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Comparing thirty-day outcomes in prosthetic and autologous breast reconstruction: A multivariate analysis of 13,082 patients?☆

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Summary *Background:* There is a paucity of multi-institutional data that directly compares short term outcomes of autologous and prosthetic breast reconstruction. The National Surgical Quality Improvement Program provides a unique data platform for evaluating peri-operative outcomes of these two main categories of breast reconstruction. It has detailed data from nearly 250 hospitals and over 13,000 patients. We performed risk-adjusted analysis of prosthetic and autologous breast reconstruction to compare 30-day morbidity outcomes.
Methods: Patients who underwent prosthetic breast reconstruction or autologous tissue reconstruction from 2006 to 2010 were identified using operation descriptions. Over 240 tracked variables were extracted for patients undergoing breast reconstruction. Thirty-day postoperative outcomes were compared, and subgroup analysis was performed on the autologous population to describe outcomes of specific flap procedures. Reconstruction was analyzed as an independent risk factor for specific complications, with propensity scores used to help standardize compared patient populations. Regression analyses were performed using SPSS (version 20.0, Chicago, IL).
Results: A total of 13,082 patients underwent breast reconstruction; 9786 patients received prosthetic reconstruction and 3296 received autologous reconstruction. Within the autologous cohort,

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1608 (48.8%) patients underwent a pedicle TRAM flap, 1079 (32.7%) had a LD flap, and 609 (18.5%) received a free flap. Autologous reconstruction patients had higher rates of overall complications (12.47% vs 5.38%, $p < .001$), wound infection (5.46% vs 3.45%, $p < .001$), prosthesis/flap failure (3.13% vs 0.85%, $p < .001$), and reoperation (9.59% vs 6.76%, $p < .001$). Risk-adjusted multivariate analysis also showed autologous reconstruction to be a significant independent predictor of specific short term outcomes.

Conclusions: Using risk-adjusted models of a large multi-institutional database, we found that — relative to prosthetic reconstruction — autologous reconstruction had higher rates of 30-day overall complications, wound infection, prosthesis/flap failure, and reoperation. This may be due, in part, to a concomitant increase in operative time and higher case complexity. Taken with other reports such as NMBRA, this study helps to educate patients and surgeons alike on potential, comparative complications during the perioperative period.

Introduction

There were over 1.6 million breast cancer diagnoses and 425,000 breast cancer related deaths in 2010, making breast cancer both the leading cancer diagnosis and cause of death due to cancer in women worldwide.[1] While breast cancer treatment options have expanded over time to include breast conservation surgery, hormone therapy, chemotherapy, and radiation, mastectomy remains a common primary treatment option for patients.[2] Those that do undergo mastectomy procedures face post-operative changes in body image, emotional and psychological well-being, and quality of life which can be both distressing and overwhelming.[3–5] However, it has been shown that breast reconstruction following mastectomy may alleviate some of the adverse effects previously assessed in this patient population.[6–10]

Over the years, the variety of breast reconstruction procedures has increased, and the efficacy of the operations offered has improved. Breasts may be reconstructed following mastectomy by making use of autologous tissue flaps or prosthetic implants with or without tissue expanders. Reported rates of breast reconstruction after undergoing a mastectomy are low amongst developed nations, ranging from 7.7% in Canada and 16.9% in Denmark to 31% in the United Kingdom and 37.5% in the United States.[10–15] With studies supporting the psychological and emotional benefits associated with post-mastectomy breast reconstruction, it is predicted that reconstruction will be offered with increasing frequency to a broader population of patients as time goes on.

There are established advantages to prosthetic tissue reconstruction, namely shorter operative times and diminished donor site morbidity.[16] Benefits of autologous tissue reconstruction include superior esthetic results compared to prosthetic reconstruction and improved outcomes in certain patient subpopulations, such as those with a preoperative history of external beam radiation therapy and chest wall involvement.[17–21] Yet both methods are not without complications. For those who do have to decide between prosthetic and autologous tissue breast reconstruction, education regarding the short and long term complications associated with various techniques is important.

Many studies evaluating reconstructive procedures have focused on only one or two techniques and utilized small patient cohorts or single surgeon/single center data, with the National Mastectomy and Breast Reconstruction Audit (NMBRA) as a notable exception.[10,22–29] This prospective multicenter study, based out of the United Kingdom, captured 15,479 women undergoing a mastectomy from January 2008 to March 2009 from 150 English NHS Trusts and 106 independent hospitals. Analysis of the 4796 women who received reconstruction has resulted in successive annual reports over the past four years attesting to the safety of mastectomy and breast reconstruction procedures. We have expanded upon their findings on short-term outcomes through the retrospective analysis of over 13,000 breast reconstruction patients.

While a prospective randomized controlled trial would provide the most reliable, unbiased comparison of outcomes, implementation of such a study would be ethically challenging. Thus, a retrospective review of a large sample population from multiple centers is an alternative means of studying short term outcomes of interest without any potential detriment to patients.

Of late, multi-institutional clinical registries have proven their utility in evidence-based medicine. These outcomes focused programs permit retrospective analysis of large patient populations across a range of geographical areas and clinical settings, which subsequently allows for both a balanced creation of risk profiles and unbiased examination of outcomes. The National Surgical Quality Improvement Program (NSQIP) was started in 1991 with aspirations of quantifying and improving surgical outcomes. The database is prospectively managed and houses de-identified patient variables from over 240 hospitals.[30–32] Employing the comprehensive nature of the NSQIP database, we aimed to assess the risk-adjusted relationship between reconstruction approaches and 30-day outcomes.

Methods

Data acquisition

The particulars of the ACS-NSQIP sampling method, data extraction, variables, and outcomes have previously been described in detail. In brief, the data is obtained from patient medical records, physician office records, and telephone interviews by trained surgical clinical nurse reviewers (SCNRs) and de-identified to maintain patient anonymity. Outcomes are monitored for the 30-day period following the primary surgery.[30–32]

Patient population

We retrospectively reviewed the NSQIP database from 2006 to 2010 for all patients undergoing either autologous tissue based breast reconstruction or prosthetic breast reconstruction with a tissue expander. Patients were identified by description (represented by a numerical code) of their primary and concurrent operations, a variable tracked through the NSQIP database. Autologous reconstruction could be further stratified into free flaps, pedicled transverse rectus abdominis myocutaneous (TRAM) flaps and latissimus dorsi (LD) flaps through description codes. Patients with the description code representing "immediate or delayed insertion of a breast prosthesis following mastopexy or mastectomy" were excluded since we could not clearly delineate which patients received a prosthesis as a component of breast reconstruction or a staged cosmetic procedure. Patients with more than one type of reconstruction were also excluded. We discerned between immediate and delayed reconstructions by the presence of a concurrently listed mastectomy procedure. Laterality was established based on the number of reconstruction descriptions listed, with one description corresponding to a unilateral procedure and two descriptions corresponding to a bilateral procedure.

Outcomes

The outcomes of primary interest in this study were overall complications, wound infection, prosthesis/flap failure, and reoperation. We defined overall complication as having $\geq$1 of the following adverse events tracked by NSQIP: superficial surgical site infection (SSI), deep SSI, organ/space SSI, wound disruption/dehiscence, pneumonia, unplanned intubation, pulmonary embolism, failure to wean from ventilator, renal insufficiency, progressive renal failure, urinary tract infection, stroke, coma, peripheral neurologic deficiency, cardiac arrest, myocardial infarction, bleeding requiring a transfusion, deep venous thrombosis (DVT), and sepsis/septic shock. Surgical complication was defined as suffering from wound infection, flap failure or wound disruption. Wound infection was defined as having $\geq$1 of the following: superficial SSI, deep SSI, or organ/space SSI. A medical complication was any other outcome not described as a flap complication. Reoperation described a return to the operating room within 30 days of the primary procedure.

Risk adjustments

Patient demographics and comorbidities were tracked as potential independent variables. Demographic data included age, race, and BMI. Medical comorbidities consisted of diabetes, dyspnea, ascites, renal disease, chronic obstructive pulmonary disease (COPD), current pneumonia, ventilator dependence, chronic steroid use, bleeding disorders, heart failure, myocardial infarction within 6 months of operation, peripheral vascular disease, disseminated cancer, weight loss of $>$10% body weight within 6 months of operation, current chemotherapy or radiotherapy, neurologic deficit, preoperative transfusion, and preoperative sepsis. Alcohol use, defined as $>$2 drinks per day, and smoking represented lifestyle variables recorded in the database.

Statistical analysis

Patient demographics, comorbidities, and outcomes were compared utilizing χ^2 tests for categorical variables and one way ANOVA tests for continuous variables. Significance was set a $p \leq .05$. If on univariate analysis the outcome had $\geq$10 occurrences and $p \leq .20$, multivariable models were built to investigate the association between reconstruction approach and specific postoperative outcome.

Propensity score calculations were performed to reduce bias attributed to the nonrandom assignment of treatment.[33] By employing a multivariate regression in which patient preoperative variables describing demographics and comorbidities were included, computed propensity scores represented the predicted probability that the patient received autologous tissue based breast reconstruction, as opposed to prosthetic breast reconstruction. The calculated propensity scores were subsequently included in the logistic regression model to decrease selection bias when exploring the association between reconstruction approach and outcome. Estimated risk scores for overall complications, wound infection, prosthesis/flap failure, and reoperation by reconstruction method were calculated as the average of probability output values from the multivariate regressions. All analyses were performed using SPSS, version 20 (Chicago, IL).

Subgroup analysis was performed on the autologous tissue based reconstruction cohort to assess the prevalence of specific flap operations and compare outcomes. Similar to the overall prosthetic and autogenous populations, patient demographics, comorbidities and outcomes were compared using χ^2 tests for categorical variables and one way ANOVA tests for continuous variables. Significance was set a $P \leq .05$.

Results

Of the 1.3 million patients captured in the NSQIP database between 2006 and 2010, 13,082 patients were identified who underwent breast reconstruction meeting inclusion criteria. Within this group, 9786 (74.8%) received tissue expander based prosthetic reconstruction and 3296 (25.2%) underwent autologous tissue based reconstruction (Figure 1). Just over one-fourth of the procedures (25.9%) were delayed reconstructions and 3359 were bilateral, resulting in 16,441 total reconstruction procedures (Table 1). Prosthetic procedures comprised over 90% of immediate procedures, whereas autologous operations constituted 77.2% of the delayed reconstruction cases. The prosthetic and autologous reconstruction patient populations were

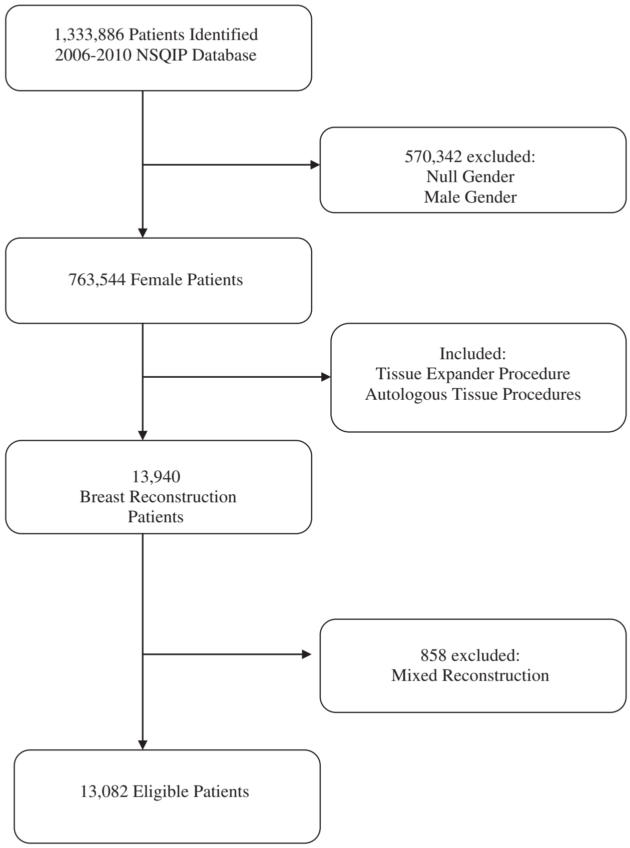

Figure 1 Patient attrition diagram.

similar with regard to diabetes, alcohol intake, chronic steroid use, and preoperative diagnosis of a bleeding disorder. The number of patients receiving pre-operative radiation did not significantly differ between the immediate and delayed reconstruction cohorts. Compared to the autogenous cohort, patients undergoing prosthetic reconstruction were more frequently younger (average age ± standard deviation (SD); 51.02 ± 10.52 vs 51.8 ± 9.70 years, $p < .001$), with little clinical significance due to the smaller autologous patient sample size. Prosthetic patients were also more often white (80.5% vs 76.8%, $p < .001$) and active smokers (14.1% vs 11.0%, $p < .001$). Those in the autologous tissue group were more often hypertensive (27.2% vs 23.1%, $< .001$), heavier (average BMI ± SD; 28.39 ± 6.11 vs 26.93 ± 6.28, $p < .001$) and had a history of a prior operation (4.4% vs 2.4%, $p < .001$) (Table 2).

Table 1 Surgical timing and bilaterality by reconstruction method.

	Immediate		Delayed	
	n	%Bilateral	*n*	%Bilateral
Tissue expander	9012	30.3%	774	10.7%
Free flap	141	13.5%	468	29.7%
LD flap	264	3.8%	815	18.5%
Pedicled TRAM	277	7.2%	1331	15.2%

Univariate analysis

There was a significant difference in operative time between the prosthetic and autologous cohorts (average time in minutes ± SD; 197.83 ± 83.58 vs 357.90 ± 191.04, $p < .001$) (Table 2). Patients undergoing autologous tissue based reconstruction experienced a postoperative complication more frequently than patients undergoing prosthetic reconstruction (12.47% vs 5.38%, $p < .001$) (Table 3). Specifically, patients receiving autologous reconstruction were more likely to have a surgical complication (8.71% vs 4.39%, $p < .001$); suffer a wound infection (5.46% vs 3.45%, $p < .001$); experience prosthesis/flap failure (3.13% vs 0.85%, $p < .001$); have wound disruption (1.24% vs 0.44%, $p < .0001$); incur a medical complication (5.92% vs 1.55%, $p < .001$); and undergo a reoperation (9.59% vs 6.76%, $p < .001$). There were also significantly higher rates of pneumonia (0.33% vs 0.06%, $p < .001$), reintubation (0.18% vs 0.04%, $p = .02$), pulmonary embolism (0.52%, vs 0.17%, $p < .001$), urinary tract infection (0.76% vs 0.2%, $p < .001$), bleeding requiring a transfusion (0.61% vs 0.28%, $p < .001$), DVT (0.61% vs 0.28%, $p < .001$), and sepsis/septic shock (1.12% vs 0.55%, $p = .001$) in this patient population.

There was not a significant difference in postoperative complication rates between prosthetic and autologous reconstruction groups for failure to wean from the ventilator, renal insufficiency, acute renal failure, stroke, coma, peripheral nerve injury, cardiac arrest, and myocardial infarction.

Multivariate analysis

Multivariate models were created to examine the influence of reconstruction technique on specific 30-day postoperative outcomes, while adjusting for confounders. Regression analysis revealed that patients receiving autologous tissue reconstruction had a higher likelihood of incurring a postoperative complication (Odds Ratio (OR) 1.47, 95% Confidence Interval (CI) 1.15–1.89) (Table 3). In particular, patients in this cohort were at increased risk for having a surgical complication (OR 1.30, 95% CI 1.02–1.66), including wound infection (OR 1.40, 95% CI 1.01–1.96) and prosthesis/flap failure (OR 1.69, 95% CI 1.08–2.62). They also had an increased likelihood of having a medical complication (OR 1.68, 95% CI 1.21–2.34), namely UTI (OR 4.18, 95% CI 1.89–9.27) and bleed necessitating a transfusion (OR 3.16, 95% CI 1.59–6.26).

Risk-adjusted regression models served an additional use in helping create estimated risk scores for overall complications, wound infection, prosthesis/flap failure, and reoperation for each reconstruction method. Results showed that autologous reconstruction had a significantly higher estimated risk for overall complications (0.12 vs 0.054, $p < .001$), wound infection (0.055 vs 0.035, $p < .001$), prosthesis/flap failure (0.031 vs 0.008, $p < .001$), and reoperation (0.097 vs 0.068, $p < .001$) compared to prosthetic reconstruction (Figure 2).

Subgroup analysis

Within the autologous tissue cohort, 1608 (48.8%) patients underwent a pedicled TRAM flap, 1079 (32.7%) had a LD flap,

Table 2 Patient characteristics by reconstruction method.

	Prosthetic $n = 9786$	Autogenous $n = 3296$	p-Value
Age	51.02 ± 10.56	51.80 ± 9.702	<.001*
BMI ((lbs/H^2))* 703)	26.93 ± 6.28	28.39 ± 6.11	<.001*
Operative time (min)	197.83 ± 83.58	357.90 ± 191.04	<.001*
Sum of RVU	26.33 ± 12.95	57.56 ± 25.56	<.001*
Race			
White	7874 (80.5%)	2530 (76.8%)	<.001*
Black	617 (6.3%)	362 (11.0%)	<.001*
Asian	241 (2.5%)	97 (2.9%)	–
Other	1054 (10.8%)	307 (9.3%)	<.001*
Outpatient	2542 (26.0%)	2530 (76.8%)	<.001*
Alcohol use	111 (1.1%)	38 (1.1%)	0.93
Diabetes	483 (4.9%)	171 (5.2%)	0.565
Active smokers	1386 (14.1%)	362 (11.0%)	<.001*
History of COPD	81 (0.9%)	23 (0.7%)	0.468
Hypertension	2265 (23.1%)	898 (27.2%)	<.001*
Steroid use	90 (0.9%)	26 (0.8%)	0.488
Bleeding disorder	69 (0.7%)	23 (0.7%)	0.966
Prior sepsis	16 (0.2%)	22 (0.7%)	<.001*
Prior operation	230 (2.4%)	146 (4.4%)	<.001*

Age, BMI, operative time, and sum of RVUs are displayed as mean ± standard deviation (SD).
*Significant value, $p \leq .05$.

and 609 (18.5%) received a free flap. Those with LD flaps were the oldest, with an average age of 52.4 years, compared to 51.8 years in the pedicled TRAM group and 50.7 years in the free flap group ($p = .003$). Patients in the free flap group had an average BMI of 29; those in the LD flap group had an average of 27.6; individuals in the pedicled TRAM cohort had an average of 28.7 ($p < .001$). There was a significant difference in the number of active smokers in each flap group: 9% of free flap recipients were active smokers, compared to 10.1% of pedicled TRAM recipients and 13.3% of LD flap recipients ($p = .008$). There were no significant differences in diabetes, prior radiation, or prior chemotherapy between the three autogenous tissue cohorts.

Complication rates for each of the autogenous tissue populations were categorized by surgical timing and compared to prosthetic outcomes in Table 5. Surgical timing appeared to have less of an impact on prosthetic outcomes than autologous outcomes. Looking at immediate and delayed procedures together, nearly one-fifth of patients who received a free flap incurred a post-operative complication, whereas 13.4% of pedicled TRAM flap patients and 7.1% of LD flap patients suffered a similar outcome ($p < .001$). Comparable trends were seen with flap failure and reoperation rates – free flap patients had the highest rates of flap failure (5.7%) and reoperation (15.6%), followed by pedicled TRAM flaps (3.4% flap failure; 9.9% reoperation) and LD flaps (1.3% flap failure; 5.7% reoperation). Wound infections occurred in 108 (6.7%) pedicled TRAM patients, 36 (5.9%) free flap patients, and 36 (3.3%) LD flap patients.

Discussion

While breast cancer remains the most common diagnosis and cause of death related to cancer in women worldwide, screening programs and tailored surgical and medical therapies have contributed to an overall decrease in mortality rates in developed countries.[1,34,35] Thus, there are a rising number of survivors who must tackle the physical, emotional, and psychological effects that follow breast cancer treatment. In certain patient populations, namely those who undergo mastectomy, breast reconstruction has been shown to assuage the burden some patients experience postoperatively by improving their overall well-being and self esteem.[6–9] Few large scale reviews such as those generated by the National Mastectomy and Breast Reconstruction Audit (NMBRA) exist to aid patient decision making. Studies by Alderman et al. and Sullivan et al. provided some degree of comparison (326 patients and 240 patients respectively) and showed no difference in overall complication rates between flap and prosthetic reconstruction.[36,37] However, both studies were hampered by low sample sizes and restricted their analysis to overall complications rather than stratifying their outcomes into individual complications. This study covering over 3 million data points and 13,000 breast reconstruction patients is the largest multi-institution analysis comparing 30-day outcomes associated with prosthetic and autologous methods. The large sample size allows for robust subset analysis, including multivariable regression modeling for specific complications such as wound infection.

The autologous and prosthetic reconstruction cohorts were similar in terms of diabetes, alcohol use, history of COPD, chronic steroid use, and bleeding disorder (Table 2). Nonetheless, a few differences were noted between the populations. Specifically, patients receiving autologous tissue flap procedures were less likely to be active smokers compared to the prosthetic group (11.0% vs 14.1%, $p < .001$), yet more likely to be hypertensive (27.2% vs 23.1%, $p < .001$) and heavier (BMI 28.39 ± 6.11 vs 26.93 ± 6.28, $p < .001$). The observed variance in BMI between the prosthetic and autologous groups is in line with previous literature stating that patients undergoing autologous operations are more often heavier than those undergoing prosthetic reconstruction. Subgroup analysis further substantiated this as patients receiving free flap reconstruction were the heaviest on average of any autologous tissue based cohort, reflecting the increased availability of abdominal tissue preferred for these technically challenging operations. However, the cause for the aforementioned differences in smoking and hypertension may be more complex, with surgeons pursuing certain reconstruction methods based on a specific comorbidity's unique potential to affect postoperative outcomes. For instance, physicians who cared for patients with a recent MI might have elected to perform prosthetic reconstruction to avoid subjecting the patient to the longer operating times found in autologous procedures.

Thirty-day complication rates are displayed in Table 3. Patients receiving autologous breast reconstruction had more than double the rate of overall complications compared to prosthetic reconstruction patients (12.47% vs

Table 3 Thirty-day postoperative outcomes for prosthetic breast reconstruction compared to autogenous breast reconstruction for cancer.

Outcomes	Prosthetic $n = 9786$ %	Autogenous $n = 3296$ %	*p*-Value[a]	Multivariable odds ratio (95% confidence interval) *without* propensity score adjustment[b]	Multivariable odds ratio (95% confidence interval) *with* propensity score adjustment[b]
Overall complications	5.38	12.47	<.001*	1.45 (1.14–1.85)*	1.47 (1.15–1.89)*
Surgical complications	4.39	8.71	<.001*	1.28 (1.01–1.62)*	1.30 (1.02–1.66)*
Wound infection[c]	3.45	5.46	<.001*	1.42 (1.03–1.96)*	1.40 (1.01–1.96)*
Superficial SSI	1.67	2.95	<.001*	1.27 (0.87–1.87)	1.2 (0.81–1.76)
Deep SSI	1.07	1.97	<.001*	1.71 (1.07–2.71)*	1.81 (1.12–2.94)*
Organ/space SSI	0.77	0.67	0.567	–	–
Prosthesis/flap failure	0.85	3.13	<.001*	1.64 (1.07–2.53)*	1.69 (1.08–2.62)*
Wound disruption	0.44	1.24	<.001*	1.86 (0.90–3.86)	1.79 (0.83–3.84)
Medical complications	1.55	5.92	<.001*	1.73 (1.26–2.39)*	1.68 (1.21–2.34)*
Pneumonia	0.06	0.33	<.001*	4.37 (1.25–15.27)*	3.51 (0.92–13.34)
Reintubation	0.04	0.18	0.02*	–	–
Pulmonary embolism	0.17	0.52	0.001*	2.08 (0.85–5.10)	1.84 (0.71–4.77)
Ventilator > 48 h	0.02	0.09	0.106	–	–
Renal insufficiency	0	0.03	0.252	–	–
Renal failure	0.03	0.06	0.605	–	–
Urinary tract infection	0.2	0.76	<.001*	3.48 (1.62–7.45)*	4.18 (1.89–9.27)*
Stroke	0.02	0	1	–	–
Coma	0	0	–	–	–
Peripheral nerve injury	0.04	0.09	0.379	–	–
Cardiac arrest	0	0.03	0.252	–	–
Myocardial infarction	0.01	0.06	0.158	–	–
Bleed requiring transfusion	0.28	0.61	<.001*	3.12 (1.60–6.09)*	3.16 (1.59–6.26)*
DVT	0.28	0.61	0.006*	1.30 (0.57–2.95)	0.992 (0.41–2.41)
Sepsis/septic shock	0.55	1.12	0.001*	1.18 (0.69–2.01)	0.97 (0.55–1.73)
Reoperation	6.76	9.59	<.001*	0.899 (0.74–1.09)	0.93 (0.76–1.14)

*Significant value, $p \leq .05$.
Odds ratios >1.0 indicate a higher likelihood of the adverse event occurring.
[a] Univariate *p* value, χ^2 tests.
[b] Odds ratio of experiencing the complication after autogenous breast reconstruction (compared to prosthetic reconstruction). Multivariate models adjusting for propensity scores were developed if there were ≥10 occurrences and if $p < .20$ on univariate analysis.
[c] Patients can be classified as having more than one type of SSI, so the subgroup percentages are larger than the overall SSI percentage.

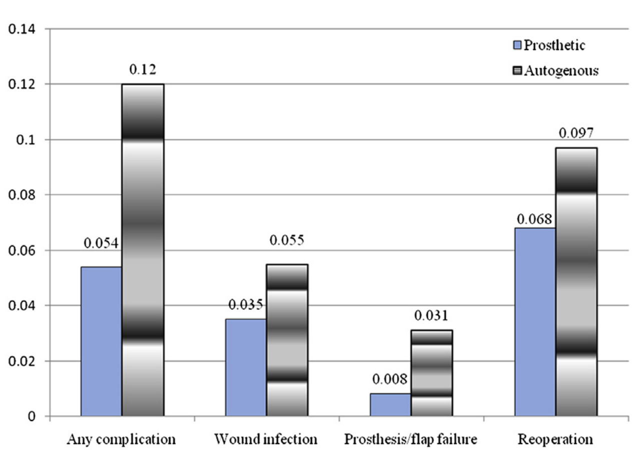

Figure 2 Estimated risk score for any complication, wound infection, prosthesis/flap failure, and reoperation by reconstruction method.

5.38%, $p < .001$). Such findings cannot be directly compared to those from the NMBRA reports due to slight differences in outcomes definitions and tracked variables. The autologous cohort was also at increased risk for wound infection (5.46% vs 3.45%, $p < .001$) and prosthesis/flap failure (3.13% vs 0.85%, $p < .001$), reflecting the strong contribution that surgical complications made to the overall complication rate. The reasoning behind these findings is certainly multifactorial in nature, and we postulate that the donor site morbidity associated with autologous procedures is one of the major contributors. Surgical timing appeared to impact autologous complication rates, with mastectomy procedures possibly contributing to the higher complications seen in the immediate reconstruction cohort (Table 5). Moreover, while nearly 80% (2614 out of 3296) of autologous procedures occurred in a delayed setting – presumably allowing patients to heal from the associated morbidity of undergoing a mastectomy alone – each delayed autologous flap subgroup had more than double the number of bilateral procedures compared to their immediate counterparts (Table 1); bilateral procedures may have presented a greater opportunity for surgical complications due in part to the larger surface area under surgical manipulation. Additionally, selection bias could have influenced post-operative outcomes, as patients with more medical comorbidities may have been directed to autologous reconstruction with the understanding that well vascularized tissue will limit complications. These patients would have subsequently been more apt to have complications independent of reconstructive technique.

Recognizing the role that baseline discrepancies in patient populations could have played in skewing post-operative outcomes, we used propensity score adjusted models to mitigate differences in patient cohorts. Risk-adjusted regression still showed autologous reconstruction to be a powerful predictor of overall complications (OR 1.47, 95% CI 1.15–1.89) (Table 3), with other predictors displayed in Table 4. Moreover, autologous reconstruction patients had significantly higher estimated risk scores for overall complications, wound infection, prosthesis/flap failure, and reoperation compared to those undergoing prosthetic reconstruction (Figure 2). Higher rates of flap failure in the autologous cohort could explain the corresponding elevated rates of reoperation, as surgeons held fewer reservations in returning to the operating room in an attempt to save a flap. Interestingly, undergoing a bilateral procedure, when compared to unilateral as a control, was not a significant independent predictor of complications.

Table 4 Risk-Adjusted Multivariate Regression: All Breast Reconstruction Procedures.

Variable	Overall complications			
	OR	95% CI		p-Value
Autologous reconstruction	1.474	1.15	1.888	0.002*
Age	1.01	1.002	1.017	0.011*
Outpatient	0.817	0.65	1.026	0.082
Obesity (BMI $\geq$ 30)	2.071	1.788	2.399	<.001*
Diabetes	1.17	0.89	1.54	0.261
Smoking	1.358	1.12	1.646	0.002*
Alcohol use	1.398	0.798	2.449	0.242
Dyspnea	1.33	0.981	1.803	0.067
COPD	1.738	0.974	3.1	0.061
Prior percutaneous coronary intervention	1.074	0.527	2.186	0.845
Prior cardiac surgery	3.189	1.752	5.803	<.001*
Hypertension	1.128	0.953	1.334	0.161
Distant cancer	1.769	0.966	3.239	0.065
Wound infection	1.677	0.868	3.239	0.124
Bleeding disorder	2.617	1.477	4.638	0.001*
Chemotherapy	1.201	0.878	1.642	0.251
Prior operation (<30 days)	1.97	1.423	2.727	<.001*
Delayed reconstruction	1.394	1.117	1.74	0.003*
Bilateral reconstruction	1.185	0.976	1.439	0.086
Sum of RVUs	0.998	0.993	1.003	0.462
Operative time (min)	1.003	1.002	1.003	<.001*

*Significant value, $p \leq .05$.

Central to autologous procedures' risk for complications is their associated technical difficultly. The intricacy of autologous procedures is best reflected in the nearly 2.5 additional hours needed to complete an autologous operation compared to a prosthetic procedure. As our multivariate regression revealed, operative time is also an independent predictor of outcomes. Thus, more time in the operating suite may in and of itself have contributed to the higher complication rates seen in the autologous cohort. Moreover, subgroup analysis showed a step-wise increase in complication rates when proceeding from LD flaps (7.1%) to pedicled TRAM flaps (13.4%) and then free flaps (19.1%). This correlated proportionately to the average operating times associated with each cohort: 4.95 h, 5.52 h, and 8.96 h for LD flaps, pedicled TRAM and free flaps, respectively. The complicated nature of autologous procedures is also represented in the average sum of Relative Value Units (RVUs) – a partial indication of procedure complexity – which were higher in the autologous patient population than in the prosthetic population. Thus, autologous tissue transfer may have an inherent tendency for more complications.

Autologous reconstruction was deemed a significant predictor of medical complications, in addition to overall complications, through risk-adjusted regression analysis (OR 1.68, 95% CI 1.21–2.34) (Table 3). Of note, the incidence of DVT and PE were higher in the autologous reconstruction population. Given that patients undergoing autologous tissue transfer procedures have a longer period of recovery and latency to ambulation than those undergoing tissue expander placements, this finding is not surprising. The protracted convalescence associated with autologous operations may have also contributed to the increased rates of pneumonia and urinary tract infections seen in this cohort. Additionally, there was a trend toward an increase in failure to wean, renal insufficiency, acute renal failure, peripheral nerve injury, cardiac arrest, and myocardial infarction in the autologous cohort, however the number of occurrences were too few to draw definitive conclusions.

While our results display higher morbidity and reoperation rates in the autologous reconstruction cohort, we give prudence to the fact that these findings reflect a very discrete time period. The advantages of autologous reconstruction over prosthetic reconstruction – namely improved aesthetics – are long term outcomes not captured in this study. Autologous operations may have higher rates of flap failure and reoperation in the 30 days following surgery, but, as a study from Rusby and associates revealed, these rates decline over time.[38] This is juxtaposed by increasing rates of reconstruction failure and reoperation seen in the prosthetic reconstruction group at five years after the initial operation. Such findings bring to light the myriad of other factors including preoperative comorbidities, radiotherapy, and aesthetic desires that serve as equipoise to the short term outcomes in our study. Each patient ranks these elements in varying levels of importance, making the decision to undergo reconstruction and which procedure to receive a personal one. Our data regarding short term outcomes after reconstruction could serve to better educate and prepare breast cancer patients for the potential post-operative difficulties they may encounter with a specific reconstruction method.

Table 5 Unadjusted complication rates stratified by reconstruction method.

Reconstruction method	Percentage with any complication	Percentage with wound infection	Percentage with prosthesis/ flap failure	Percentage of women who had a flap with flap complications[a]	Non-local/systemic complication[b]	Percentage with a reoperation
Immediate reconstruction						
Tissue expander only (n = 9012)	5.38%	3.43%	0.84%	N/A	1.56%	6.95%*
Free flap (n = 141)	21.99%	6.38%	4.26%	11.35%	14.89%	19.86%
LD flap (n = 264)	10.61%*	5.30%*	0.76%	6.82%	5.30%*	4.92%
Pedicled TRAM flap (n = 277)	18.41%*	10.47%*	5.05%	15.16%*	7.22%	13.00%
Delayed reconstruction						
Tissue expander only (n = 774)	5.30%	3.75%	0.90%	N/A	1.29%	4.65%*
Free flap (n = 468)	18.59%	5.77%	6.20%	12.18%	10.26%	14.32%
LD flap (n = 815)	6.01%*	2.70%*	1.47%	4.42%	2.45%*	6.01%
Pedicled TRAM flap (n = 1331)	12.40%*	5.94%*	3.01%	8.87%*	5.41%	9.24%

* denotes significant difference between immediate and delayed reconstruction outcomes within a specific procedure type, $p \leq .05$.
N/A = not available.
[a] Flap complication is defined as ≥1 of the following: wound infection, wound disruption/dehiscence, graft/flap failure.
[b] Non-local/systemic complication is the equivalent of a medical complication, as defined in our Methods section.

Even though the NSQIP database allows for robust, unbiased, and statistically powerful studies, the study is a reflection of the accuracy of the program's data entry and coding. While we assume minimal differences, there may be discrepancies in training and data entry practice between institutions that result in erroneous input. Additionally, as mentioned in our methods section, some procedure description codes are ambiguous and place limits on patient selection. Specifically, prosthetic cases in this study could have received an acellular dermal sheet as a surgical adjunct, which could have impacted outcomes. Moreover, there are nuances that limit the database's applicability to plastic and reconstructive surgery. First, the database is confined to tracking 30-day postoperative outcomes, eliminating potential evaluation of long term complications such as capsular contracture and implant malposition. Moreover, the database does not account for any aesthetic outcomes, which may be a major reason to consider autologous reconstruction. Additionally, due to the tracking algorithms associated with NSQIP, only radiotherapy received immediately prior to an operation was recorded. It is a generally held belief that autologous reconstruction will be better in a hostile hypovascular environment than prosthetic reconstruction. Hence, there may be a skew in outcomes due to radiotherapy. Certain patient care variables, such as preoperative antibiotics, are not tracked. While it is assumed that preoperative antibiotics are standard of care, there may be some variation in regimens that could impact complication rates. Lastly, the patient populations had known differences in patient demographics. A propensity score helps to dampen the impact of such differences in the regression model, but a randomized controlled trial would have provided the most well balanced, unbiased outcomes data.

Conclusion

Using risk-adjusted models of a large multi-institutional database, we found that — relative to prosthetic reconstruction — autologous reconstruction had higher rates of 30-day overall complications, wound infection, prosthesis/flap failure and reoperation. This may be due, in part, to a concomitant increase in operative time and higher case complexity. Taken with other reports such as NMBRA, this study helps to educate patients and surgeons alike on potential, comparative complications during the perioperative period.

Conflict of interest statement

The authors have no financial disclosures relevant to this paper.

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Ethical approval

De-identified patient information is freely available to all institutional members who comply with the National Surgical Quality Improvement Program (NSQIP) Data Use Agreement. The Data Use Agreement implements the protections by the Health Insurance Portability and

Accountability Act (HIPPA) of 1996 and the NSQIP Hospital Participation Agreement.

Disclosure

The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

References

1. Forouzanfar Mohammad H, Foreman Kyle J, Delossantos Allyne M, et al. Breast and cervical cancer in 187 countries between 1980 and 2010: a systematic analysis. *Lancet* 2011;**378**(9801):1461–84.
2. Kennedy T, Stewart AK, Bilimoria KY, et al. Treatment trends and factors associated with survival in T1aN0 and T1bN0 breast cancer patients. *Ann Surg Oncol* 2007;**14**(10):2918–27.
3. Bransfield DD. Breast cancer and sexual functioning: a review of the literature and implications for future research. *Int J Psychiatry Med* 1982;**12**:197.
4. Silberfarb PM, Maurer LH, Crouthamel CS. Psychosocial aspects of neoplastic disease: I. Functional status of breast cancer patients during different treatment regimens. *Am J Psychiatry* 1980;**137**:450.
5. Asken MJ. Psychoemotional aspects of mastectomy: a review of recent literature. *Am J Psychiatry* 1975;**132**:56.
6. Schain WS. Breast reconstruction: update of psychosocial and pragmatic concerns. *Cancer* 1991;**68**:1170.
7. Rowlan JH, Holland JC, Chaglassian T, Kinne D. Psychological response to breast reconstruction: expectations for and impact on postmastectomy functioning. *Psychosomatics* 1993;**34**:241.
8. Teimourian B, Adham MN. Survey of patient's responses to breast reconstruction. *Ann Plast Surg* 1982;**9**:321.
9. Wilkins EG, Cederna PS, Lowery JC, et al. Prospective analysis of psychosocial outcomes in breast reconstruction: one-year postoperative results from the Michigan Breast Reconstruction Outcome Study. *Plast Reconstr Surg* 2000;**106**(5):1014–25.
10. *National mastectomy and breast reconstruction audit*. United Kingdom: Healthcare Quality Improvement Partnership; 2011.
11. Platt J, Baxter N, Zhong T. Breast reconstruction after mastectomy for breast cancer. *CMAJ* 2011;**183**(18):2109–16.
12. Baxter N, Goel V, Semple JL. Utilization and regional variation of breast reconstruction in Canada. *Plast Reconstr Surg* 2005;**115**(1):338–9.
13. Kruper L, Holt A, Xu XX, et al. Disparities in reconstruction rates after mastectomy: patterns of care and factors associated with the use of breast reconstruction in southern California. *Ann Surg Oncol* 2011;**18**:2158–65.
14. Francis SH, Ruberg RL, Stevenson KB, et al. Independent risk factors for infection in tissue expander breast reconstruction. *Plast Reconstr Surg* 2009;**124**(6):1790–6.
15. Tseng JF, Kronowitz SJ, Sun CC, et al. The effect of ethnicity on immediate reconstruction rates after mastectomy for breast cancer. *Cancer* 2004;**101**:1514–23.
16. Elliott LF, Beegle PH, Hartrampf Jr CR. The lateral transverse thigh free flap: an alternative for autogenous-tissue breast reconstruction. *Plast Reconstr Surg* 1990;**85**(2):169–78.
17. Atisha D, Alderman AK. A systematic review of abdominal wall function following abdominal flaps for postmastectomy breast reconstruction. *Ann Plast Surg* 2009;**63**(2):222–30.
18. Yueh JH, Slavin SA, Adesiyun T, et al. Patient satisfaction in postmastectomy breast reconstruction: a comparative evaluation of DIEP, TRAM, latissimus flap, and implant techniques. *Plast Reconstr Surg* 2010;**125**(6):1585–95.
19. Kroll SS, Baldwin B. A comparison of outcomes using three different methods of breast reconstruction. *Plast Reconstr Surg* 1992;**90**(3):455–62.
20. Craft RO, Colakoglu S, Curtis MS, et al. Patient satisfaction in unilateral and bilateral breast reconstruction. *Plast Reconstr Surg* 2011;**127**(4):1417–24.
21. Veiga DF, Neto MS, Ferreira LM, et al. Quality of life after pedicled TRAM flap delayed breast reconstruction. *Br J Surg* 2004;**57**:252–7.
22. Tonseth KA, Hokland BM, Tindholdt TT, et al. Patient-oriented outcomes after breast reconstruction with deep inferior epigastric perforator flaps. *Scand J Plast Reconstr Surg Hand Surg* 2007;**41**(4):173–7.
23. Lin KY, Johns FR, Gibson J, Long M, Drake DB, Moore MM. An outcome study of breast reconstruction: presurgical identification of risk factors for complications. *Ann Surg Oncol* 2001;**8**(7):586–91.
24. McCarthy CM, Mehrara BJ, Riedel E, et al. Predicting complications following expander/implant breast reconstruction: an outcomes analysis based on preoperative clinical risk. *Plast Reconstr Surg* 2008;**121**(6):1886–92.
25. Parks JR, Hammond SE, Walsh WW, Adams RL, Chandler RG, Luce EA. Human acellular dermis (ACD) vs. No-ACD in tissue expansion breast reconstruction. *Plast Reconstr Surg* 2012. [Epub ahead of print].
26. Leyngold MM, Stutman RL, Khiabani KT, et al. Contributing variables to post mastectomy tissue expander infection. *Breast J* 2012;**18**(4):351–6.
27. Nahabedian MY, Tsangaris T, Momen B, Manson PN. Infectious complications following breast reconstruction with expanders and implants. *Plast Reconstr Surg* 2003;**112**(2):467–76.
28. Disa JJ, Ad-El DD, Cohen SM, Cordeiro PG, Hidalgo DA. The premature removal of tissue expanders in breast reconstruction. *Plast Reconstr Surg* 1999;**104**(6):1662–5.
29. Padubidri AN, Yetman R, Browne E, et al. Complications of postmastectomy breast reconstruction in smokers, exsmokers, and nonsmokers. *Plast Reconstr Surg* 2001;**107**(2):350–1.
30. Khuri SF, Daley J, Henderson W, et al. The Department of Veterans Affairs' NSQIP: the first national, validated, outcome-based, risk-adjusted, and peer-controlled program for the measurement and enhancement of the quality of surgical care. National VA Surgical Quality Improvement Program. *Ann Surg* 1998;**228**(4):491–507.
31. Khuri SF, Daley J, Henderson W, et al. The National Veterans Administration Surgical Risk Study: risk adjustment for the comparative assessment of the quality of surgical care. *J Am Coll Surg* 1995;**180**(5):519–31.
32. Birkmeyer JD, Shahian DM, Dimick JB, et al. Blueprint for a new American College of Surgeons: National Surgical Quality Improvement Program. *J Am Coll Surg* 2008;**5**(207):777–82.
33. D'Agostino R. Tutorial in biostatistic propensity score methods for bias reduction in the comparison of a treatment to a non-randomized control group. *Stat Med* 1998;**17**:2265–81.
34. Benson JR, Jatoi I. The global breast cancer burden. *Future Oncol* 2012;**8**(60):697–702.
35. Panieri E. Breast cancer screening in developing countries. *Best Pract Res Clin Obstet Gynaecol* 2012;**26**(2):283–90.
36. Alderman AK, Wilkins EG, Kim HM, et al. Complications in postmastectomy breast reconstruction: two-year results of the Michigan Breast Reconstruction Outcome Study. *Plast Reconstr Surg* 2002;**109**:2265.
37. Sullivan SR, Fletcher DR, Isom CD, Isik FF. True incidence of all complications following immediate and delayed breast reconstruction. *Plast Reconstr Surg* 2008;**122**(1):19–28.
38. Rusby JE, Waters RA, Nightingale PG, England DW. Immediate breast reconstruction after mastectomy: what are the long-term prospects? *Ann R Coll Surg Engl* 2010;**92**(3):193–7.