing the literature. We did this because insurance companies go through the same effort of reviewing the literature, but not necessarily reviewing the cost-effectiveness or the value regarding clinical effectiveness of this approach. By being proactive as surgeons and creating a narrative by showing both the clinical and cost benefits of liposuction in this scenario, we are advocating for appropriate coverage. Nonetheless, as with any body of literature, there are biases present. As with any evidence-based approach, surgeons must acknowledge this bias and still decide whether to use liposuction in fat-dominant lymphedema. We hope that by addressing the literature and assessing cost, we can facilitate the decision-making based on the evidence present. While performing such a cost-effectiveness analysis between a conservative, nonsurgical approach and an operative approach in the treatment of lymphedema may appear unfair, such clinical decision-making for a surgeon is a real-world issue, and as such, this form of decision analysis assessing value is not only reasonable but also necessary. Past publications in other specialties have compared nonsurgical approaches to surgical approaches when addressing clinical treatments, empirically justifying this analysis approach.[18,19]

CONCLUSIONS

Debulking surgery with power-assisted liposuction for the treatment of chronic lymphedema demonstrates improved extremity volume and quality of life. It is consistently covered by insurance in multiple countries throughout the world for this reason. Our study found that the additional costs of this surgical intervention can be justified from a cost-utility perspective. This is the first study to demonstrate that debulking surgery is more cost-effective than conservative therapy alone.

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