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Individualized Risk Prediction Tool for Serious Wound Complications after Mastectomy With and Without Immediate Reconstruction

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Abstract

Background: A greater proportion of patients with surgical risk factors are undergoing immediate breast reconstruction after mastectomy, resulting in the need for better risk prediction to inform decisions about the procedure. Our objective was to leverage clinical data to restructure a previously developed risk model to predict serious infectious and noninfectious wound complications after mastectomy only and mastectomy plus immediate reconstruction for use during a surgical consultation.

Methods: We established a cohort of women ≥ 21 years of age undergoing mastectomy from 7/1/2010–12/31/2015 using electronic health records from two hospitals. Serious infectious and non-infectious wound complications, defined as surgical site infection, dehiscence, tissue necrosis, fat necrosis requiring hospitalization or surgical treatment, were identified within 180 days after surgery. Risk factors for serious wound complications were determined using modified Poisson regression, with discrimination and calibration measures. Bootstrap validation was performed to correct for overfitting.

Results: Among 2,159 mastectomy procedures, 1,410 (65.3%) included immediate implant or flap reconstruction. Serious wound complications were identified after 237 (16.8%) mastectomy plus reconstruction and 30 (4.0%) mastectomy only procedures. Independent risk factors for serious wound complications included immediate reconstruction, bilateral mastectomy, higher

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body mass index, depression, and smoking. The optimism-corrected C statistic of the risk prediction model was 0.735.

Conclusions: Immediate reconstruction, bilateral mastectomy, obesity, depression, and smoking were significant risk factors for serious wound complications in this population of women undergoing mastectomy. Our risk prediction model can be used to counsel women before surgery concerning their individual risk of serious wound complication post-mastectomy.

INTRODUCTION

Breast reconstruction is increasingly performed after mastectomy in women with breast cancer,[1–3] particularly implant-based reconstruction.[1,2] The increasing use of post-mastectomy breast reconstruction (PMBR) coincides with, and is at least partly driven by, increased use of mastectomy over breast-conserving surgery in women with early stage breast cancer[3] and increased performance of contralateral prophylactic mastectomy.[1–3]

Immediate breast reconstruction accounts for the majority of PMBR,[1] and is often recommended since it is thought to provide psychosocial benefits compared to delayed reconstruction.[4,5] The perceived benefit of immediate reconstruction may not take into account, however, the potential for increased risk of surgical site infection (SSI) and non-infectious wound complications (NIWCs) that can lead to delays in initiating chemo- and radiotherapy.[6–8] Development of these wound complications may ultimately impact the potential for oncologic cure, survival, quality of life, cosmesis, psychosocial well-being, return to work, and overall healthcare costs.[9–11]

The proportion of women with high-risk characteristics who undergo immediate implant reconstruction has increased three-fold since the late 1990s, and increased utilization of immediate PMBR has been reported in all high-risk groups including the elderly, women with advanced breast cancer, women with comorbidities, and in women who required adjuvant radiotherapy.[12] Therefore, the current case-mix of women undergoing immediate PMBR includes more women at higher risk of wound complications. Given the increased risk of serious wound complications with immediate reconstruction it is important to provide individual risk counseling and involve patients in shared decision-making regarding the use and timing of PMBR. Although several tools are available to predict complications after immediate PMBR, the existing models lack generalizability due to restriction to only autologous reconstruction,[13,14] or only nipple sparing mastectomy.[15] Jonczyk et al. recently reported development and validation of the Breast Cancer Risk Calculator for a variety of localized and systemic complications in women undergoing breast cancer surgery with or without immediate PMBR, but over 40% of the development cohort had breast conserving surgery, associated with much lower risk of wound complications.[16,17]

A tool to predict a woman's individual risk of wound complications following mastectomy would be helpful in guiding discussions surrounding immediate PMBR at the time of surgery consultation(s). We previously developed a risk prediction model specifically for SSI after mastectomy.[18] Our prior model did not include NIWCs as an outcome, although it did include superficial infections that likely have minimal impact on morbidity. More serious infections and NIWCs resulting in hospitalization and/or surgical treatment are of particular

concern, since they may delay the start of adjuvant chemotherapy and radiotherapy which may impact patients' long term outcome. Our prior model was developed using administrative data, which has the disadvantage of poor sensitivity for some important wound complication risk factors, particularly obesity and smoking. The objective of this study was to develop a more comprehensive model using clinical data available at the time of a surgical consultation. Incorporation of those clinical data would improve accuracy of detection of important risk factors for serious infectious and noninfectious wound complications after mastectomy with or without immediate reconstruction. The goal was to develop a prediction tool that could be incorporated into the electronic health record (EHR) to provide individualized risk information at the time of breast oncologic and/or plastic surgeon consultations. Such a tool would facilitate discussions of personalized strategies to reduce the risk of serious postoperative complications and inform shared decision making about the risks and benefits of undergoing immediate PMBR.

METHODS

This study was approved by the Human Research Protection Offices of Washington University with a waiver of informed consent.

Patient Population:

We conducted a retrospective cohort study using EHR and billing data from one academic and one community hospital in a U.S. metropolitan area. We identified all mastectomy operations among women aged ≥ 21 years from 7/1/2010 to 12/31/2015 using International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) procedure codes 85.33–85.36 and 85.41–85.48, ICD-10 Procedure Coding System (ICD-10-PCS) codes 0HTT0ZZ, 0HTU0ZZ, and 0HTV0ZZ, and the surgeon description in the operating log via the electronic BJC Clinical Data Repository. Mastectomies identified by ICD codes were verified by review of the surgeon description in the operating log and anesthesia duration; mastectomies identified by the operating log only were reviewed in the EHR to confirm the procedure was performed.

Serious Wound Complications:

Potential SSIs and NIWCs were initially identified using microbiology culture results and/or diagnosis and procedure codes suggestive of a wound complication in all medical encounters within the hospital network within 180 days after mastectomy (Appendix Table 1). Surgical site infections were verified by review of outpatient and hospital records for signs/symptoms of infection, procedures, and microbiology data. We defined clinically apparent infections at the surgical site as the documentation of signs/symptoms of infection or of signs/symptoms suggestive of infection (i.e., positive intraoperative culture or cellulitis necessitating implant removal) by the general, surgical oncology, or plastic surgeon or the infectious diseases physician, or documented signs suggestive of an infection.[19] NIWCs were verified by review of outpatient and hospital records and surgeon description of tissue necrosis, fat necrosis, or wound dehiscence. Both infections and NIWCs were further restricted to more serious complications, defined as those requiring hospitalization and/or surgical treatment, including

implant removal, debridement, and/or incision and drainage in the operating room, at the bedside, in the hospital, or in the clinic.

Risk Factors for Serious Wound Complications:

Potential risk factors for complications were based in part on our previous risk prediction model for SSI[18] and included age, current smoking, body mass index, chest radiotherapy in the 2 years prior to mastectomy, relevant comorbidities, and operative factors (Appendices 2–3). Comorbidities as defined by Elixhauser were based on ICD-9-CM/ICD-10-CM diagnosis codes recorded in the two years before and during the mastectomy admission[20] using the Klabunde algorithm (requiring 1 inpatient record or 2 outpatient records >30 days apart)[21] as well as medications noted on home medication review and discharge instructions (Appendix Table 2, captured electronically or by manual medical record review).

Potential operative risk factors included unilateral versus bilateral mastectomy, immediate breast implant or flap reconstruction, axillary dissection, and sentinel lymph node biopsy, identified by ICD-9-CM and ICD-10-PCS procedure codes and the surgeon description in the operating log (Appendix Table 3). Procedures identified only by a procedure code or only in the surgeon description were confirmed by medical record review.

Statistical Analysis:

We assessed potential risk factors for wound complications separately in the mastectomy only population and the mastectomy plus immediate reconstruction population, since the factors associated with increased risk of complications varied in the two populations. Potential risk factors were assessed with univariate chi-square and Fisher's exact tests, as appropriate. For comorbidities, the identification method with the strongest association with serious wound complications was selected for the initial model. Risk factors with $p < 0.2$ in univariate analysis were included in multivariable generalized linear models with Poisson distribution, log link, and robust standard errors, to estimate relative risks. We estimated relative risks rather than odds ratios since the outcome of serious wound complications was not rare (and therefore the odds ratios did not approximate the relative risks). The models were refined manually by sequentially removing risk factors in order of the highest global Wald statistic p-value, with assessment of changes in discrimination of the model via the C statistic and calibration of the model via the Hosmer-Lemeshow test.[22–24]

After development of the individual models for complications after mastectomy only and mastectomy plus immediate reconstruction, we constructed a combined model for serious wound complications after mastectomy, including variables considered for the two individual models plus a variable for whether the operation included reconstruction. We assessed the value of added variables in the combined model based on discrimination and calibration, as described above. Empirical bootstrap confidence intervals were calculated for the final model using 500 bootstrap samples,[25] and a C statistic was calculated for each bootstrap sample to determine the variability of the C statistic. Finally, we performed bootstrap validation to estimate optimism, a measure of overfitting, and compute an optimism-corrected C statistic.[26,27] REDCap and SAS v9.4 (SAS Institute Inc., Cary, NC) were used for data management and analysis.

RESULTS

A total of 2,159 mastectomy procedures were performed in 2,127 women (1,677 (78.8%) Caucasian, 363 (17.1%) Black, and 87 (4.1%) other or unknown race/ethnicity) during the study period. The median age of women undergoing mastectomy was 53 years (interquartile range 45–63 years). Fifty-one percent of mastectomies were bilateral (n=1,094) and 81.4% (n=1,758) included a lymph node procedure (sentinel node or axillary dissection). Sixty-five percent of patients (n=1,410) underwent immediate PMBR including 1,271 (58.9%) undergoing subpectoral implant (85% (n = 1,080) with a tissue expander), 108 (5.0%) undergoing flap, and 31 (1.4%) undergoing flap plus implant reconstruction.

A total of 267 (12.4%) procedures with serious wound complications in 266 women were confirmed within 180 days of mastectomy; the incidence of complications was higher following mastectomy plus immediate PMBR (237 [16.8%]) versus mastectomy only (30 [4.0%], p <0.001). The distribution of the type of wound complication by reconstruction (yes/no) and type of reconstruction is reported in Table 1.

Among patients who had mastectomy plus immediate reconstruction, variables associated with serious wound complications eligible for inclusion in the initial multivariable model ($p < 0.2$ in bivariate analysis) included bilateral mastectomy, congestive heart failure (CHF), anticoagulant medications, hypertension, psychoses, diabetes, depression, smoking, and obesity (Appendix Table 4). In multivariable analysis, factors associated with significantly increased risk of serious wound complications after mastectomy plus immediate reconstruction included all three classes of obesity, depression, and smoking. Bilateral mastectomy was associated with marginally increased risk of serious wound complication (Table 2). Among patients who had mastectomy only, variables eligible for inclusion in the initial multivariable model based on association with serious wound complications included sentinel lymph node biopsy (protective), axillary dissection, CHF, hypertension, psychoses, diabetes, rheumatologic disease, chronic lung disease, obesity, and previous radiotherapy (Appendix Table 4). In multivariable analysis, factors associated with significantly increased risk of serious wound complications after mastectomy only included morbid obesity (BMI ≥ 40), previous radiotherapy, and rheumatologic disease. Axillary dissection and BMI 30–35 were associated with marginally increased risk of serious wound complication after mastectomy only (Table 2).

After development of the multivariable models for the two individual cohorts (mastectomy only and mastectomy plus immediate reconstruction), we incorporated those factors with $p < 0.2$ in the individual bivariate analyses into a combined multivariable model for the entire mastectomy cohort. We did not include axillary dissection in the initial model, despite it being marginally significant in the mastectomy-only cohort, because of the decreasing trend in utilization of axillary dissection.[28] The final prediction model for serious wound complication included implant or autologous flap reconstruction, bilateral mastectomy, obesity categories, CHF, depression, diabetes treatment, hypertension, previous radiotherapy, psychoses, and smoking (Table 3). The risk of wound complications increased with successively higher BMI categories. Discrimination of the model was very good, with a C statistic of 0.743 in the final model and an optimism-corrected C statistic of 0.735,

indicating only a small degree of overfitting. The model was well-calibrated (Hosmer-Lemeshow $P = 0.761$), with the observed versus predicted values for risk of complications aligning well across deciles of risk (Figure 1).

The cohort was divided into four strata based on predicted risk of serious wound complications. Over 50% of observed complications occurred in women in the highest predicted risk stratum (> 16% predicted risk), with over 99% of the women in the highest risk stratum having undergone mastectomy plus immediate reconstruction (Table 4). Over 95% of women who underwent mastectomy only had predicted risk of serious wound complication ≤ 9.5% (two lowest strata), and 83% of the total serious wound complications after mastectomy only (25/30) occurred in women in those two strata. Conversely, since the baseline risk of serious wound complication was 7% in women undergoing immediate reconstruction, the two highest risk strata were composed almost entirely of those women. Among women who underwent mastectomy plus immediate reconstruction, 14% (33/237) of the total serious wound complications occurred in women within the lowest stratum of predicted risk (> 4.6–9.5%), while 60% (142/237) were observed in women within the highest risk stratum.

DISCUSSION

We developed a novel risk prediction tool for serious wound complications requiring hospitalization and/or surgical treatment after mastectomy with or without immediate reconstruction utilizing risk factor information readily available in the electronic medical record at the time of surgical consultation(s). This new predictive tool expands on a prior risk prediction model we developed for surgical site infection after mastectomy using administrative claims data.[18] In our cohort, 4% of women who underwent mastectomy only and 16.8% of those who underwent mastectomy plus immediate reconstruction developed a serious wound complication within 180 days of surgery. Overall 40% of the serious wound complications, all of which required hospitalization and/or implant removal, debridement or incision and drainage, were noninfectious complications. This demonstrates the serious morbidity resulting from both infectious and noninfectious wound complications. Immediate reconstruction was the most important predictor of serious wound complications after mastectomy; bilateral mastectomy, higher classes of obesity, depression, and smoking were also important factors contributing to risk of wound complications.

A number of tools for predicting complications after mastectomy have been proposed. Kim and colleagues developed the Breast Reconstruction Risk Assessment (BRA) score for immediate PMBR using the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database to predict 30-day SSI[29] and the Tracking Operations and Outcomes for Plastic Surgeons (TOPS) database to predict 30-day wound complications (SSI, seroma, dehiscence, flap loss, explanation, and reoperation).[14] The same group has since externally validated and updated their models using institutional data,[30] and expanded the tool to BRA-XL to predict 1-year complications (including tissue necrosis).[31,32] Martin et al. found poor discrimination in validating the complications included in the TOPS-based prediction tool. However, their cohort included exclusively prepectoral expander-based reconstruction, and skin necrosis, which was not included as

an outcome in the BRA score, was the most common complication.[33] O'Neill found the BRA score calculator could not accurately identify patients at risk for surgical complications among women undergoing immediate flap reconstruction, however, the BRA score was developed in a primarily implant reconstruction cohort.[34]

In addition to the BRA score and our prior SSI risk prediction model,[18] a few other research groups have developed prediction tools for wound complications after PMBR. Roy et al. developed and internally validated a model for 90-day complications (primarily wound) after immediate microvascular PMBR.[13] Weights were assigned to four risk factors (smoking, obesity, prior radiotherapy, and comorbidity), and the resulting score was categorized into three risk groups. The rate of complications increased by risk group, and the validation cohort performed well (C statistic=0.7). Frey and colleagues developed and internally validated a model for wound complications after immediate reconstruction with nipple-sparing mastectomy.[15] Their model included 12 risk factors, and a calculator was provided to predict risk. The duration of follow up for complications was not stated, and complications included flap or nipple necrosis, hematoma, seroma, and minor infections treated by oral antibiotics. The model performed relatively well (C statistic=0.67), and the incidence of complications increased by decile of predicted risk.

Jonczyk and colleagues included an infection complications risk model in their Breast Cancer Risk Calculator. The infection complications model included SSI (superficial, deep, and organ space infections), but also urinary tract infection, sepsis and septic shock. The model was developed using 2005–2017 NSQIP data for women with *in situ* or invasive cancer undergoing breast conserving surgery or mastectomy.[16] The infectious complications model performed moderately well in internal validation, with a C statistic of 0.67.

Naoum and colleagues used machine learning to predict risk of infection and reconstruction failure after immediate or delayed PMBR using data from 1,600 patients over a 20-year period.[35] Predictors included comorbidities but also operative details, including number of lymph nodes sampled, adjuvant therapy, and number of malignant lymph nodes. The infection model had a C-statistic in ten-fold cross-validation of 0.73.

Importantly, many of the risk factors we identified in our model are modifiable and/or actionable. High risk patients could be counseled regarding the option of delaying or not undergoing reconstruction, to reduce risk. Similarly, patients considering contralateral prophylactic mastectomy without a clinical indication could be advised regarding the higher risk of wound complications. Obesity and smoking are modifiable risk factors that could be addressed by having the patient undergo delayed reconstruction after weight loss or smoking cessation. Finally, depression was associated with serious wound complications in our cohort. In our prior mastectomy risk model depression was also independently associated with increased risk of surgical site infection,[18] and we found increased risk of surgical site infection associated with depression in a large spinal fusion population.[36] Although the mechanism for this association is unknown, it is possible that patients with depression are less able to adhere to preoperative and/or postoperative instructions, restrictions, or follow up care, or are more likely to have less social support. Interventions could include addressing unmet anti-depressant medication needs, considering postoperative home health

care for assistance with wound care, and/or patient navigator assistance with accessing healthcare services.

We intentionally designed our risk model to include only variables routinely available at the time of an oncologic and/or plastic surgery consultation, to facilitate shared decision making for choice of immediate reconstruction. Thus, our model does not contain variables based on information that would not be complete before surgery. For this reason, the need for adjuvant radiotherapy was not included, since at our institution lymph node assessment is not routinely available prior to mastectomy, and upstaging based on pathologic examination of the mastectomy specimen is not infrequent. We did not include two vs. one-stage implant reconstruction as a variable in the model, since the assessment of flap vascularity is often done in the operating room to determine whether direct-to-implant placement can be performed, and thus the determination of type of implant may not be known prior to surgery.

Our study has several strengths. The final model performed well according to measures of calibration and discrimination and accurately predicted risk of serious wound complications after mastectomy across the range of predicted risk in our cohort. The degree of overfitting was small based on internal validation via bootstrapping, which suggests that our risk prediction model is generalizable. We expanded our previous risk prediction model for mastectomy to include noninfectious wound complications, and restricted our outcomes of interest to serious wound complications. Our rationale was patient-centered in that serious outcomes, such as hospitalization and/or implant removal, would be most concerning to patients considering immediate PMBR due to the morbidity associated with the complication and potential to delay adjuvant treatment. We included complications up to 180 days post-mastectomy to better estimate risk, as 30-day measures such as those reported by NSQIP underestimate risk, particularly among patients undergoing reconstruction.[31,32,37,38] We also restricted outcomes to wound complications that can impact the surgical outcome and delay adjuvant treatment, rather than including systemic and other localized complications (e.g., sepsis, urinary tract infection) associated with disparate risk factors. We previously reported that wound complications after immediate reconstruction were associated with a median delay of 14 and 20 days in start of adjuvant chemotherapy and radiotherapy, respectively.[6]

Unlike most other risk scores examining complications after mastectomy, we included women undergoing mastectomy only so that we could calculate the independent risk of immediate reconstruction. This could be helpful in shared decision-making conversations to clearly present a patient's individual risk, with and without immediate reconstruction, since all factors in the model are available pre-operatively. For example, a woman undergoing unilateral mastectomy with a normal range BMI and none of the risk factors in the model would have a predicted risk of serious wound complications of 1.4% after mastectomy only and 7.0% after mastectomy plus immediate reconstruction. By comparison, a woman undergoing bilateral mastectomy who smokes and has a BMI in the 35–39.9 range would have a predicted risk of complications of 7.3% after mastectomy only and 36.9% after mastectomy plus immediate reconstruction. Providing patients such individualized risk of complications, with and without reconstruction, may be more helpful in framing discussions during a surgical consultation than reporting only overall complication rates. This could

also lead to frank discussions, particularly with higher-risk patients, concerning potential delays in adjuvant chemo- and radiotherapy,[6–8] employment disruption, and additional out-of-pocket expenses associated with complications.

Our study has several limitations. Our two study hospitals were from the same hospital system, and its patients may not be representative of all patients who have mastectomy. The total number of complications in the mastectomy only cohort was small, resulting in limited power to detect significant associations with individual risk factors. The majority of the PMBR procedures in our study were implant-based utilizing a tissue expander, so our risk prediction model may not predict as well for women undergoing flap reconstruction. At the time period of our study the vast majority of women underwent skin-sparing mastectomy, but use of a nipple-sparing technique was uncommon. Thus, external validation is needed to further assess the generalizability of the risk prediction model in practice. Further validation with more recent data will be needed due to current trends in mastectomy and reconstruction, including nipple-sparing mastectomy, prepectoral implants, and immediate, one-stage implant reconstruction.

We developed a highly robust prediction model for serious wound complications after mastectomy, with or without immediate breast reconstruction. The model includes potentially modifiable risk factors that patients could potentially address to reduce their risk. This model could be incorporated into surgical consultations via a shared-decision tool, to counsel women on their individual risk of serious wound complications after mastectomy.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Conflicts of interest (Previous 3 years)

MAO reports consultant work and grant funding from Pfizer for work outside the submitted manuscript. VJF reports her spouse is the Chief Clinical Officer at Cigna Corporation.

TMM reports advisory board, investigator-initiated grant, and device development royalties for RTI Surgical. He reports former investigator-initiated grants and advisory board work with Allergan, and an unencumbered research award from Sientra.

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Synopsis:

We developed a new risk prediction model for serious wound complications in women undergoing mastectomy at two hospitals including only information available before surgery. This tool will enable discussion of individualized risk-reduction strategies with women considering mastectomy with immediate reconstruction.

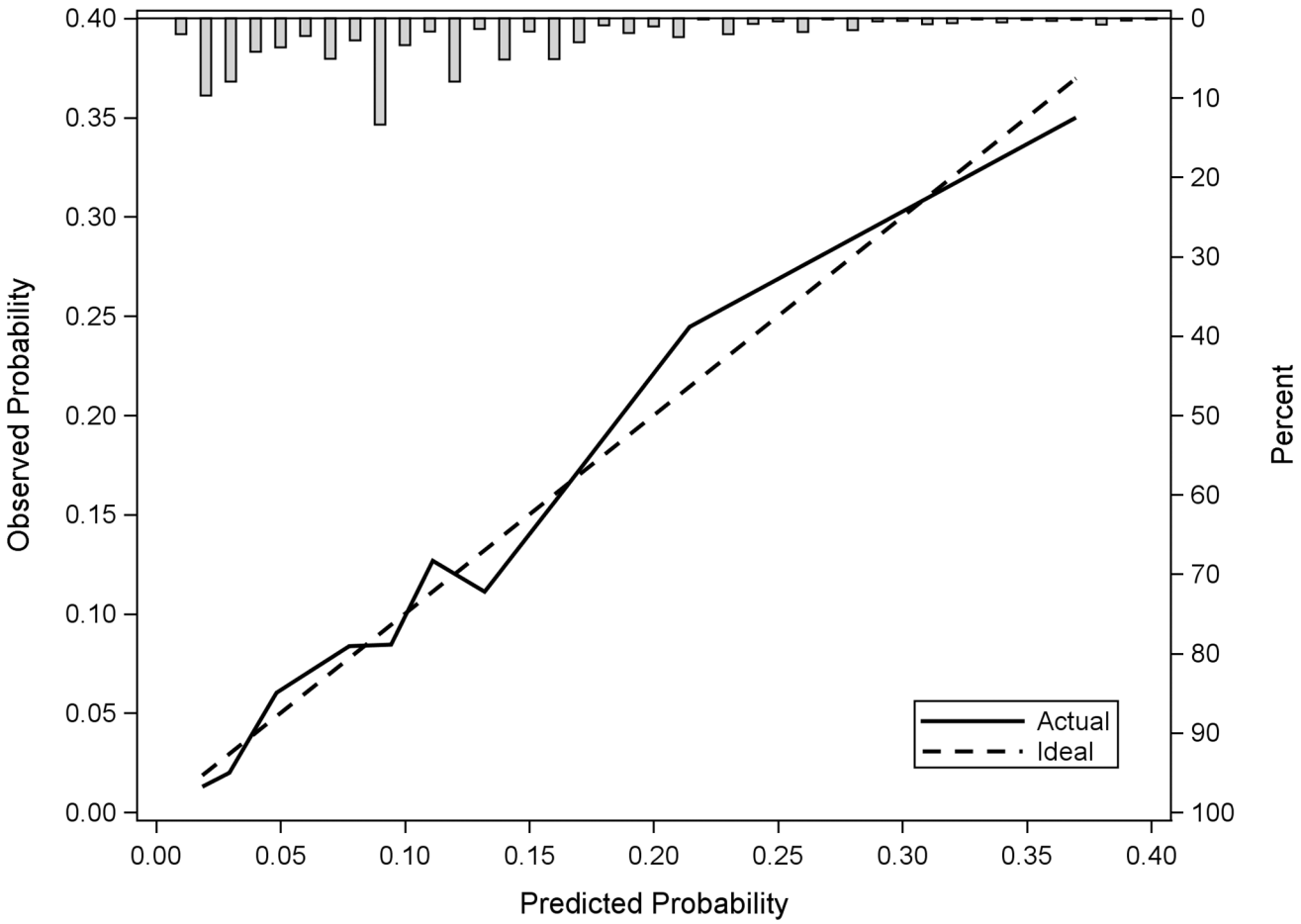

Figure 1. Observed Versus Predicted and Distribution of the Probability of Serious Wound Complications After Mastecomy.

The primary X- and Y-axes show the observed versus predicted probablity of serious wound complication by decile. The secondary Y-axis displays the percent distribution of the predicted probability of serious wound complications, as depicted by the bar graph on the secondary X-axis. The predicted probability displayed in the X-axis was truncated at 40% probability; the predicted probability for 2.4% of the cohort was > 40%.

Table 1.

180-day Incidence of Serious Wound Complications After 2,159 Mastecomy Procedures

Serious Wound Complication[a]	**Total Mastectomy Cohort, N = 2,159 n (%)**	**Mastectomy Only, N = 749 n (%)**	**Mastectomy Plus Reconstruction (Implant and/or Flap), N = 1,410 n (%)**	**Mastectomy Plus Implant Reconstruction, N = 1,271 n (%)**	**Mastectomy Plus Flap Reconstruction, N = 139[b] n (%)**
Surgical site infection	158 (7.3)	22 (2.9)	136 (9.6)	120 (9.4)	16 (11.5)
Cellulitis only requiring hospitalization	38 (1.8)	3 (0.4)	35 (2.5)	33 (2.6)	2 (1.4)
Tissue necrosis	100 (4.6)	4 (0.5)	96 (6.8)	73 (5.7)	23 (16.5)
Dehiscence	79 (3.4)	8 (1.1)	71 (5.0)	48 (3.8)	23 (16.5)
Fat necrosis only	1 (0.05)	0	1 (0.07)	0	1 (0.7)
Any serious wound complication	267 (12.4)	30 (4.0)	237 (16.8)	199 (15.7)	38 (27.3)

[a]Complications were not mutually exclusive, other than surgical site infection and cellulitis (diagnoses of both cellulitis and surgical site infection were counted only as surgical site infection). Of the 267 procedures with a wound complication, 169 (63.3%) had one complication, 61 (22.8%) had two complications, 29 (10.9%) had three complications, and 8 (3.0%) had four complications reported.

[b]Includes 31 women with implant plus autologous flap.

Table 2.

Individual Multivariable Models of Independent Risk Factors for Serious Wound Complications After Mastectomy Only and After Mastectomy Plus Immediate Reconstruction

Risk Factor	Relative Risk (95% Confidence Interval)	
	Mastectomy Only (n=749)	**Mastectomy Plus Immediate Reconstruction (n=1,410)**
Axillary dissection	1.95 (0.98, 3.89)	N/A
Bilateral mastectomy	N/A[a]	1.23 (0.96, 1.57)
Body mass index		
< 25.0	1.00	1.00
25.0 to <30.0	2.17 (0.44, 10.74)	1.24 (0.89, 1.72)
30.0 to <35.0	4.11 (0.89, 18.97)	1.68 (1.20, 2.36)
35.0 to <40.0	3.64 (0.69, 19.37)	2.52 (1.80, 3.52)
≥ 40.0	12.81 (2.87, 57.10)	2.50 (1.66, 3.77)
Previous radiotherapy	2.61 (1.17, 5.81)	N/A
Rheumatologic disease (dx/rx)	2.78 (1.09, 7.08)	N/A
Depression (dx/rx)	N/A	1.70 (1.35, 2.13)
Smoker	N/A	1.81 (1.38, 2.36)
Model C statistic	0.777	0.672

[a]Not applicable

Table 3.

Combined Multivariable Model of Risk Factors for Serious Wound Complications After Mastectomy

Risk Factor	Parameter Estimate (Beta)[a]	Relative Risk (95% Confidence Interval)[b]
Intercept	−4.2773	
Immediate reconstruction	1.6178	5.04 (2.74, 6.11)
Bilateral mastectomy	0.3031	1.35 (1.05, 1.58)
Body mass index		
< 25.0		1.00
25.0 to <30.0	0.2053	1.23 (0.83, 1.52)
30.0 to <35.0	0.5207	1.68 (1.15, 2.06)
35.0 to <40.0	0.8107	2.25 (1.55, 2.78)
≥ 40.0	1.0207	2.78 (1.83, 3.46)
Congestive heart failure (dx/rx)	0.2865	1.33 (0.82, 1.75)
Depression (dx/rx)	0.3863	1.47 (1.20, 1.71)
Diabetes medication	0.2065	1.23 (0.87, 1.57)
Hypertension (dx/rx)	0.1811	1.20 (0.94, 1.41)
Previous radiotherapy	0.2747	1.32 (0.86, 1.69)
Psychoses diagnosis	0.3972	1.49 (0.52, 2.23)
Smoker	0.5488	1.73 (1.37, 2.06)

[a]Risk of serious wound complication = Log(RR) = −4.2773 + 1.6178*(immediate reconstruction) + 0.3031*(bilateral mastectomy) + 0.2053*(body mass index 25.0 to <30.0) + 0.5207*(body mass index 30.0 to < 35.0) + 0.8107* (body mass index 35.0 to < 40.0) + 1.0207* (body mass index ≥ 40.0) + 0.2865*(congestive heart failure) + 0.3863*(depression) + 0.2065*(diabetes medication) + 0.1811*(hypertension) + 0.2747*(previous radiotherapy) + 0.3972*(psychoses) + 0.5488*(smoking). For example, the calculated risk for serious wound complication in women undergoing reconstruction with no other risk factors would be Log(RR) = −4.2773 + 1.6178*1 = .06998 =~ 7%.

[b]Confidence intervals based on bootstrapping. Model C statistic = 0.743. Optimism-corrected C statistic = 0.735. Bootstrap models C statistic mean = 0.747 (standard deviation = 0.016).

Table 4.

Distribution of Serious Wound Complications Within Strata of Predicted Risk

Predicted Risk of Serious Wound Complications (Quartiles)[a]	**# Serious Wound Complications Among all Patients (% within the Individual Risk Group**[b]**)**	**# Serious Wound Among PMBR Patients (% of the Total Serious Wound Complications in Women with PMBR**[c,d]**)**	**% of Total Observed Wound Complications Within Cohort (Total N with Complications = 267)**[e]
Low Risk (0–4.6%) (n= 539)	12 (2.2)	0	4.5
Moderate Risk (>4.6–9.5%) (n= 563)	46 (8.2)	33 (68.6)	17.2
High Risk (>9.5–16.0%) (n= 541)	66 (12.2)	62 (94.5)	24.7
Highest Risk (>16.0%) (n= 516)	143 (27.2)	142 (99.4)	53.6

[a] Predicted risk of serious wound complication based on the multivariable model presented in Table 3, cartegorized in quartiles.

[b] Expressed as a row percentage. For example, in the low risk population 12/539 had a serious wound complication, which = 2.2%.

[c] The percentage is the number of serious wound complications in women with PMBR/total number of serious wound complications in the risk category. For example, in the moderate risk population, 33/46 serious complications occurred in women with PMBR, which = 68.6%.

[d] The baseline predicted risk of serious wound complication for women with immediate reconstruction was 7%; thus no women with reconstruction were included in the lowest risk stratum.

[e] Expressed as a column percentage, equal to the percentage of serious wound complications divided by the total number of 267 serious wound complications. For example, in the highest risk group there were a total of 143 women with serious wound complications/267 total with wound complications = 53.6%