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Increasing body mass index increases complications but not failure rates in microvascular breast reconstruction: A retrospective cohort study

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KEYWORDS
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Summary *Background:* Obesity is often considered a relative contra-indication for microvascular autologous breast reconstruction. We hypothesize that although obesity is associated with increased post-operative complications, abdominally based microvascular post mastectomy breast reconstruction can still be achieved with high rates of success.
This study analyses the relationship between increasing body mass index (BMI) and post-operative complications at a high volume specialist centre, with a particular focus on serious complications.
Methods and Results: Nine hundred and sixty patients undergoing 1460 microvascular breast reconstructions were included in the study. Obese patients (BMI $\geq$ 30 kg/m^2) accounted for 37.7% of the cohort and were more likely to have co-morbidities, a history of smoking and bilateral reconstruction. Post-operative surgical complications occurred in 156 patients (16.3%) and medical complications occurred in 10 patients (1.0%). There was no significant difference between the flap failure rates in patients with normal BMI $<$ 25 kg/m^2 (1.2% of patients, 0.9% of flaps) and obese patients (1.9% of patients, 1.2% of flaps, $p = 0.07$). Obesity was an independent predictor of overall complications (OR 1.7, CI 0.81-2.74, $p = 0.001$) but not medical complications or flap failure (OR 1.3, CI 0.43-5.8, $p = 0.161$ and OR 1.2, CI 0.66-6.1, $p = 0.091$). There was a linear relationship between increasing BMI and overall complication rates, but serious complications remained uncommon even in morbidly obese patients.

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Conclusion: This large single-centre study demonstrates that although obesity increases the risk of overall complications, microvascular breast reconstruction can be safely and successfully achieved in the vast majority of patients. Obese patients should be carefully counselled pre-operatively, but increased BMI should not be considered a contra-indication for microvascular breast reconstruction.

Introduction

Obesity rates are increasing worldwide, with more than 36% of adults in the US now obese and rates expected to rise to 48% by 2030. Obesity is a well-recognized risk factor for breast cancer in postmenopausal women, and accordingly, an increasing proportion of women who undergo mastectomy are obese.[1]

Post mastectomy breast reconstruction (PMBR) confers clear, quantifiable psychosexual benefits and has become an important part of breast cancer treatment for many women.[2,3] However, breast reconstruction is an entirely elective procedure and as such the associated risks and benefits must be carefully balanced. Obesity is associated with increased post-operative complication rates in many surgical procedures including breast cancer surgery.[4] Studies have indicated that obese women are at high risk for post-operative complications following PMBR, and this may result in decreased reconstruction rates in patients with high body mass indices (BMIs).[5-7] The increased risk of complications applies to both implant-based and autologous reconstruction techniques, and there is significant disagreement in the current literature regarding which modality represents a safer option in obese women.[8-10] As microvascular autologous reconstruction is a complex and lengthy procedure, many surgeons consider obesity a relative contraindication. However, microvascular techniques using excess abdominal tissue often represent the best option for achieving natural and aesthetically pleasing reconstructions in obese women. Studies suggest that patient reported satisfaction following microvascular breast reconstruction is independent of BMI.[11,12]

Although many studies have identified obesity as an independent risk factor for complications following microvascular reconstruction, the exact nature of the associated complications and the impact on successful reconstruction is poorly defined. As obesity is a modifiable risk factor, it is essential that surgeons have a thorough understanding of the effects of increasing BMI on surgical outcomes so that patients can be appropriately counselled pre-operatively. We hypothesize that although obesity is associated with increased post-operative complications, microvascular PMBR can still be achieved with high rates of success.

The purpose of this study is to characterize the relationship between increasing BMI and adverse outcomes following microvascular autologous breast reconstruction at a single specialist centre with a particular focus on serious complications and reconstructive failure.

Materials and methods

Data source and collection

Institutional Research Ethics Board approval was obtained for this study. All patients who underwent microvascular breast reconstruction using an abdominal free flap at the Breast Restoration Program, University Health Network, Toronto, Canada between January 2009 and February 2018 were identified from a prospectively maintained institutional database, and patients with complete datasets were eligible for inclusion in the study. Data were collected on patient demographics (age, BMI and smoking status), comorbidities, surgical procedures (timing and laterality of reconstruction) and adjuvant treatment (chemotherapy and radiation). Details of post-operative complications occurring within 60 days of surgery were collected and categorized. Complications were defined as any medical or surgical events that were not part of the expected post-operative course, such as reoperation, readmission, wound dehiscence, surgical site infection, cardiovascular, pulmonary or cerebrovascular events and thromboembolic disease. Total flap loss was defined as a complete failure where the flap in its entirety was removed. Cases where a portion of the flap ($\geq$ 20%) did not survive and required debridement or other intervention in either the office or operating room were considered partial failures.

Patients were stratified by BMI into normal (BMI $<$25 kg/m^2), overweight (BMI 25–29.9 kg/m^2) and obese (BMI $\geq$ 30 kg/m^2) groups. The obese group was also subdivided according to the World Health Organisation (WHO) classification of obesity (Class I BMI 30–34.9 kg/m^2, Class II BMI 35–39.9 kg/m^2 and Class III $\geq$ 40 kg/m^2).

Statistical analysis

Statistical analyses were performed using R version 3.0.2. Mean, standard deviation (SD) and range of all continuous variables were calculated and compared using one-way analysis of variance and post-hoc Tukey's test. The frequencies of all categorical variables were calculated and compared using Pearson's chi-squared and Fisher's exact tests. Multivariable analysis was conducted using logistic regression to determine independent predictors of post-operative complications and to examine the relationship between obesity and specific adverse outcomes. Multivariate models were constructed using backward stepwise selection. The

Table 1 Characteristics of the cohort stratified by body mass index (BMI).

	Normal Weight	Overweight	Obese	*P* value
BMI	$<25\,kg/m^2$	25-29.9 kg/m^2	$\geq 30\,kg/m^2$	
N (%)	243 (25.3%)	355 (37.0%)	362 (37.7%)	
	Mean +/− SD (Range)	**Mean +/− SD (Range)**	**Mean +/− SD (Range)**	
BMI	23.02 +/− 1.43 (19.06 - 24.99)	27.6 +/− 1.24 (25.0 - 29.9)	33.44 +/− 3.26 (30.0 - 46.1)	0.001*
Age	50.09 +/− 7.86 (30 - 71)	50.68 +/− 8.72 (29 - 77)	53.37 +/− 9.58 (24 - 74)	0.86
	N (%)	**N(%)**	**N(%)**	
Comorbidity	52 (21.4%)	98 (27.6%)	141 (38.9%)	0.02*
Active Smoker	14 (5.8%)	21 (5.9%)	17 (4.6%)	0.09
Ex-smoker	32 (13.2%)	65 (18.3%)	82 (22.65%)	0.04*
Bilateral	97 (39.9%)	192 (54.1%)	211 (58.3%)	0.03*
Immediate	112 (46.1%)	138 (38.8%)	142 (39.2%)	0.72
Chemotherapy	131 (53.9%)	194 (54.6%)	196 (54.1%)	0.56
Radiation	114 (46.9%)	187 (52.6%)	185 (51.1%)	0.09
Hormone	102 (41.9%)	176 (49.6%)	180 (49.7%)	0.07

* Denotes statistical significance.

Table 2 Final multivariate logistic regression model. *Denotes statistical significance.

	Odds Ratio (Confidence Interval)	*P* value
BMI $\geq 30\,kg/m^2$	1.52 (0.81-2.32)	0.002*
Age $\geq$ 65 years	0.96 (0.42-1.11)	0.294
Comorbidities	1.46 (0.71-2.54)	0.058
Active Smoker	1.12 (0.59-1.96)	0.081
Immediate Reconstruction	1.49 (0.94-3.12)	0.008*
Bilateral Reconstruction	1.04 (0.51-1.82)	0.412
Previous Radiation	1.31 (0.72-2.06)	0.061

variables were tested for correlation prior to inclusion in the model. In addition, interaction terms that were included to ensure interaction between variables did not significantly affect the accuracy of the final model. The Hosmer-Lemeshow test and c-statistic were used to assess the goodness of fit and predictive power of the models, respectively.

Results

One thousand and forty nine patients underwent microvascular breast reconstruction using deep inferior epigastric artery perforator flaps during the study period. Nine hundred and sixty patients who underwent 1460 breast reconstructions had complete datasets and were included in the study.

The majority of the patients in the cohort were overweight (37.0% BMI 25-29.9 kg/m^2) or obese (37.7% BMI $\geq$ 30 kg/m^2). The demographics of the cohort are summarized in Table 1. Obese patients were significantly more likely to have comorbidities ($p = 0.02$), a history of smoking ($p = 0.04$) and bilateral reconstruction ($p = 0.03$) compared to patients with normal BMI (Table 1).

Multivariable logistic regression models were constructed to identify independent predictors of complications. The final multivariate model (Table 2) confirmed an independent association between complications and increased BMI (Odds Ratio [OR] 1.51, confidence interval [CI] 0.81-2.32, $p = 0.002$) and immediate reconstruction (OR 1.49, CI 0.94 - 3.12, $p = 0.008$). There was no significant correlation between variables or interaction effect observed in the model ($p > 0.05$), and the model showed good fit (Hosmer-Lemeshow $p = 0.58$) and acceptable predictive power (c-statistic 0.69).

One hundred and fifty six (16.3%) patients experienced a surgical complication post-operatively while 10 (1.0%) had medical complications. The nature of the complications observed in each BMI group is summarized in Table 3. There was no significant difference between complication rates in overweight (BMI 25-29.9 kg / m^2) patients and those with normal BMI ($<25\,kg/m^2$). Obese patients (BMI $\geq$ 30 kg/m^2) had significantly higher rates of complications than patients with normal BMI (23.2% versus 13.1%, $p = 0.002$, Table 4). Obese patients also had higher re-operation rates (11.3% versus 6.9%, $p = 0.04$). There was no significant difference between medical complication rates in obese patients and those with normal BMI (1.6% versus 0.4%, $p = 0.62$). Obesity was independently associated with complications in general (OR 1.7, CI 0.81-2.74, $p = 0.001$) but not re-operation or medical complications (Table 4).

Total flap failure occurred in 13 cases (1.3% of patients, 0.9% of flaps). There was no significant difference between the flap failure rates in patients with BMI $< 25\,kg/m^2$ (1.2% of patients, 0.9% of flaps) and obese patients (1.9% of patients, 1.2% of flaps, $p = 0.07$). Partial flap failure occurred in 10 cases (1% of patients, 0.7% of flaps) with no significant increase in the obese group (1.4% of patients, 0.8% of flaps, $p = 0.09$). There was no significant association between

Table 3 Surgical and medical post-operative complications observed in the cohort.

	Normal ($N=243$)	Overweight ($N=355$)	Obese ($N=362$)	Total ($N=960$)
Surgical	31 (12.7%)	47 (13.2%)	78 (21.5%)	156 (16.3%)
Dehiscence	5 (2.0%)	10 (2.8%)	23 (6.3%)	38 (3.9%)
Infection	7 (2.9%)	11(3.1%)	21 (5.8%)	39 (4.0%)
Hematoma	10 (4.1%)	15 (4.2%)	17 (4.7%)	42 (4.4%)
Microsurgical	9 (3.7%)	11 (3.1%)	17 (4.7%)	37 (3.8%)
Medical	1 (0.4%)	3 (0.8%)	6 (1.7%)	10 (1.0%)
PE / DVT	1 (0.4%)	2 (0.5%)	2 (0.6%)	7 (0.5%)
Cardiac	0	1 (0.3%)	3 (0.8%)	2 (0.2%)
UTI	0	0	1 (0.3%)	1 (0.1%)

PE; pulmonary embolus, DVT; deep vein thrombosis, UTI; urinary tract infection.

Table 4 Complication rates stratified by weight and multivariate logistic regression demonstrating relationship between obesity and complications.

	Normal	Overweight	All Obese	OR (CI)
Total 960	243 (25.3%)	355 (37.0%)	362 (37.7%)	
Total Complications	32 (13.1%)	50 (14.0%)	84 (23.2%)	1.7 (0.81-2.74) $p=0.001$*
***Re*-operation**	17 (6.9%)	25 (7.0%)	41 (11.3%)	1.4 (0.69-3.8) $p=0.062$
Total Failure	3 (1.2%)	3 (0.8%)	7 (1.9%)	1.2 (0.66-16.1) $p=0.091$
Partial Failure	2 (0.8%)	3 (0.8%)	5 (1.4%)	1.08 (0.92-9.81) $p=0.22$
Medical Complications	1 (0.4%)	3 (0.8%)	6 (1.6%)	1.3 (0.43-15.8) $p=0.161$

* Denotes statistical significance. *OR (CI); odds ratio (confidence interval).*

Table 5 Complication rates and multivariate logistic regression model for any complication for each obese class.

	Obese I	Obese II	Obese III	*P* value#
Total (362)	248 (25.0%)	82 (8.5%)	32 (3.3%)	
Total Complications	54 (21.7%)	21 (25.6%)	11 (34.4%)	0.008*
***Re*-operation**	26 (10.5%)	11 (13.4%)	4 (12.5%)	0.09
Total Failure	4 (1.6%)	2 (2.4%)	1 (3.2%)	0.06
Partial Failure	4 (1.6%)	3 (3.6%)	0 (0%)	0.40
Medical complications	5 (2.0%)	1 (1.2%)	0 (0%)	0.34
Risk of complications	1.62 (0.34-3.88)	1.88 (0.84-4.11)	2.04 (1.8-8.92)	
OR (CI)^	$p=0.009$*	$p=0.004$*	$p=0.001$*	

\# obese III compared to obese I.
* Denotes statistical significance.
^ Multivariate model includes BMI, comorbidities, timing of reconstruction, smoking and radiation.*OR(CI); odds ratio (confidence interval).*

obesity and total (OR 1.2, CI 0.66-16.1, $p=0.091$) or partial (OR 1.08, CI 0.92 - 9.81, $p=0.22$) flap loss (Table 4).

Sub analysis of obese patients revealed a linear relationship between overall complication rates and increasing BMI (Table 5, Figure 1). Class III obese patients had significantly higher rates of complications (34.4%) than patients with Class II (25.6%, $p=0.04$) or Class I obesity (21.7%, $p=0.008$). The rates of total or partial flap failure did not differ significantly between the groups, but the small numbers of events limit this analysis.

Discussion

This is one of the largest single-centre studies examining the effects of BMI in microvascular breast reconstruction. This study demonstrates that although overall complication rates are higher in obese women, reconstructive failure rates remain low. In addition, medical complications are rare even in morbidly obese patients. These findings confirm that microvascular breast reconstruction is safe and successful in the vast majority of patients irrespective of BMI.

Our results are in keeping with other studies that demonstrate increasing overall complication rates in obese patients.[7,13-19] Nelson et al. identified a linear relationship between increasing BMI and wound complications, following microvascular breast reconstruction in a series of 682 patients.[16] This correlates with our observation that obese patients were more likely to develop wound infection and dehiscence, and these complications more commonly resulted in surgical intervention in this group.

Conversely, our finding that flap failure rates do not increase significantly in obese patients is contrary to many

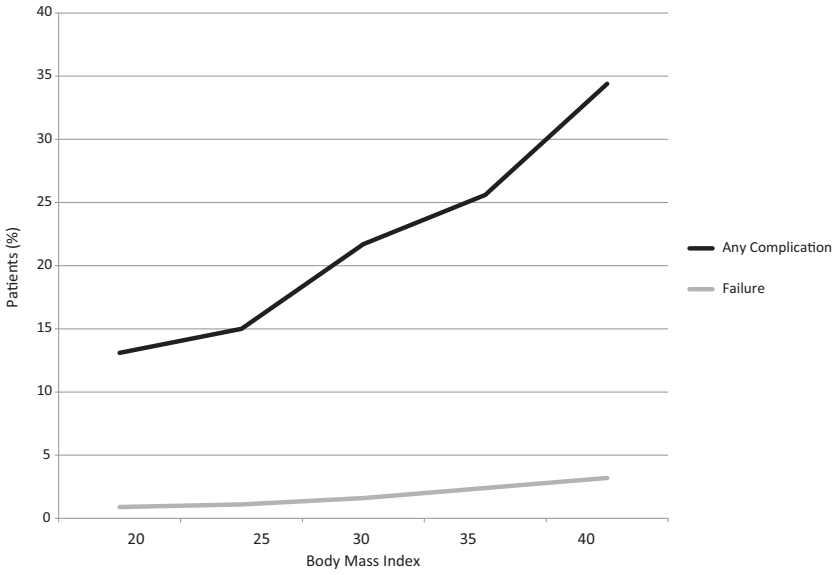

Figure 1 Complication rates increase in a linear fashion with increasing BMI, but flap failure rates remain low and relatively stable.

other reports.[13-15] Seidenstuecker et al. reported significantly higher flap loss rates in obese patients, and Chang et al. recommended that free flap breast reconstruction should be avoided in morbidly obese patients due to high risk of failure.[20,21] Mehrara et al. also found obesity to be a major predictor of flap complications.[22] Similarly, our finding that there was no significant increase in medical complications in obese patients is at odds with other studies.[5,17]

This study was conducted at a single specialist centre. We have considerable experience with microvascular PMBR in obese patients, illustrated by the fact that more than one third of the study cohort had a BMI in excess of 30 kg/m^2. This contrasts with the relatively small proportion of obese women included in some previous studies.[20-22] This may contribute to the observed low rate of medical complications and reconstructive failure, and we acknowledge that these results may not apply to other centres. At our unit, we strive to keep operating times relatively short and have a restrictive approach to perioperative intravenous fluids and blood transfusions.[23,24] We use a barbed-suture progressive tension technique for abdominal donor site closure. We encourage early mobilization on the first post-operative day and discharge from hospital on the third or fourth post-operative day in unilateral and bilateral cases, respectively. In addition, all patients receive both mechanical and pharmacological thromboembolic prophylaxis in the perioperative period.

Our experience and these modifications in practice may explain our findings that medical complication and flap failure rates did not increase significantly in obese patients at our institution. Likewise, many of the previous studies reporting associations between high BMI and medical complications are based on aggregate data and do not report the volume or clinical caseload of individual institutions.[17,25] Complication rates following microvascular PMBR can vary widely between centres, and microvascular success rates are linked to institutional experience and volumes.[26] Reports from a number of other high volume microsurgical centres support our findings that obesity is a risk factor for complications in general but not flap failure.[8,27,28]

We do not have a strict BMI cut off for patients who request microvascular PMBR. However, we recognise that overall complication rates can be very high in morbidly obese women, and these patients must be provided with accurate information and extensively counselled preoperatively to assist them in the decision making process.[29] In addition, we have previously demonstrated that high BMI can have significant synergistic interaction with other risk factors such as smoking and immediate reconstruction. (Roy et al. 2019, In Press) Accordingly, we consider each patient individually and evaluate their personal risk profile as part of the pre-operative assessment. The findings of this study will aid pre-operative discussions as they clearly illustrate how increasing BMI is directly linked to increased postoperative complications. This may motivate some patients to lose weight prior to reconstruction to optimize safety and outcomes of surgery.

We acknowledge the limitations of our study. Although most of the data were collected prospectively, we relied on retrospective chart review for some information on complications. There may be an element of subjectivity with regard to reporting of minor complications, but serious events such re-operation, partial or total flap failure and medical events are always accurately recorded. The low flap failure rates in the subgroups may mean the study is underpowered to detect significant differences, but this problem is common to all studies of rare events. This study only considered medical and surgical complications occurring in the acute post-operative period and did not include long-term complications such as fat necrosis and abdominal donor site functional morbidity, which may be increased in obese women. We considered comorbidities collectively and did not examine the impact of specific conditions such as diabetes on post-operative outcomes. All patients in this study had an abdominal flap, which is the most common

microvascular technique in obese women, but we recognize that these results may not apply to other free flaps.

Conclusion

This large single centre study demonstrates that obese patients have a higher risk of complications following microvascular breast reconstruction. Risk increases with increasing BMI, but medical complication and flap failure rate remain low. Obesity alone should not be considered a contraindication to microvascular reconstruction, but patients should be carefully counselled on their increased risk for complications.

Conflicts of interest

None

Funding

None

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