Development and Internal Validation of the Abdominoplasty Risk Calculator

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PATIENT SAFETY

Background: Risk calculators are an emerging tool that provide granular, individualized risk estimation. Presently, there is a paucity of risk calculators specific to plastic surgery. Abdominoplasty is a popular plastic surgery procedure associated with moderate risks of complications, such as surgical-site infection and dehiscence, and would benefit from the ability to provide patients with accurate, personalized risk assessment.

Methods: Abdominoplasties from the National Surgical Quality Improvement Program 2005 to 2014 database were identified by Current Procedural Terminology code. Relevant perioperative variables included age, body mass index, sex, smoking history, diabetes, American Society of Anesthesiologists class, pulmonary comorbidities, hypertension, bleeding disorders, and operative duration. Multiple logistic regressions were used to generate 30-day risk models for medical complications, surgical-site infection, wound dehiscence, and reoperation. Internal validation of model performance was conducted using C-statistics, Hosmer-Lemeshow tests, and Brier scores.

Results: Among the 2499 cases identified, complication rates were as follows: medical complications, 3.8 percent; superficial surgical-site infection, 2.4 percent; deep or organ-space surgical-site infection, 1.6 percent; wound dehiscence, 1.0 percent; and reoperation, 2.0 percent. Risk prediction models were constructed and all demonstrated good predictive performance, with mean predicted risks closely matching observed complication rates. The distributions of predicted risk were wide and contained outliers with very high risk. A user-friendly, open-access online interface for these models is published at AbdominoplastyRisk.org.

Conclusions: The authors developed an internally valid risk calculator for which individual patient characteristics can be input to predict 30-day complications after abdominoplasty. Given that estimated risk can vary widely, individualized risk assessment is a way to enhance shared decision-making between surgeon and patient. (*Plast. Reconstr. Surg.* 141: 34e, 2018.)

Accurate assessment and communication of risk to patients are central tenets of preoperative planning before any elective plastic surgical procedure. Historically, risk assessments were made using population-based risk estimates reported in the literature. However, such estimates can often underestimate or overestimate risk for any given individual patient. Even when surgeons and patients have data regarding how particular comorbidities and other factors affect a procedure's risk, it is difficult to understand how

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different comorbidities may interact and additively affect the absolute risk. With the advent of large, national surgical data registries spanning hundreds of thousands of procedures, it is now possible to generate robust surgical risk calculators that can account for many granular details and provide a more accurate *individualized* risk assessment. Given the benefits of using risk calculators for patient risk counseling, the Centers for Medicare and Medicaid Services may even provide incentives for surgeons who are able to discuss patient-specific risks with their patients.[1] Examples of such risk calculators include the American College of Surgeons Surgical Risk Calculator[2] and those of several other specialties.[3–10]

Within plastic surgery, however, there is a paucity of risk calculators, with the Breast Reconstruction Risk Assessment being one of the few available.[11] Plastic surgeons perform many other procedures that would benefit from individualized risk estimation, such as abdominoplasty. Indeed, the American Society of Plastic Surgeons reported abdominoplasty to be the sixth most common cosmetic operation in 2016, the American Society for Aesthetic Plastic Surgery reported it as the third most common in 2015, and both organizations show that it continues to grow in popularity each year.[12,13] Although other aesthetic procedures such as rhytidectomy, blepharoplasty, and rhinoplasty see more cases each year, abdominoplasty is associated with more risk of significant surgical complications such as surgical-site infections,[14–19] with some studies reporting minor complication rates as high as 25 percent.[20]

Possible risk factors for abdominoplasty complications include body mass index, diabetes, smoking, American Society of Anesthesiologists class, and hypertension,[17,18,20–25] but how an individual patient's constellation of comorbidities affect their overall risk of adverse outcomes is not clear. Arguably, aesthetic procedures such as abdominoplasty are among the most important for which to have accurate risk assessments; even small risks become major considerations given that these procedures are generally not medically necessary and patients may be responsible for costs of additional treatment. With high expectations for these procedures, even minor complications can negatively impact patient satisfaction if they are not adequately counseled.[26] For these reasons, abdominoplasty is an ideal procedure for which to develop a risk calculator for 30-day complications. Our aim was to develop and package this risk calculator into a user-friendly, open-access, online platform. By providing an easily accessible way to use our findings online, we hope to improve risk assessment and patient counseling.

PATIENTS AND METHODS

Data Collection

Cases were queried from the National Surgical Quality Improvement Program 2005 to 2014 database. The National Surgical Quality Improvement Program's data collection methodology has been described elsewhere.[27,28] Briefly, data are independently abstracted by trained surgical nurses from participating institutions. Over 250 variables are tracked, including demographics, comorbidities, perioperative details, and outcomes occurring within 30 days of the primary operation. To ensure data quality, complete follow-up data are collected through correspondence or direct telephone encounters with surgical patients, and data submitted to the National Surgical Quality Improvement Program are subject to random audits. The data set has a disagreement rate of less than 1.8 percent, and researchers found its outcomes to be consistent with their own institutional results.[28,29] Deidentified patient information is freely available to all institutional members who comply with the National Surgical Quality Improvement Program Data Use Agreement. The Data Use Agreement implements the protections afforded by the Health Insurance Portability and Accountability Act of 1996. The Northwestern Institutional Review Board has deemed this retrospective study of deidentified data exempt from institutional review board review and approval.

Cohort Selection, Perioperative Variables, and Outcomes

Using the National Surgical Quality Improvement Program 2005 to 2014 data set, abdominoplasty procedures were identified when the primary Current Procedural Terminology code was 15847, or when the primary Current Procedural Terminology code was 15830 with an additional Current Procedural Terminology code of 15847.[30–32] To remove outliers, patients were removed from the cohort if they had recorded ages of younger than 18, or if their body mass indexes were less than 10 or greater than 50. Cases with missing values for any of the variables of interest were omitted to support a robust analysis.

We selected relevant perioperative variables to include in statistical analysis and modeling based on known risk factors described in the abdominal

contouring literature and our own clinical experience. This interactive model-building approach is superior to statistically automated methods of selecting variables.[33] Ultimately, we included age, body mass index, sex, smoking history, diabetes (both type 1 and type 2 and forms), American Society of Anesthesiologists class, operative duration greater than 6 hours, bleeding disorders including chronic anticoagulation not discontinued before surgery, and hypertension requiring medication; and pulmonary comorbidities defined as dyspnea, chronic obstructive pulmonary disease, ventilator dependence, or current pneumonia. On preliminary analysis, the effect of having a concurrent procedure performed (the most common being liposuction, hernia repair, or breast surgery) was not significant on multivariate models. Therefore, this variable was excluded from final analysis.

The primary outcomes of interest were complications occurring within 30 days of the operation. The National Surgical Quality Improvement Program reports superficial, deep, and organ-space surgical-site infection. Deep and organ-space surgical-site infections were examined as a composite outcome, being more clinically serious than a superficial surgical-site infection. The data set also reports occurrences of dehiscence and reoperation. Finally, an array of medical complications is reported, including pneumonia, unexpected reintubation, ventilator dependence for over 48 hours, pulmonary embolism, deep vein thrombosis, renal insufficiency/failure, urinary tract infection, stroke, peripheral nerve injury, myocardial infarction, bleeding requiring transfusion, and sepsis/septic shock. These were combined into a composite medical complications outcome. Precise definitions of these outcome events are provided in the National Surgical Quality Improvement Program user manual.[28]

Statistical Analysis

Univariate analysis was conducted to determine correlations between complications and each of the perioperative variables of interest. The Pearson chi-square or Fisher's exact test was used for categorical variables, and the Mann-Whitney *U* test was used for continuous variables.

Separate multiple logistic regression models were generated for medical complications, surgical-site infection, dehiscence, and reoperation, to predict the chance of the complication based on the perioperative variables. When there were insufficient data for a particular perioperative variable to be reliably used in one of the regression models, it was excluded for that model. To assess the accuracy and predictive capabilities of these models, internal validation was conducted using C-statistics for model discrimination, Hosmer-Lemeshow tests for model calibration, and Brier scores for overall model accuracy. Each of these metrics excels in some aspects and falls short in others; considering all of them provides the most nuanced understanding of a predictive model's performance.[2,34–36] All statistical analysis was performed with IBM SPSS Version 23 (IBM Corp., Armonk, N.Y.).

Development of the Online Risk Calculator Platform

These risk models were transformed into a user-friendly graphic interface allowing for quick risk calculation. The risk calculator is hosted on an open-access online platform at AbdominoplastyRisk.org. Clinicians and/or patients input simple information into the fields and receive absolute probability estimates for each complication.

RESULTS

Cohort Characteristics and Outcomes

A total of 2499 cases performed between 2005 and 2014 met inclusion criteria and were included in the analysis. Table 1 describes the characteristics of the cohort, a large majority of whom were female. The mean age and body mass index were 46 ± 12 years and 29.1 ± 5.8 kg/m^2, respectively. Importantly, 9.4 percent of patients were smokers within the previous year, 13.6 percent of patients had American Society of Anesthesiologists classes of 3 or greater, 21.2 percent of patients had hypertension requiring medication, and 6 percent of patients had diabetes. Pulmonary comorbidities and bleeding disorders were relatively rare.

Table 2 outlines the complication rates of the cohort. Medical complications occurred in 3.8 percent of patients, with bleeding requiring transfusion constituting the majority of these complications, followed by sepsis/septic shock and venous thromboembolism. Within the 30-day postoperative period, superficial surgical-site infection occurred in 2.4 percent of patients, deep or organ-space surgical-site infection occurred in 1.6 percent of patients, dehiscence occurred in 1.0 percent of patients, and unplanned reoperation occurred in 2.0 percent of patients. On univariate analysis, most perioperative variables of interest had statistically significant correlations with the occurrence of one of the complications (Table 3).

Table 1. Cohort Characteristics

	Value
No.	2499
Mean age ± SD, yr	46 ± 12
Mean BMI ± SD, kg/m^2	29.1 ± 5.8
Sex	
Male	7.2%
Female	92.8%
Smoker within past year	
No	90.6%
Yes	9.4%
Diabetes	
No	93.4%
Yes	6.6%
ASA class	
1–2	86.4%
≥3	13.6%
Hypertension requiring medication	
No	78.8%
Yes	21.2%
Bleeding disorder	
No	99.1%
Yes	0.9%
Pulmonary comorbidity	
No	98.0%
Yes	2.0%
Operative duration	
<6 hr	94.9%
>6 hr	5.1%

BMI, body mass index; ASA, American Society of Anesthesiologists.

Table 2. Observed Complication Rates

	Rate (%)	
Complication	Overall	BMI > 35 kg/m^2
Superficial surgical-site infection	2.4	5.1
Deep or organ-space infection	1.6	4.0
Dehiscence	1.0	3.5
Unplanned reoperation	2.0	5.9
Any medical complication	3.8	9.3
Bleeding requiring transfusion	2.0	5.3
Sepsis/septic shock	0.8	2.1
Venous thromboembolism	0.6	1.6
Urinary tract infection	0.3	0.5
Pneumonia	0.2	0.3
Others	0.2	0.7

BMI, body mass index.

Subgroup Analysis of Body Mass Index as a Risk Factor

Patients affected by a complication had significantly higher body mass indexes on average than those patients who did not have a complication (33.0 kg/m^2 versus 28.8 kg/m^2; $p < 0.001$) (Table 3). We performed a subgroup analysis of high–body mass index cases (body mass index >35 kg/m^2) to further characterize the effect. This subgroup of 376 patients had complication rates far exceeding those of the general cohort (Table 2). The rates of dehiscence and reoperation were especially greater in this subgroup (3.5 and 3.0 times the rate of the general cohort, respectively).

Risk Modeling and Model Performance

Risk models for medical complications, superficial surgical-site infection, deep or organ-space surgical-site infection, dehiscence, and reoperation were developed on the basis of the selected perioperative variables; the beta values for each variable are shown in Table 4. Body mass index remained a strong, independent risk factor for complications. Distributions of predicted risk for each of the four models are depicted in Figure 1, where it is clear that there is very broad spread of values around the means. Each model also demonstrates positively skewed distributions, suggesting the existence of high-risk outliers pulling the population mean away from its median.

Every model produced acceptable calibration, discrimination, and accuracy based on C-statistic, Hosmer-Lemeshow test, and Brier score (Table 5). The models' C-statistics ranged from 0.687 to 0.777, suggesting good discriminatory ability. The Hosmer-Lemeshow tests were uniformly nonsignificant across all models, indicating goodness of fit within the models. Brier scores were acceptably low for all models, ranging from 0.0097 to 0.0360, demonstrating excellent overall accuracy of the models.

Online Risk Calculator

Figures 2 through 4 depict examples of the user interface of AbdominoplastyRisk.org. Three sample cases are shown to illustrate the calculator's practical utility in clinical scenarios. In the first example (Fig. 2), a healthy female patient with a normal body mass index and no major comorbidities is shown to have an overall medical complication risk of 1.74 percent, well below the cohort's average. In the second example (Fig. 3), we have altered the hypothetical patient to be older, obese, a smoker, and with an American Society of Anesthesiologists class of 2; her overall medical complication risk climbs to 4.95 percent. Finally, in the last example (Fig. 4), the patient is now morbidly obese with body mass index of 40 kg/m^2, diabetic, a smoker, and with an American Society of Anesthesiologists class of 3; her estimated overall risk of medical complication is 19.82 percent.

DISCUSSION

Abdominoplasties are popular plastic surgery procedures with a risk of postoperative complications such as surgical-site infection. Accurate risk prediction may improve patient selection to reduce such complications, which are associated with high additional costs and negative effects on

Table 3. Univariate Analysis of Perioperative Variables and Occurrence of Any Complication

Characteristic	No Complication		Any Complication		*p*
	No.	%	No.	%	
Sex					
Female	2142	92.3	178	7.7	0.002
Male	150	85.7	25	14.3	
Diabetes					
No	2168	92.8	167	7.2	<0.001
Yes	128	78.0	36	22.0	
Smoker within 1 yr					
No	2088	92.3	175	7.7	0.027
Yes	208	88.1	28	11.9	
Pulmonary comorbidity					
No	2256	92.1	193	7.9	0.002
Yes	40	80.0	10	20.0	
Hypertension					
No	1835	93.2	133	6.8	<0.001
Yes	461	86.8	70	13.2	
Bleeding disorder					
No	2277	91.9	200	8.1	0.342
Yes	19	86.4	3	13.6	
ASA class					
1–2	2020	93.5	140	6.5	<0.001
≥3	276	81.4	63	18.6	
Operative duration >6 hr					
No	2177	91.8	195	8.2	0.440
Yes	119	93.7	8	6.3	
Mean age, yr	45		49		0.125
Mean BMI, kg/m^2	28.8		33.0		<0.001

ASA, American Society of Anesthesiologists; BMI, body mass index.

Table 4. Beta Values for Each Complication Model

Patient Characteristic	Complication Model (Beta Values)				
	Medical Complication	Superficial SSI	Deep or Organ-Space SSI	Dehiscence	Unplanned Reoperation
Age	0.002	0.013	0.024	0.007	0.029
BMI	0.088	0.088	0.061	0.145	0.078
Male*	0.194	0.007	–0.081	0.100	0.601
Diabetes	0.691	0.264	0.569	–0.614	0.440
Smoker within 1 yr	0.642	0.272	1.122	0.443	1.064
Pulmonary comorbidity	0.190	–0.007	0.467	0.196	–0.265
Hypertension requiring medication	0.234	0.122	–0.266	–0.879	0.277
Bleeding disorder	1.520	—	—	—	—
ASA class ≥3	–0.032	0.257	1.135	0.952	0.673
Operative duration >6 hr	0.255	—	—	—	—
Model constant	–6.313	–7.178	–7.651	–9.600	–8.263

SSI, surgical-site infection; BMI, body mass index; —, empty values where insufficient data existed to include variable in model; ASA, American Society of Anesthesiologists.
*Compared to female patients.

patient safety and satisfaction. Studies show that increased body mass index, diabetes, smoking, and other comorbidities are associated with increased odds of abdominoplasty complications.[17,21–23] In this study, univariate analysis largely supported existing understanding of risk factors (Table 3). However, the exact effect of these risk factors on absolute total risk has been unclear, given that patients do not simply have one of these comorbidities—they may have some but not others.

The availability of large-scale, national surgical databases makes it possible to extrapolate from thousands of cases and create statistically robust predictive models that permit individualized risk calculation for unique patients. Using the National Surgical Quality Improvement Program data set, we assembled a large, nationwide sample of 2499 patients to develop robust statistical models describing the risk of several 30-day postoperative complications based on granular, individualized patient details. Risk calculators have grown in popularity in the past several years because of their ability to improve risk prediction by providing individualized assessments of risk

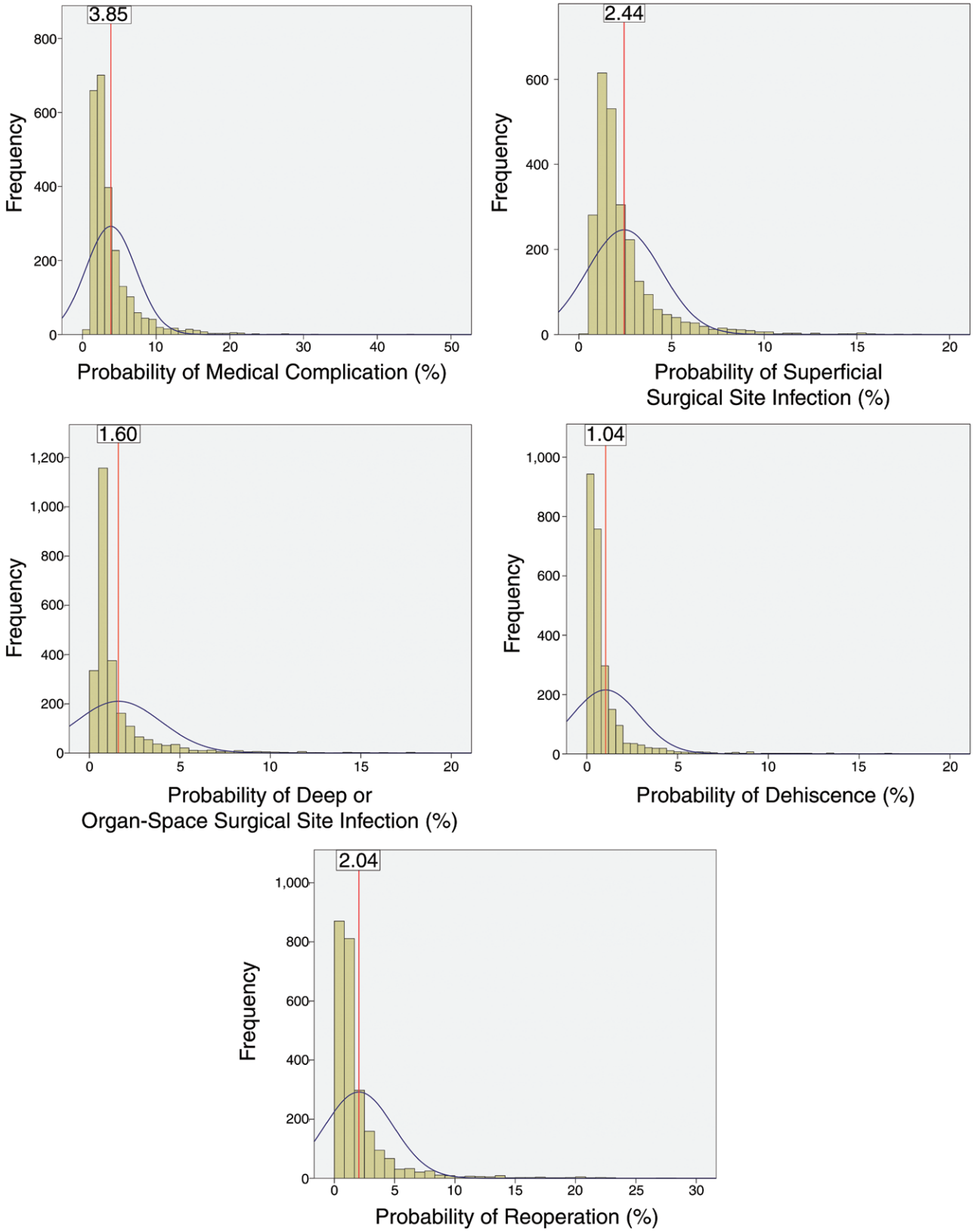

Fig. 1. Distribution of predicted risk of (*above*, *left*) medical complication, (*above*, *right*) superficial surgical-site infection, (*center*, *left*) deep or organ-space surgical-site infection, (*center*, *right*) dehiscence, and (*below*) reoperation. *Blue curves* indicate a normal distribution centered around the mean predicted risk (*red line*).

Table 5. Model Performance Metrics

	Medical Complication	Superficial SSI	Deep or Organ-Space SSI	Dehiscence	Reoperation
C-statistic	0.17	0.687	0.777	0.749	0.776
Hosmer-Lemeshow	0.231	0.770	0.825	0.200	0.782
Brier score	0.0360	0.0235	0.0152	0.0097	0.0194

SSI, surgical-site infection.

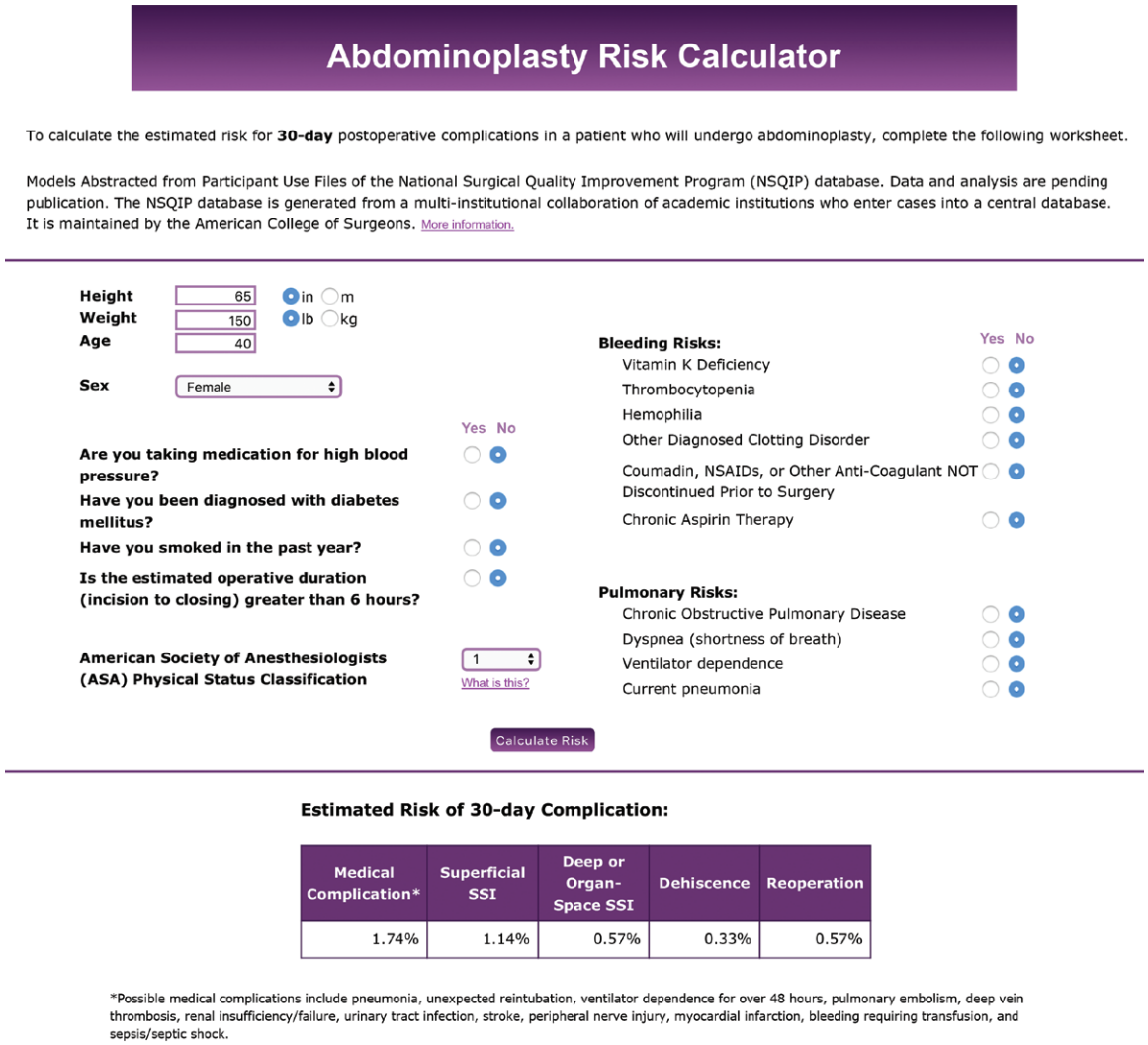

Fig. 2. Sample risk calculator inputs and outputs for representative patients. A healthy 40-year-old woman.

based on a patient's unique characteristics and comorbidities. This allows surgeons to engage in detailed, shared decision-making with patients and gives the opportunity to know in advance their patients' absolute risks, modify surgical planning and technique as necessary, and better prioritize their postoperative surveillance for complications.

Figures 2 through 4 provide concrete examples of how the calculator can be clinically relevant. One could offer a healthy, normal–body mass index, 40-year-old woman seeking abdominoplasty the average risk of medical complication, approximately 3.8 percent (Fig. 2). However, she would comprehend her individual risk much better by using her individualized risk estimate, which in fact places her risk at only 1.74 percent. Intuitively, a 40-year-old woman with a body mass index of 30 kg/m^2 who smoked within the past year would be at higher risk than the healthy 40-year-old woman of normal weight—but by

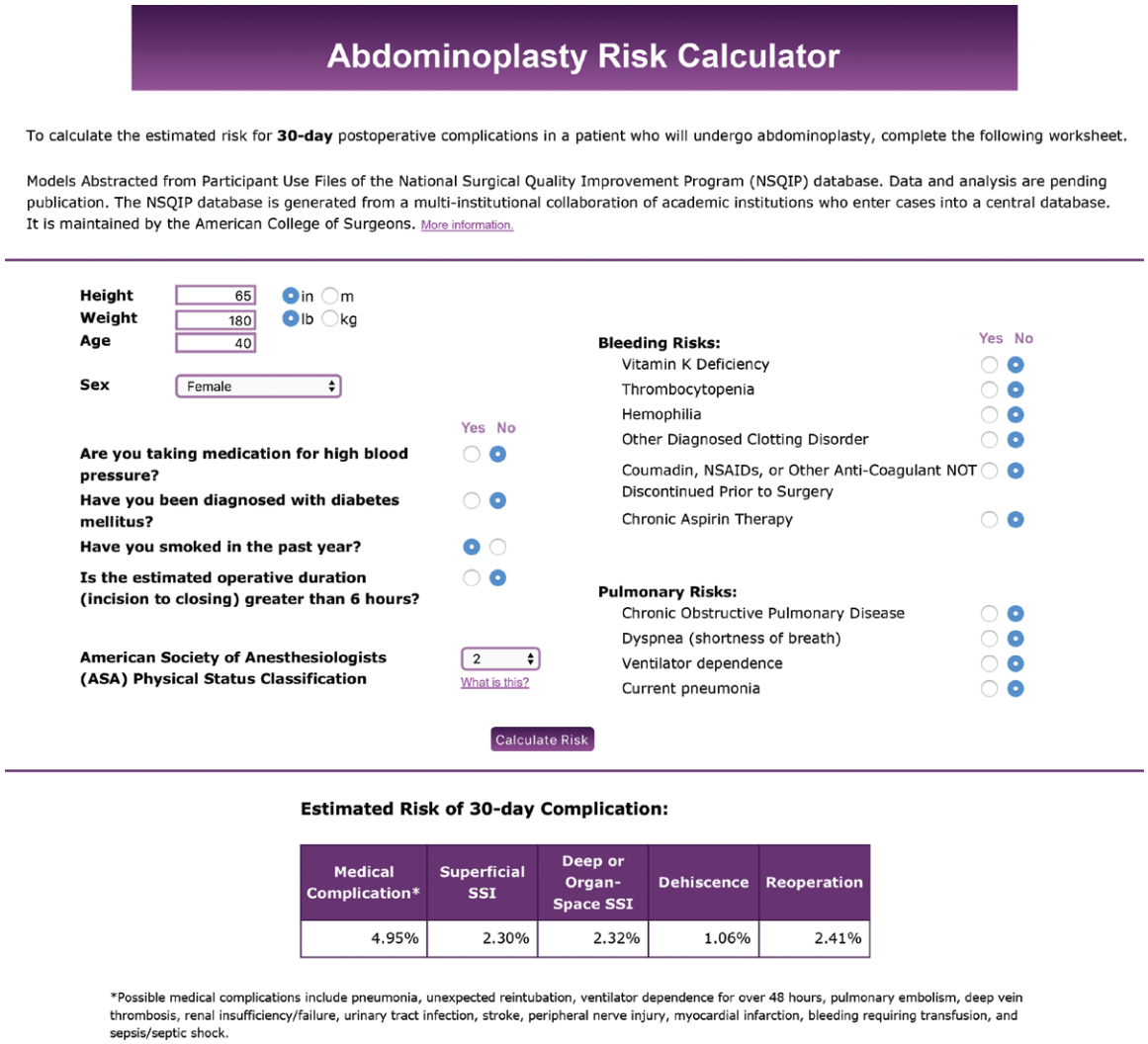

Fig. 3. Sample risk calculator inputs and outputs for representative patients. A 40-year-old woman with a body mass index of 33 kg/m^2, American Society of Anesthesiologists class of 2, and recent smoking.

how much is the risk increased? Again, use of an individualized risk calculator helps to clarify the patient's absolute risk of a medical complication, which for this patient would be 4.95 percent. As a patient has more and more comorbidities, the benefit of a risk calculator that can accommodate multiple variables becomes increasingly evident. If this patient now becomes morbidly obese with a body mass index of 40 kg/m^2, with both diabetes and recent smoking, the risk of medical complication increases dramatically to 19.82 percent. Without a risk calculator, combining these patient factors to derive an absolute risk estimate would be very challenging.

The wide distribution of predicted risks of complications, shown in Figure 1, further underlines the importance of individualized risk calculation for abdominoplasty. Pooled risks reported in the literature will inevitably underestimate or overestimate for a great number of patients. The positive skew of the distribution further suggests that population-based risk estimates tend to overestimate risk because of high-risk outliers. The implication is that abdominoplasties may be even safer for most people than traditionally cited. Although many surgeons may already have a clinical intuition about which patients will be at low or high risk, quantification of this absolute risk prediction can help to make assessments more objective and easily accessible to more patients. In addition, a systematic and numeric way of estimating absolute risk for individual patients permits more nuanced constructions of protocols and algorithms designed to optimize patient selection; maximize positive outcomes; and minimize complications, costs, and patient dissatisfaction.

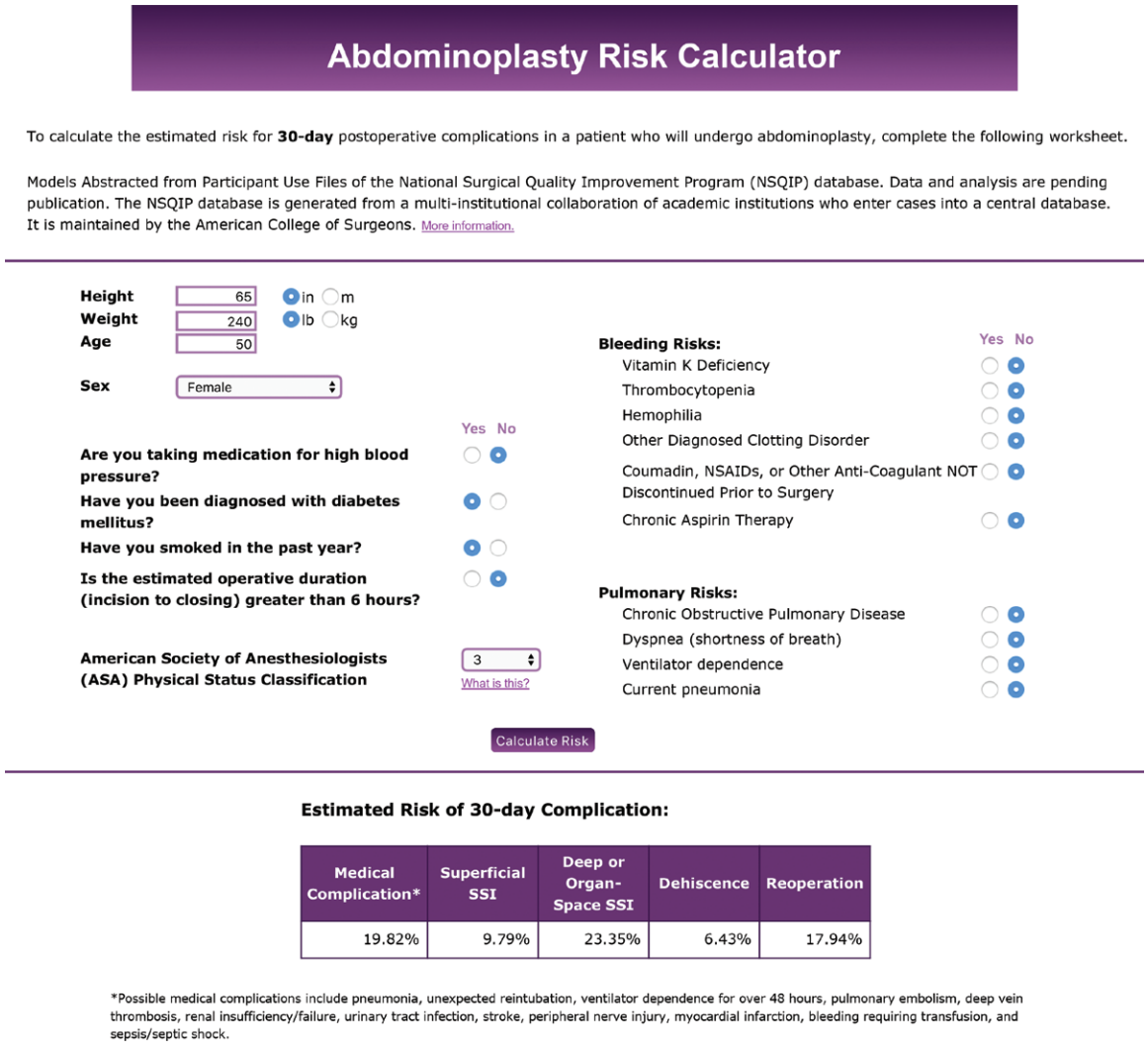

Fig. 4. Sample risk calculator inputs and outputs for representative patients. A 50-year-old woman with a body mass index of 40 kg/m^2, diabetes, recent smoking, and an American Society of Anesthesiologists class of 3.

Our models have sufficient internal validity based on their calibration and discriminatory ability (Table 5). Indeed, our models' Brier scores—a good measure of both discrimination and calibration—are comparable to currently existing surgical risk calculators such as the Breast Reconstruction Risk Assessment and the American College of Surgeons National Surgical Quality Improvement Program Universal Risk Calculator[2,11,37] (Table 6). Furthermore, the average observed and predicted risks of complications in this cohort are in agreement with the findings of previous studies. For instance, using the CosmetAssure database, Winocour et al. found abdominoplasties to have an overall major

Table 6. Literature-Reported Brier Scores for Other Risk Calculators

	Range of C-Statistics	Range of Brier Scores
BRA score surgical complications*	0.623–0.684	0.032–0.128
ACS NSQIP universal risk calculator†	0.650–0.952	0.008–0.082

BRA, Breast Reconstruction Risk Assessment; ACS, American College of Surgeons; NSQIP, National Surgical Quality Improvement Program.
*Kim JY, Mlodinow AS, Khavanin N, et al. Individualized risk of surgical complications: An application of the breast reconstruction risk assessment score. *Plast Reconstr Surg Glob Open* 2015;3:e405.
†Bilimoria KY, Liu Y, Paruch JL, et al. Development and evaluation of the universal ACS NSQIP surgical risk calculator: A decision aid and informed consent tool for patients and surgeons. *J Am Coll Surg.* 2013;217:833–842.e1.

infection rate (which excluded minor infections not requiring an emergency room visit, hospital admission, or reoperation) of 1.1 percent, similar to our deep or organ-space surgical-site infection rate of 1.6 percent.[17] That same study found an 0.8 percent rate of venous thromboembolism, again similar to our cohort's rate of 0.5 percent. Further comparison between these two studies is challenging becasue their respective databases track different complications and have varying definitions for certain complications. The National Surgical Quality Improvement Program captures a wider array of complications, as CosmetAssure tracks only complications that are reported for payment purposes, excluding minor surgical-site infections and wound problems. The CosmetAssure cohort of abdominoplasties also has a slightly younger age (43 years) and lower average body mass index (26.7 kg/m^2), and fewer diabetics (2.8 percent), differences that may also be contributing to variation in overall outcomes between the two studies. Nevertheless, where the two data sets overlap, the similarities in observed outcomes suggests that this present study is externally valid for patients not captured by the National Surgical Quality Improvement Program.

We noted body mass index to be a particularly strong independent risk factor for complications in our risk models. Each point of body mass index conferred an additional additive beta value between 0.058 and 0.140 (Table 4). Risk of dehiscence was most sensitive to body mass index, likely reflecting increased skin closure tension in these patients. A subgroup analysis of patients with a body mass index greater than 35 kg/m^2 recapitulated this increased risk across all complications, especially for dehiscence and reoperation (Table 2). However, medical complications were also dramatically increased in this subgroup (9.3 percent; 2.4 times greater than the general cohort). Whether some of this risk follows a patient even after massive weight loss surgery or is a direct result of massive weight loss would be an intriguing question to explore in future studies; presently, the literature is conflicted as to whether prior massive weight loss is a true risk factor, and by what mechanism such a risk factor may be driven.[38–41] The National Surgical Quality Improvement Program only tracks weight loss greater than 10 percent in the last 6 months before surgery, and both the quantity and timeframe of this weight loss are likely inadequate for this context.[42]

Current abdominal contouring literature examining the risk of multiple concurrent procedures, such as liposuction or hernia repair, is somewhat conflicted. However, numerous authors have observed that performing other procedures in addition to abdominoplasty, such as liposuction or hernia repair, does not necessarily increase the risk of complications significantly.[43–50] Similarly, preliminary multivariate analysis for our study showed that concurrent procedures did not have consistent or significant impact on the risk of complication and therefore were not included in our risk-prediction models. Further prospective studies can better answer this question, and even provide more data to incorporate into the risk calculator equations.

This study is not without limitations. Currently, our calculator does not account for variances between surgeons, such as technique, skill, and facility. Future work may focus on adding the ability for surgeons to enter their own observed average complication rates to adjust the models on a surgeon-specific basis. By its nature as a retrospective study, there will be some degree of selection bias, although the National Surgical Quality Improvement Program's data collection methods have strict quality control methods that attempt to reduce such biases. However, the database itself comes with limitations, such as the inability to track whether patients are given prophylactic anticoagulation or whether patients have undergone massive weight loss. The National Surgical Quality Improvement Program also lacks some plastic surgery–specific complications data such as delayed wound healing, seroma, poor scarring, and asymmetry. The clinical significance of some of the National Surgical Quality Improvement Program's reported complications may be small, as in the case of minor wound dehiscence that do not greatly impact the final outcome. Furthermore, complications are tracked only up to 30 days postoperatively, and some important complications may occur outside of this window. Minor revisions, for instance, often occur months after the initial procedure. Aesthetic outcomes, which are of great interest to both surgeons and patients, are also unavailable in national databases such as CometAssure and the National Surgical Quality Improvement Program. The National Surgical Quality Improvement Program was chosen as the initial base for the risk calculator because of its robust data collection, large sample size, and broad representation of facilities nationwide; however, in the future, other large-scale databases may supplement the current National Surgical Quality Improvement Program analysis to calculate risks of a greater variety of outcomes, and

more preoperative factors such as surgical technique and massive weight loss patients. We recognized the current limitations of National Surgical Quality Improvement Program data by designing the risk calculator to be modular and easily modifiable when new data become available. Finally, although the C-statistics, Hosmer-Lemeshow tests, and Brier scores of our risk models signify good internal validity, the ultimate test of the applicability of this risk calculator will be a comparison of its predictions against other cohorts.

CONCLUSIONS

Abdominoplasties demonstrate diverse risk predicated on variance in patient comorbidities. We developed an internally validated risk calculator for which granular patient characteristics can be input to predict 30-day complications after abdominoplasty. This individualized risk assessment can enhance shared decision-making between surgeon and patient, and is available online at www.AbdominoplastyRisk.org.

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