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A Cost–Utility Analysis of the Use of −125 mm Hg Closed-incision Negative Pressure Therapy in Oncoplastic Breast Surgery

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Background: Closed-incision negative pressure therapy (ciNPT) decreases the rate of wound complications in oncoplastic breast surgery (OBS) but at a fiscal cost. Our aim was to examine the cost-utility of ciNPT in OBS.

Methods: A literature review was performed to obtain the probabilities and outcomes for the treatment of unilateral breast cancer with OBS with ciNPT versus without. Reported utility scores in the literature were used to calculate quality-adjusted life years (QALYs) for each health state. A decision analysis tree was constructed with rollback analysis to determine the more cost-effective strategy. An incremental cost–utility ratio was calculated. Sensitivity analyses were performed.

Results: OBS with ciNPT is associated with a higher clinical effectiveness (QALY) of 33.43 compared to without (33.42), and relative cost increase of $667.89. The resulting incremental cost-utility ratio of $57432.93/QALY favored ciNPT. In one-way sensitivity analysis, ciNPT was the more cost-effective strategy if the cost of ciNPT was less than $1347.02 or if the probability of wound dehiscence without was greater than 8.2%. Monte Carlo analysis showed a confidence of 75.39% that surgery with ciNPT is more cost effective.

Conclusion: Despite the added cost, surgery with ciNPT is cost-effective. This finding is a direct result of decreased overall wound complications with ciNPT. *(Plast Reconstr Surg Glob Open 2024; 12:e6163; doi: 10.1097/GOX.0000000000006163; Published online 1 October 2024.)*

INTRODUCTION

Patients with breast cancer often have co-morbidities or may need operations that involve extensive undermining to tissue and may be at increased risk for postoperative complications. The risk of complication depends on the surgical approach and type of reconstruction performed.[1–3]

Oncoplastic breast surgery (OBS), a breast conserving cancer surgery option in which the patient's own breast tissue is preserved for reconstruction using volume displacement or replacement techniques after a large partial mastectomy, has an overall complication rate around 10%–30%, higher than that of partial mastectomy alone.[4–8] Extensive dissection and breast tissue resection provides a lower positive margin rate but also contributes to higher wound complication rates. Complications include delayed wound healing (10%), infection (5%), and fat and nipple necrosis (1%–2%).[5–7] Risk factors for increased complications are obesity (body mass index >40), smoking, and radiation.[9,10] Interestingly, patients with a higher body mass index and macromastia are better candidates for OBS, with studies showing a lower complication rate in obese women who undergo oncoplastic breast reconstruction as compared with immediate reconstruction following total mastectomy.[11] Methods to prevent wound complications are key to prevent the delay of adjuvant treatments, like radiation, which is almost always indicated in OBS, as delays in adjuvant therapies can affect disease recurrence and overall survival.

Previous studies have supported the use of prophylactic closed incision negative pressure therapy (ciNPT) to decrease the incidence of wound complications in general surgery patients.[12–14] The Prevena system (KCI

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Medical, San Antonio, Tex.) is a ciNPT device that can be applied to closed incisions with continuous 125 mm Hg of negative pressure for up to 14 days. By providing negative pressure to the wound surface, it reduces lateral wound tension, promotes proliferation of local wound factors required for granulation tissue formation, and improves lymphatic drainage.[15,16] Newer studies have promoted its use in breast surgery,[17,18] and more recent data have shown a decreased rate of postoperative complications using Prevena in OBS.[19] Bloom et al demonstrated the cost-effectiveness of ciNPT in vascular surgery groin incisions, but there is a paucity of data in OBS.[20] The aim of our study was to perform a cost-effectiveness analysis evaluating closed-incision negative pressure therapy (ciNPT) use in oncoplastic breast surgery.

Takeaways

Question: Is the use of closed-incision negative pressure therapy (ciNPT) in oncoplastic breast surgery cost effective?

Findings: Use of ciNPT is cost effective due to the decreased overall wound complications with ciNPT.

Meaning: Despite the added cost, ciNPT is cost effective and should be considered in oncoplastic breast surgery.

MATERIALS AND METHODS

Reference Case

This cost–utility model included a hypothetical cohort of patients with unilateral breast cancer. The base case was defined as a 45-year-old patient who was planned to undergo unilateral OBS with contralateral symmetry reduction. In this scenario, this patient could either have a Prevena Bella ciNPT dressing placed on the oncoplastic side or have a standard surgical dressing. Life expectancy of the patients in this cohort from the time of surgery was estimated to be 36.1 years.

Decision Model and Probabilities

Tree Age Software Pro Version 2020 (Tree age Software, Inc., Williamstown, Mass.) was used to construct a decision model comparing the two treatment options (Fig. 1). In this model, under each arm of the decision tree, the probability, costs, and utilities of each health state were incorporated. Both treatments, OBS with contralateral symmetry reduction with and without Prevena had the same postoperative outcomes: successful surgery, seroma, hematoma, infection, and wound dehiscence, with different probabilities. Successful surgery was defined as a reconstruction without any of these complications. The health states and probabilities were obtained from a literature review

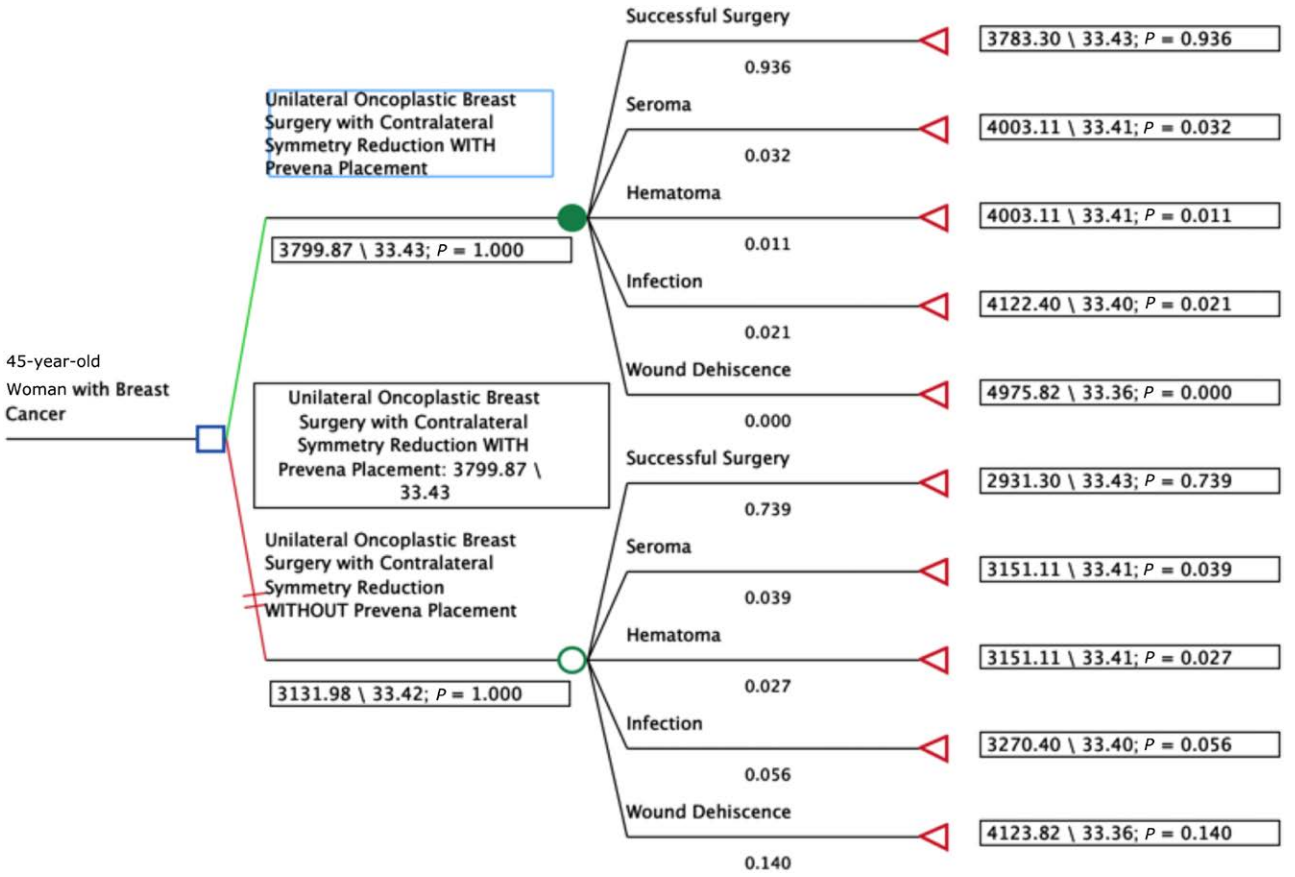

Fig. 1. Decision tree. The top green line represents the cost-effective strategy.

Table 1. Utilities, CPT, and Cost

Health State	Utility Score	CPT	Cost (US$)
Unilateral OBS with contralateral symmetry reduction with Prevena Bella	0.926	19301, 19318×2	3799.87
+ Successful surgery	0.926	19301, 19318×2	3783.30
+ Seroma	0.64 (4wk)	+ 10140	4003.11
+ Hematoma	0.64 (4wk)	+ 10140	4003.11
+ Infection	0.59 (4wk)	+ 10180	4122.40
+ Wound dehiscence	0.61 (12wk)	+ 11042, 14001	4975.82
Unilateral OBS with contralateral symmetry reduction without Prevena Bella	0.926	19301, 19318×2	3131.98
+ Successful surgery	0.926	19301, 19318×2	2931.30
+ Seroma	0.64 (4wk)	+ 10140	3151.11
+ Hematoma	0.64 (4wk)	+ 10140	3151.11
+ Infection	0.59 (4wk)	+ 10180	3270.40
+ Wound dehiscence	0.61 (12wk)	+ 11042, 14001	4123.82

Baseline cost is derived from 2023 Medicare CPT Reimbursement.

of oncoplastic breast surgery with and without the use of Prevena.[19,21] The literature review had two independent reviewers (C.W. and J.B.), and any disagreements were resolved by the senior author's judgment (A.C.).

Costs and Perspective

The model was constructed from the perspective of the third-party payer, which has been well described in the literature and our previous work.[9,20,22–25] Publicly available cost data from 2023 Medicare current procedure terminology (CPT) codes was used. Direct surgical costs of both procedures, as well as associated costs of each health state, were reported in 2023 US dollars (Table 1), which were defined as the summation of the Centers for Medicare and Medicaid Services reimbursement amounts for each procedure and complication. The willingness to pay was determined to be $100,000.00 per quality-adjusted life year (QALY) that has been used in past cost-effectiveness analyses.[26,27]

Utilities

Utility scores of all health states of oncoplastic breast surgery were obtained from previously published utility scores, which represented health states on a scale ranging from 0 (death) to 1 (perfect health).[28–30] These utility scores (Table 1) were then converted to QALYs. Patients with minor complications (seroma, hematoma, and infection) were estimated to recover within four weeks and return to the baseline level of a successful surgery. Wound dehiscence was estimated to take 12 weeks to return to baseline to account for the prolonged healing time.

The following example illustrates how QALY was obtained for our 45-year-old patient. Similar examples have been published in our past work.[9,20,22–25] Life expectancy for an average American is 81.1 years (per data from National Center for Health Statistics). Therefore, for a 45-year-old patient, life expectancy is 36.1 years. A patient with a wound dehiscence undergoing unilateral OBS with symmetry reduction with Prevena is expected to have utility of 0.61 and recover within 12 weeks. The utility of a successful surgery without complication is 0.926.

Number of health years remaining = average life expectancy – average age of patient

81.1 years – 45 years = 36.1 years

Duration of health state

12 weeks/52 weeks = 0.231 years

QALY:

(utility of health state) x (duration of health state) + (utility of successful procedure) x (remaining life years)

(0.61) (0.231) + (0.926) (36.1 – 0.231) = 33.36 $/QALYs

Incremental Cost–Utility Ratio

An incremental cost–utility ratio (ICUR) was then calculated using the formula below:

$$\text{ICUR} = \frac{(\text{Expected cost of OBS with Prevena} - \text{Expected cost of OBS without Prevena})}{(\text{Expected QALY of OBS with Prevena} - \text{Expected QALY of OBS without Prevena})}$$

A cost-effective approach was defined as an ICUR of less than $100,000.

SENSITIVITY ANALYSIS

To account for the inherent variability in this form of decision analysis, two forms of sensitivity analyses (SA) were performed. One-way (deterministic) sensitivity analysis was conducted for each variable and varied to determine the impact on the result. Probabilistic sensitivity analysis using Monte Carlo simulation was also performed to further account for uncertainty in our model. In this type of SA, the effect of simultaneously changing the values of each variable was evaluated. Variables included in this analysis were cost of Prevena (gamma), cost of wound dehiscence (gamma), probability of wound dehiscence without Prevena (beta), utility of successful surgery (beta), and utility of wound dehiscence (beta).

Decision-analysis Quality Assessment

This study was performed in accordance with the consensus guideline recommendations as described by the CHEERS criteria[31] and in accordance with the principles outlined in the Declaration of Helsinki.

RESULTS

Decision tree analysis (Fig. 1) demonstrated that unilateral oncoplastic breast surgery with contralateral symmetry reduction with Prevena placement is associated with

Table 2. Cost-Effectiveness for Each Treatment Arm

Procedure	Costs		Effectiveness		Incremental Cost/QALY
	Total Cost (US$)	Incremental Cost (US$)	Effectiveness (QALY)	Incremental Effectiveness	ICUR
Unilateral oncoplastic breast surgery with contralateral symmetry reduction with Prevena placement	3799.87	667.89	33.43	0.01	57,432.93
Unilateral oncoplastic breast surgery with contralateral symmetry reduction without Prevena placement	3131.98		33.42		

a higher QALY of 33.43 compared with surgery without Prevena placement (33.42), with a higher increment of clinical effectiveness of 0.01 and relative increased cost of $667.89 (Table 2). Rollback analysis favored unilateral oncoplastic breast surgery with contralateral symmetry reduction with Prevena placement as compared with without Prevena placement with an ICUR of 57,432.93 (Table 2). Notable probabilities in the decision tree (Fig. 1) included a lower rate of wound dehiscence with Prevena placement (0%) compared with without Prevena placement (14%).

Deterministic Sensitivity Analysis

In one-way, deterministic sensitivity analysis, unilateral oncoplastic breast surgery with contralateral symmetry reduction with Prevena placement reached a threshold point and remained the more cost-effective strategy if the cost of Prevena was less than $1347.02 (Fig. 2A) or if the probability of wound dehiscence without Prevena was less than 8.2% (Fig. 2B). A tornado diagram analysis (Fig. 3) identified the cost of Prevena as the greatest variable of uncertainty.

Probabilistic Sensitivity Analysis

Monte Carlo simulation demonstrated a confidence of 75.39% in favor of oncoplastic breast surgery with Prevena (Fig. 4).

DISCUSSION

Postoperative wound complications, including surgical site infections (SSI), wound dehiscence, seroma, and hematoma are a common cause of morbidity in the surgical patient population, and incur a significant cost burden on the US healthcare system.[32] Breast surgery, although considered a clean procedure, is not without complications, and those with breast cancer are at a higher risk. The complication rate varies with the type of reconstruction performed (2%–40%) and with the patient's preexisting conditions.[1] Since the introduction of the Women's Health and Cancer Rights Act in 1998, which guarantees coverage of all procedures related to a breast cancer diagnosis, reconstructive rates have rightfully increased.[33] This highlights the importance of an understanding of the complication rates and potential methods to decrease them.

In a retrospective cohort analysis conducted using the American College of Surgeons National Surgical Quality Improvement Program database of over 200,000 breast cancer procedures nationwide, Jonczyk et al[1] demonstrate the overall complication rate based on the type of surgical intervention. Partial mastectomy had a rate of 2.25% compared to OBS at 3.2%, mastectomy at 6.56%, mastectomy with implant placement at 5.68%, and mastectomy with muscular flap at 13.04%. Most complications were wound complications, such as wound dehiscence and SSI. Higher rates of complications were seen in smoking, radiation, obesity, and diabetes. Olsen et al calculated the cost of an SSI in a patient undergoing breast surgery to be $4091, which further speaks to the need for interventions to decrease complications, especially in breast cancer patients, as complications can delay adjuvant treatment.[32]

Multiple studies have demonstrated that the prophylactic use of ciNPT can help to decrease the complication rate, especially in the higher risk patient population.[17,19,34,35] Newer studies in the OBS patient population have demonstrated a decreased overall complication rate in the ciNPT cohort, compared with the standard surgical dressing of skin glue and steri-strip skin adhesive closure (16.9% versus 5.3%), specifically decreasing the rate of wound dehiscence requiring operative intervention.[19] The ciNPT system applies a highly porous material under suction to the wound surface, increasing granulation tissue formation and decreasing lateral tension, all working towards improved wound healing.[15] More recently, expert panel consensus guidelines describe indications to consider ciNPT as two or more of the following: diabetes, obesity, hypoalbuminemia, renal insufficiency, chronic obstructive pulmonary disease, current tobacco use, tobacco cessation in the past 3 months, corticosteroid use, and recent or current chemotherapy.[12]

Despite its clinical benefit, there are no studies to our knowledge elucidating its cost effectiveness. Here, we show that ciNPT is cost effective in OBS, if the cost of Prevena is less than $1347.02 or if the probability of wound dehiscence without Prevena is less than 8.2%, which is in line with previous literature demonstrating its cost effectiveness in other fields such as vascular and orthopedic surgery.[20,34,35] The additional cost of a ciNPT system to an operation is outweighed by the avoidance of the potential increased exorbitant cost of a complication, specifically wound dehiscence.

Although a novel finding, this study is not without limitations. As with all cost–utility analyses, the utility scores, derived from validated surveys given to surgeons, are subject to variation and bias. However, an argument favoring the use of surgeons when assessing utility scores is that they understand and treat the entire spectrum of complications depicted in the decision tree scenario and therefore have a comparative perspective more so than any other party in how severe one complication may be relative to another.

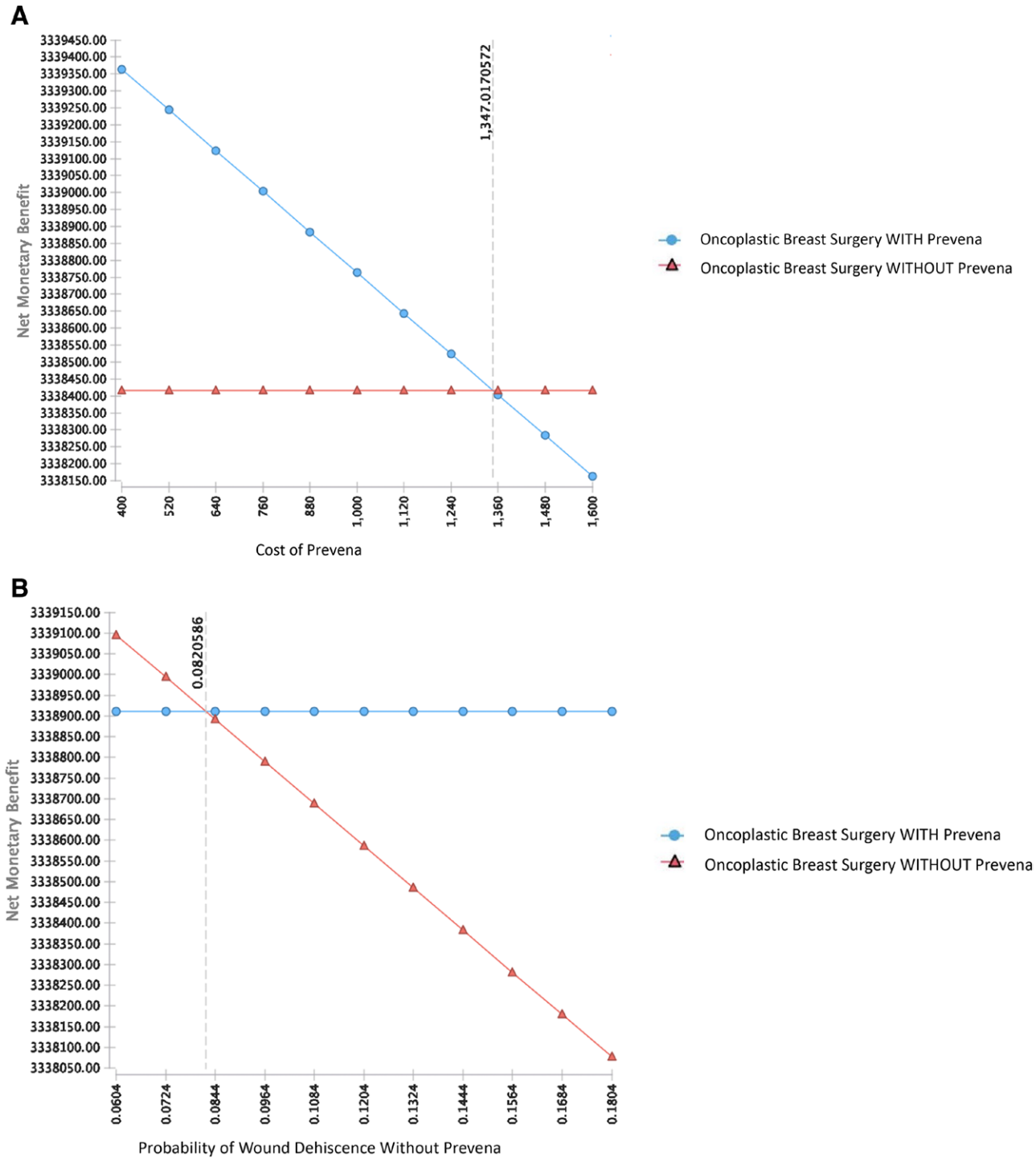

Fig. 2. A, One-way sensitivity analysis. At willingness-to-pay (WTP) of $100,000, oncoplastic breast surgery with Prevena remains the more cost-effective strategy if the cost of Prevena is less than $1347.02. B, One-way sensitivity analysis. At WTP of $100,000, oncoplastic breast surgery with Prevena remains the more cost-effective strategy if the probability of wound dehiscence without Prevena is less than 8.2%.

Second, our wound complication rates were lower in the ciNPT arm and, surprisingly, the literature review depicted a very low wound dehiscence rate for the ciNPT arm with studies from differing health systems showing similar outcomes reinforcing generalizability.[19,21] To accommodate this, we included wound dehiscence in both our deterministic and probabilistic sensitivity analyses to demonstrate that even with variability (and higher rates of wound dehiscence) our conclusion favoring ciNPT as cost-effective would hold true. We performed a sensitivity analysis to account for a rate of wound dehiscence up to 2%, at which point we did not find a change

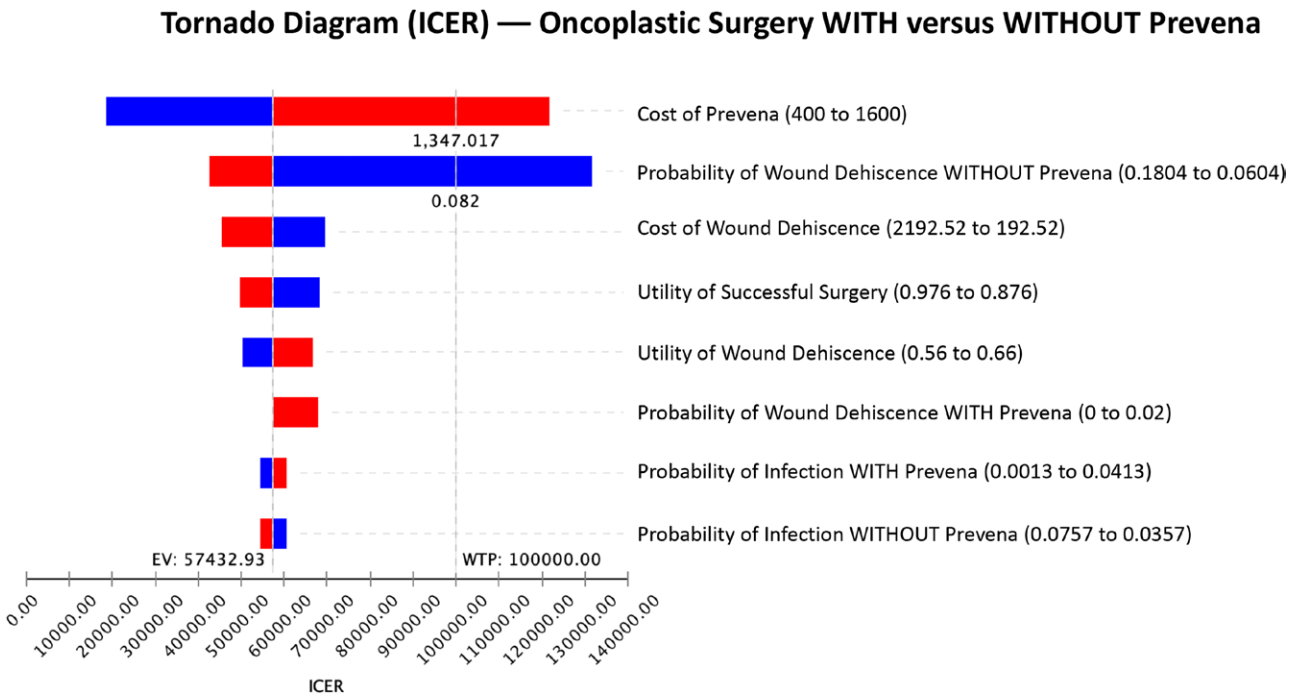

Fig. 3. Tornado diagram (incremental cost-effectiveness ratio) identifying the greatest variable of uncertainty as the cost of Prevena.

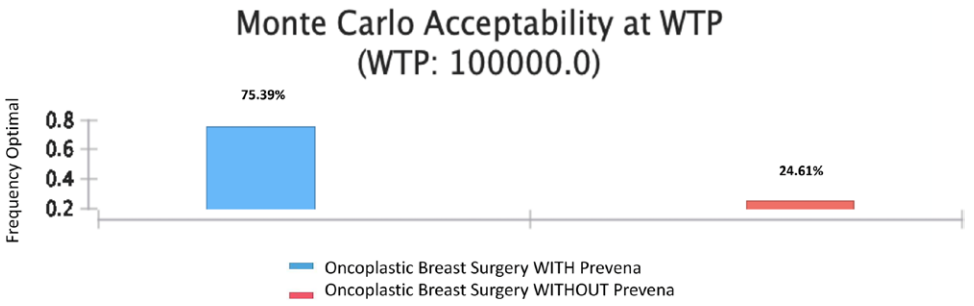

Fig. 4. Probabilistic sensitivity analysis Monte Carlo acceptability at WTP $100,000. A confidence of 75.39% that our conclusion, oncoplastic breast surgery with Prevena is the cost-effective strategy.

in our conclusion that Prevena is cost-effective. An additional one-way sensitivity analysis was performed, which showed that as long as the rate of wound dehiscence with Prevena is less than 5.8%, it remains cost-effective. It could be argued that the extremely low wound dehiscence rate may not be true for other institutions and so our results may not be generalizable to those institutions; however, a much higher rate of wound dehiscence in the non-Prevena arm would also further increase costs and worsen clinical effectiveness.

Finally, we acknowledge that the difference in clinical effectiveness (QALY) between OBS with ciNPT and without ciNPT is close (33.43 versus 33.42, respectively). Although a difference in the clinical effectiveness of 0.01 may seem insignificant, it represents a clinically significant benefit when calculating the ICUR, which considers clinical effectiveness (QALY) and cost. Fundamentally, the cost-effectiveness is the quotient of the cost divided by the clinical effectiveness so a clinical benefit as small as 0.01 can possibly represent a substantial advantage to the more clinically beneficial technology being compared. There have been several past studies demonstrating cost-effectiveness with small clinical effectiveness differences when evaluating other techniques or technologies.[22,36] One could argue the importance of this as such a process heavily values the clinical benefit that a technology offers. In this case, the ICUR demonstrates that Prevena is cost-effective at $57,432.93 per QALY, which is less than the $100,000/QALY willingness to pay cut-off (the dollar amount defined in the literature as cost-effective for an additional QALY).

CONCLUSIONS

Despite the added cost, surgery with ciNPT is cost-effective. This finding is a direct result of the decreased overall wound complications with ciNPT. These findings support current literature which promotes the use of

ciNPT in patients with an increased risk of wound complications (diabetes, smoking, etc.) and is the first to show its cost effectiveness in OBS. Use of ciNPT should therefore be considered postoperatively in oncoplastic procedures.

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DISCLOSURES

Dr. Chatterjee is a consultant for 3M and DeRoyal. All the other authors have no financial interest to declare in relation to the content of this article.

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