Impact of Obesity on Outcomes in Breast Reconstruction: A Systematic Review and Meta-Analysis

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Abstract

Background Increased rates of both breast cancer and obesity have resulted in more obese women seeking breast reconstruction. Studies demonstrate that these women are at increased risk for perioperative complications. A systematic review was conducted to assess the outcomes in obese women who underwent breast reconstruction following mastectomy.
Methods Cochrane, PUBMED, and EMBASE electronic databases were screened and data were extracted from included studies. The clinical outcomes assessed were surgical complications, medical complications, length of postoperative hospital stay, reoperation rate, and patient satisfaction.
Results Out of 33 studies met the inclusion criteria for the review and 29 provided enough data to be included in the meta-analysis (71,368 patients, 20,061 of whom were obese). Obese women (body mass index > 30 kg/m^2) were 2.29 times more likely to experience surgical complications (95% confidence interval (CI) 2.19–2.39; $p < 0.00001$), 2.89 times more likely to have medical complications (95% CI 2.50–3.35; $p < 0.00001$), and had a 1.91 times higher risk of reoperation (95% CI 1.75–2.07; $p < 0.00001$). The most common complication, wound dehiscence, was 2.51 times more likely in obese women (95% CI 1.80–3.52; $p < 0.00001$). Sensitivity analysis confirmed that obese women were more likely to experience surgical complications (risk ratio 2.36, 95% CI 2.22–2.52; $p < 0.00001$).
Conclusions This study provides evidence that obesity increases the risk of complications in both implant-based and autologous reconstruction. Additional prospective and observational studies are needed to determine if the weight reduction prior to reconstruction reduces the perioperative risks associated with obesity.

Keywords
- plastic surgery
- breast reconstruction
- obesity
- breast surgery complication
- breast cancer

Obesity has reached global epidemic proportions and is imposing a significant public health concern. The most recent data by the World Health Organization (WHO), which defines obesity as having a body mass index (BMI) of ≥30 kg/m^2, states that 13% of the world's adult population is obese.[1]

Obesity rates are even higher in women with 40% of the global female population being overweight and 15% obese.[1] Additionally, breast cancer is on the rise, accounting for ~30% of all newly reported cancer cases in women.[2,3] Consequently, it is likely that the proportion of women seeking

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breast reconstruction in the obese population will increase,[4] and it is imperative to evaluate the efficacy of available reconstructive techniques in these patients, as well as the rates of complications associated with these procedures.

It is well known that obese women have an increased risk for perioperative complications in various surgical procedures, including breast reconstruction.[5] The higher risk of medical complications in these patients creates unique challenges to health care systems.[6] Research suggests that obese women are also more likely to experience complications in both autologous and prosthetic breast reconstruction, with obese women demonstrating complication rates of 25% in comparison to 14% in nonobese individuals.[7]

Although it is believed that a high BMI (>30 kg/m^2) increases the risk of complications in breast reconstruction, a detailed comparison of the risks associated with the available reconstructive options has been elusive. Improved understanding of the effects of weight on surgical outcomes will enable health care professionals to identify the best strategy for each individual patient to minimize adverse effects. This review seeks to analyze and summarize the literature to provide a better understanding of the risks associated with breast reconstruction in obese women.

Patients and Methods

Selection Criteria

This review was conducted in line with the Cochrane Handbook for Systematic Reviews of Interventions version 5.1.0.[8] A protocol was published a priori[9] and the review was registered on the Research Registry UIN: reviewregistry191 (http://www.researchregistry.com). Cochrane, PUBMED, and EMBASE electronic databases were screened from their inception to 1 June 2016 using the keywords: obesity, weight, BMI, breast reconstruction, breast autologous tissue flap, breast free flap, transverse rectus abdominis myocutaneous (TRAM) flap, free muscle-sparing TRAM flap, pedicled TRAM flap, deep inferior epigastric perforators (DIEP) flap, latissimus dorsi myocutaneous (LDM) flap, superficial inferior epigastric artery flap (SIEA), breast tissue expander, and breast implant. The search format was tailored to the syntax of each database.

The inclusion criteria were cohort studies, case series, randomized controlled trials, and case–control studies reporting on breast reconstruction outcomes in obese women (BMI > 30 kg/m^2) who underwent mastectomy for the treatment of breast cancer. The following surgical interventions were considered: prosthetic implants, including acellular dermal matrix use and tissue expander, and autologous reconstruction, including LDM flaps, pedicled, free and muscle sparing TRAM flaps, SIEA flaps, and DIEP flaps. These interventions were selected on the basis of the fact that they are the most commonly used reconstructive techniques, allowing us to set some limits to our search strategy. Given the inclusion of generic terms like breast reconstruction, we feel that the search strategy would be comprehensive. The inclusion and exclusion criteria are listed in ►**Table 1**.

The article selection process was a two-stage process completed by two reviewers (AP and BAS). Data were extracted into Microsoft Excel 2011 (Microsoft, Redmond, WA). First, the citation, title, and abstracts of studies from the search were independently screened to identify potentially relevant studies. The full manuscripts of articles that passed through this stage were then assessed for eligibility. Any inconsistency between the two reviewers was resolved by a third reviewer who was consulted to achieve consensus (DPO).

Quality Assessment

The grading of recommendation assessment, development, and evaluation (GRADE) guidelines were used to assess the methodological quality of the studies.[10]

Statistical Analysis

This meta-analysis was performed using RevMan (Review manager V5.2.6) in line with the Cochrane Collaboration and the Quality of Reporting of Meta-analyses guidelines.[11] The risk ratio (RR) were calculated using the fixed-effects model and heterogeneity was quantified using the I^2 and χ^2 statistics with the corresponding *p*-values.

Subgroup Analysis

Surgical complications were subdivided into wound infection and dehiscence, hematoma, seroma, fat necrosis, partial and total flap failure, and hernia occurrence. Additional analyses were performed to investigate the difference between surgical complication occurrence in implant versus autologous reconstruction and the difference between the nonobese population, and obesity Class I (30–34.9 kg/m^2), II (35–39.9 kg/m^2), and III (>40 kg/m^2) as defined by WHO.[12]

Sensitivity Analysis

A sensitivity analysis was performed to assess whether the outcomes were altered when the analysis was restricted to higher quality studies.

Results

Primary Studies Included in the Literature Review

A search of PUBMED yielded 102 articles and Embase yielded another 146 potentially relevant publications. No additional articles were identified from the Cochrane database (►**Fig. 1**). Of the 248 studies identified, 125 were excluded on the basis of their title, and 79 were based on their abstract. Full manuscripts were evaluated for 44 publications but only 33 fulfilled the entry criteria.[7,13–44] Eleven papers were excluded because: (a) they did not provide appropriate numerical data necessary for statistical analysis[45–50] and (b) they used the same patient population in different studies.[51–55] In cases utilizing the same population with an overlapping study period, only the study with the largest number of patients was included.

Main Study Characteristics and Methodological Quality Assessment

Of the 33 included studies only three were prospective (►**Table 2**). All studies were case series and had a level of

Table 1 Inclusion and exclusion criteria

Inclusion criteria
Cohort studies, case series, randomized controlled trials, and case–control studies
Prospective and retrospective studies
Patients who underwent breast reconstruction following a mastectomy for the treatment of breast cancer
Female patients of any age
Patients that underwent prosthetic implant (saline or silicone) or autologous tissue flap (TRAM flap, pedicled TRAM flap, free muscle-sparing TRAM flap, LDM flap, DIEP flap, SIEA flap) breast reconstruction
At least one primary outcome reported
Exclusion criteria
Unpublished trials and reports, case reports, duplicate studies, cost-effectiveness studies, and studies that do not provide the original data such systematic reviews, meta-analyses, editorials, discussions, commentaries and letters
Non–English language studies
Studies conducted on cadavers or animals
Studies conducted on male or transgender patients
Studies with no data on complications
Studies that used combined techniques
Studies that do not indicate a reason for the procedure
Patients who underwent breast reconstruction for aesthetic purposes or for traumatic breast defects
Studies that did not specify the number of patients

Abbreviations: DIEP, deep inferior epigastric perforators; LDM, latissimus dorsi myocutaneous; SIEA, superficial inferior epigastric artery flap; TRAM, transverse rectus abdominis myocutaneous.

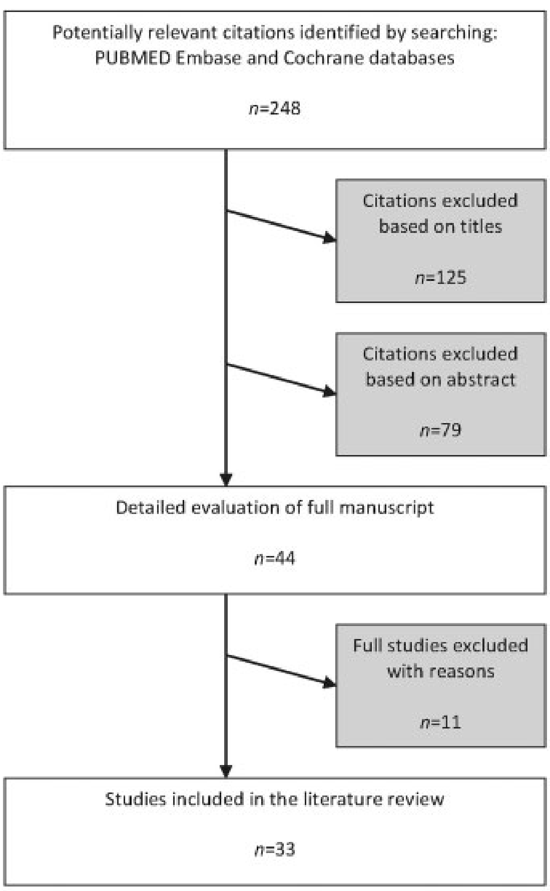


Fig. 1 The selection process of the studies included in the literature review.

evidence (LoE) of 4 as defined by the Oxford Centre for Evidence-Based Medicine.[56] No randomized controlled trials were found. Eighteen studies were specifically designed to investigate the effect BMI has on breast reconstruction,[7,13,15–19,23,25,26,30–33,38,42–44] whereas 15 studies investigated general risk factors, one of which was obesity.[14,20–22,24,27–29,34–37,39–41] Numerical data for meta-analysis could be extracted from 29 papers, six of which investigated prosthetic reconstruction,[7,13,14,22,27,28] 22 investigated autologous reconstruction,[15,18–21,23,25,26,29–37,39–43] and five looked at both.[16,17,24,38,44] Two studies presented data only from obese patients, comparing morbidly with non-morbidly obese patients, but were included in our meta-analysis as the prevalence of complications in these studies was not significantly different from that in other studies.[30,31] Fourteen of 29 studies were of low or very low quality on the GRADE scale. Fifteen studies that were comparative were deemed moderate quality.[13,15,17,18,23,25,26,30–34,36,39,42]

Definitions of Outcome Measures

Surgical Complications

This outcome was reported in 30 studies.[7,13–20,22–37,39–43] Wound infection was investigated in 25 studies,[7,13,15–18,20,22–33,35,39–43] wound dehiscence in 12,[13,16–18,20,22,24,27,28,30,32,36] abdominal hernia in 14,[15,18,23,29–31,34,36,37,39–43] hematoma in 17,[7,13,15,17,18,22,26,29,30,32,33,35,39–43] seroma in 18,[7,13,15,17,18,22,23,25,26 29–35,41,42] flap failure in 23,[7,15–20,22–26,29–35,40–43] and fat necrosis in 17 studies.[15,17,18,23,25,26,29–32,35,37,39–43]

Table 2 Studies included in the literature review

Study	Year	Country[a]	Type of study	Reconstructive technique	No. of patients	Outcomes
Huo et al	2016	USA	Retrospective	Autologous	549	Surgical
Sinha et al	2016	Australia	Retrospective	DIEP, msTRAM, SIEA	29	Surgical, medical, reoperation, satisfaction
Alipour et al	2015	Iran	Retrospective	TRAM	14	Surgical, reoperation
Massenburg et al	2015	USA	Retrospective	Pedicled and free TRAM, LD	2,433	Surgical, medical
Mennie et al	2015	UK	Retrospective	Pedicled and free TRAM, DIEP	208	Reoperation
Selber et al	2015	USA	Retrospective	ADM	94	Surgical
Fischer et al	2014	USA	Retrospective	TRAM, DIEP, SIEA	272	Surgical, medical, length of stay
Fischer et al	2014	USA	Retrospective	Implant, TE, pedicled and free TRAM, LD	4,321	Surgical, medical, reoperation
Nelson et al	2014	USA	Prospective	Autologous	57	Surgical, medical, reoperation
Nguyen et al	2014	USA	Retrospective	TE, implant	175	Surgical, reoperation
Ozturk et al	2014	USA	Retrospective	TRAM	63	Surgical, medical, reoperation
Wink et al	2014	USA	Retrospective	Implant	374	Surgical, medical, reoperation
Fischer et al	2013	USA	Retrospective	Implant	3,741	Surgical, medical, reoperation
Fischer et al	2013	USA	Retrospective	TE	2,390	Surgical, reoperation
Hanwright et al	2013	USA	Retrospective	TE, pedicled and free TRAM, LD flap	3,636	Surgical, medical, reoperation
Ireton et al	2013	USA	Retrospective	Pedicled TRAM	21	Surgical
Garvey et al	2012	USA	Retrospective	Implant, TE, msTRAM, DIEP, SIEA	700	Surgical, reoperation
Momeni et al	2012	USA	Retrospective	DIEP, msTRAM, SIEA	28	Surgical, medical, length of stay
Ochoa et al	2012	USA	Retrospective	DIEP	258	Surgical
Yezhelyev et al	2012	USA	Retrospective	LDF	103	Surgical
Seidenstuecker et al	2011	Germany	Prospective	DIEP, msTRAM	79	Surgical
Appleton et al	2010	Canada	Retrospective	DIEP	39	Surgical, medical
Rossetto et al	2010	Brazil	Retrospective	TRAM	39	Surgical
Wan et al	2010	USA	Retrospective	DIEP, msTRAM	103	Surgical
Atisha et al	2007	USA	Retrospective	Implant, TE, pedicled and free TRAM	47	Satisfaction
Greco et al	2007	USA	Retrospective	Autologous	62	Surgical, reoperation
McCarthy et al	2007	USA	Retrospective	Implant, TE	110	Surgical
Mehrara et al	2006	USA	Retrospective	Free TRAM	85	Surgical, medical, reoperation
Selber et al	2006	USA	Retrospective	Free TRAM	80	Surgical
Spear et al	2005	USA	Retrospective	TRAM	30	Surgical, medical
Moran et al	2001	USA	Retrospective	TRAM	114	Surgical, medical
Kulkarni et al	2001	USA	Retrospective	Implant, autologous	53	Satisfaction
Chang et al	2000	USA	Prospective	Free TRAM	64	Surgical

Abbreviations: ADM, acellular dermal matrix; DIEP, deep inferior epigastric artery perforator; LD, Latissimus Dorsi; MS, muscle-sparing; SIEA, superficial inferior epigastric artery; TE, tissue expander; TRAM, transverse rectus abdominis myocutaneous.
[a]Institution of lead author.

Medical Complications

Medical complications were reported in 14 studies.[16,18,20,23–28,31,35,40,42,43] Ten studies included deep venous thrombosis (DVT) in their definition[16,18,20,23,24,26,27,40,42,43] and seven studies included pulmonary embolism (PE).[16,18,20,23,24,27,42] Four studies included any National Surgical Quality Improvement Program-defined endpoints such as PE, myocardial infarction, pneumonia, urinary tract infection, sepsis, stroke, and coma in their definition.[16,20,24,27]

Length of Postoperative Hospital Stay

This was reported in four studies which defined the length of stay in days.[23,26,31,43] All four studies were limited to autologous reconstruction.

Reoperation

This was reported in 12 studies.[13,16,18,21,24–28,30,39,40] Reoperation was defined in numerous ways, for example, two studies defined it as unplanned return to the operating room within 30 days.[24,27] One study provided four reasons for reoperation: tissue expander explantation, tissue expander exchange, conversion to autologous reconstruction, and ultimate failure of reconstruction.[13] Another focused on hernia repair.[21] For the purpose of this study, any reason for return to the operating room was classified as reoperation.

Patient Satisfaction

Patient satisfaction was reported in three studies[18,38,44] and two of these assessed it using the BREAST-Q, a module measuring postreconstruction satisfaction on six subscales: (1) satisfaction with breasts; (2) psychosocial well-being; (3) sexual well-being; (4) physical well-being with respect to chest/abdomen donor site; (5) satisfaction with outcome; and (6) satisfaction with information provision.[18,44] The third study used a module, which assessed (1) general satisfaction with the treatment process including information provision, decision making and surgery and (2) aesthetic satisfaction in terms of breast contour and softness.[38]

Results for the Overall Meta-Analysis

The 29 studies that were analyzed involved 71,368 patients, including 20,061 obese patients. ►**Tables 3**, **4**, and **5** summarize the results of the primary outcomes of interest. Overall, obese women were more likely to experience surgical (RR 2.29, 95% CI 2.19–2.39; $p < 0.00001$) and medical complications (RR 2.89, 95% CI 2.50–3.35; $p < 0.00001$) and had a higher chance of returning to the operating room (RR 1.91, 95% CI 1.75–2.07; $p < 0.00001$).

Subgroup Analysis

►**Table 6** shows the subgroup analysis for surgical complications. Obese women were more likely to experience fat necrosis (RR 1.65, 95% CI 1.31–2.07; $p < 0.0001$), seroma (RR 1.96, 95% CI 1.57–2.45; $p < 0.00001$), partial flap failure (RR 1.60, 95% CI 1.06–2.41; $p = 0.03$), total flap failure (RR 1.97, 95% CI 1.34–2.91; $p = 0.0006$), wound dehiscence (RR 2.51, 95% CI 1.80–3.52; $p < 0.00001$), wound infection (RR 2.34, 95% CI 2.03–2.69; $p < 0.00001$), and hernia (RR 1.67, 95% CI 1.15–2.43; $p = 0.007$). No significant difference was found for the occurrence of hematoma.

Subgroup analysis for type of reconstruction (►**Tables 7** and **8**) showed that obese women were more likely to experience surgical complications during both implant (RR 2.64, 95% CI 2.25–3.09; $p < 0.00001$) and autologous reconstruction (RR 2.59, 95% CI 2.27–2.55; $p < 0.00001$).

Subgroup analysis for surgical complications in the different classes of obesity was based on four studies, two of which looked at flap complications[23,32] and two at implant failure.[27,28] Class II obese patients (RR 1.84, 95% CI 1.56–2.17; $p < 0.00001$) were more likely to develop surgical complications than Class I (RR 1.32, 95% CI 1.15–1.50; $p < 0.0001$) or III patients (RR 1.66, 95% CI 1.36–2.03; $p < 0.00001$) undergoing reconstruction (►**Table 9**). Class III patients were more likely to develop complications than Class I patients. Three of the four studies included in this subgroup analysis showed these results.[27,28,32]

Subgroup analysis for medical complications was not possible as the majority of papers gave the overall number of medical complications, without distinguishing the specific complication.[18,24,25,31] As only two papers provided numbers for specific medical complications the data were deemed inadequate for subgroup analysis.[16,23]

Sensitivity Analysis

When performing the meta-analysis with just the comparative studies, again the group of obese women was more likely to experience surgical complications (RR 2.36, 95% CI 2.22–2.52; $p < 0.00001$) and the RR was comparable to the analysis with all studies (►**Table 10**). A summary of the RRs of all outcomes is presented in ►**Table 11**.

Discussion

Main Findings

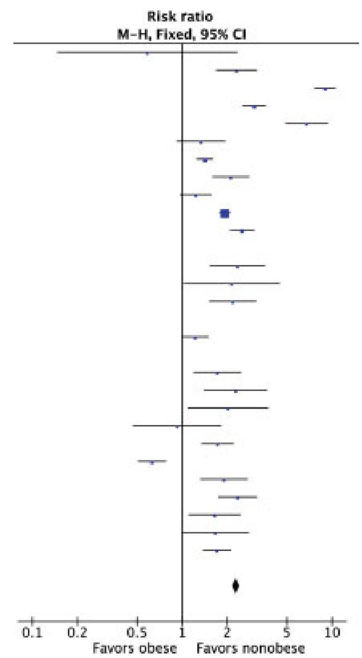
Surgical Complications

Consistent with this meta-analysis, there is a well-documented correlation between obesity and the development of both surgical and medical complications in the perioperative period. Obesity increases the risk for complications by influencing the normal physiology through various mechanisms. For example, animal studies have shown that the skin of obese mice is mechanically weaker and unable to generate as much hydrothermal isometric force as the skin of lean mice, believed to be due to a mismatch between the increase in skin surface area and collagen deposition.[57] In addition, decreased collagen deposition results in impaired wound healing in obese mice.[58] Overall, obese animal models display impaired myofibroblast activity and collagen maturation, processes which are both necessary for proper healing of surgical wounds.[59]

In addition, obesity is associated with a chronic, low-grade systemic inflammation referred to as metainflammation. This type of inflammation displays minimal increase in circulating proinflammatory factors and lacks the typical clinical signs of

Table 3 Forest plot for surgical complications (SC) in obese versus nonobese women

Study	Obese		Nonobese		Weight	RR
	SC	Total	SC	Total	%	M-H Fixed, 95% CI
Alipour et al (2016)	2	14	11	45	0.3	0.58 [0.15, 2.33]
Sinha et al (2016)	26	29	28	72	1.0	2.31 [1.68, 3.16]
Huo et al (2016)	523	549	135	1,274	4.8	8.99 [7.66, 10.56]
Massenburg et al (2015)	298	2,433	179	4,422	7.5	3.03 [2.53, 3.62]
Wink et al (2014)	97	374	47	1,229	1.3	6.78 [4.88, 9.42]
Fischer et al (2014a)	178	272	249	540	9.9	1.42 [1.25, 1.61]
Ozturk et al (2014)	47	63	42	119	1.7	2.11 [1.59, 2.80]
Nguyen et al (2014)	36	175	58	376	2.2	1.33 [0.92, 1.94]
Nelson et al (2014)	39	57	61	110	2.5	1.23 [0.97, 1.57]
Fischer et al (2014b)	792	4,321	1,116	11,742	35.6	1.93 [1.77, 2.10]
Fischer et al (2013b)	38	2,390	47	6,915	1.4	2.34 [1.53, 3.58]
Ireton et al (2013)	13	21	0	0		Not estimable
Fischer et al (2013a)	51	3,741	68	10,844	2.1	2.17 [1.52, 3.12]
Cleveland et al (2013)	14	272	13	540	0.5	2.14 [1.02, 4.48]
Hanwright et al (2013)	211	3,636	216	9,350	7.2	2.51 [2.09, 3.02]
Garvey et al (2012)	391	700	0	0		Not estimable
Momeni et al (2012)	9	28	0	0		Not estimable
Yezhelyev et al (2012)	65	103	90	174	4.0	1.22 [0.99, 1.50]
Ochoa et al (2012)	47	165	42	253	2.0	1.72 [1.19, 2.48]
Seidenstuecker et al (2011)	18	79	48	479	0.8	2.27 [1.40, 3.70]
Appleton et al (2010)	32	39	50	105	1.6	1.72 [1.34, 2.21]
Rossetto et al (2010)	8	39	37	167	0.8	0.93 [0.47, 1.83]
Wan et al (2010)	15	103	22	306	0.7	2.03 [1.09, 3.75]
Greco et al (2007)	36	62	109	118	4.5	0.63 [0.51, 0.78]
McCarthy et al (2007)	28	108	106	776	1.5	1.90 [1.32, 2.73]
Selber et al (2006)	38	80	85	420	1.6	2.35 [1.74, 3.16]
Spear et al (2005)	16	30	55	170	1.0	1.65 [1.11, 2.46]
Moran et al (2001)	32	114	18	107	1.1	1.67 [1.00, 2.79]
Chang et al (2000)	40	64	240	654	2.5	1.70 [1.37, 2.11]
Total (95% CI)		20,061		51,307	100.0	2.29 [2.19, 2.39]
Total SC	3,140		3172			



Abbreviations: CI, confidence interval; RR, risk ratio.
Heterogeneity $Chi^2 = 637.13$, df $= 25$ ($p < 0.00001$); $I^2 = 96\%$.
Test for overall effect: $Z = 35.94$ ($p < 0.00001$).

inflammation and may play a part in decreased flap survival.[60] Furthermore, the high mass of adipose tissue surrounding the perforating vessels in certain types of autologous reconstructions may compromise the patency of their lumen, consequently resulting in a decreased blood supply to the flap.[61] In addition, flap loss may be related to the increase in arterial thrombosis and secondarily to increased pedicle tension.[23] Overall, tissue flaps in obese patients are heavier and larger, and a limited vascular supply is may not able to adequately perfuse the greater volume of tissue.[15]

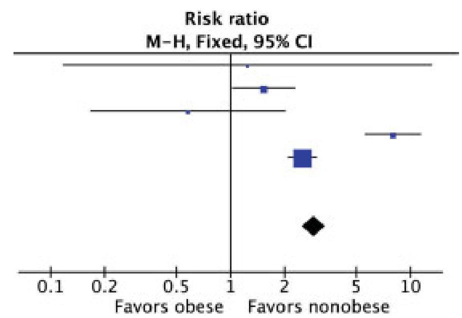
The increased occurrence of infection and necrosis is believed to be due to poor perfusion of the edges of the reconstruction furthest from the vascular inflow leading to relative hypoxia of these tissues.[62] Seroma formation is believed to be due to dead space formation in poorly perfused adipose tissue.[63] Furthermore, given that obesity is associated with increased intraabdominal pressure, it is believed this is what weakens the abdominal wall contributing to the increased risk of hernia occurrence.[64] Furthermore, hypoxia impairs collagen synthesis resulting in deficient healing. Research has also suggested that obesity may cause hernia occurrence by increasing the likelihood of wound infection.[65] A deficiency of macronutrients and micronutrients has also been suggested as a possible cause of inadequate wound healing in obese individuals.[62]

Medical Complications

The higher occurrence of medical complications seen in this meta-analysis is not surprising, as obese patients often have multiple medical comorbidities, which increase the risk for postoperative medical complications such as DVT and PE.

Table 4 Forest plot for medical complications (MC) in obese versus nonobese women

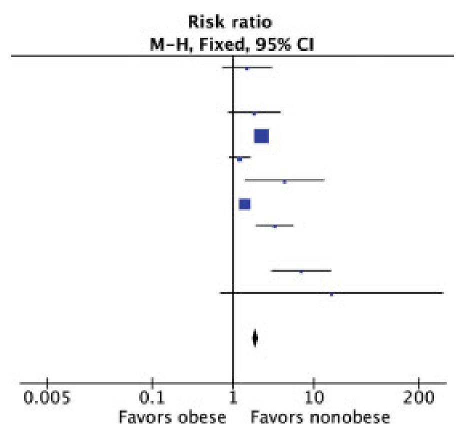
Study	Obese		Nonobese		Weight	RR
	MC	Total	MC	Total	%	M-H Fixed, 95% CI
Sinha et al (2016)	1	29	2	72	0.6	1.24 [0.12, 13.17]
Fischer et al (2014a)	37	272	48	540	17.7	1.53 [1.02, 2.29]
Nelson et al (2014)	3	57	10	110	3.7	0.58 [0.17, 2.02]
Fischer et al (2014b)	115	4,321	39	11,742	11.5	8.01 [5.58, 11.50]
Hanwright et al (2013)	211	3,636	216	9,350	66.4	2.51 [2.09, 3.02]
Momeni et al (2012)	1	28	0	0		Not estimable
Total (95% CI)		8,343		21,814	100.0	2.89 [2.50, 3.35]
Total MC	368		315			



Abbreviations: CI, confidence interval; RR, risk ratio.
Heterogeneity $Chi^2 = 49.16$, df = 4 ($p < 0.00001$); $I^2 = 92\%$.
Test for overall effect: Z = 14.27 ($p < 0.00001$).

Table 5 Forest plot for reoperation rates (reop) in obese versus nonobese women

Study	Obese		Nonobese		Weight	RR
	Reop	Total	Reop	Total	%	M-H Fixed, 95% CI
Sinha et al (2016)	9	29	15	72	1.3	1.49 [0.74, 3.02]
Alipour et al (2016)	0	14	0	45		Not estimable
Mennie et al (2015)	7	208	142	7,721	1.1	1.83 [0.87, 3.86]
Fischer et al (2014b)	519	4,321	628	11,742	50.7	2.25 [2.01, 2.51]
Nguyen et al (2014)	46	175	82	376	7.8	1.21 [0.88, 1.65]
Nelson et al (2014)	9	57	4	110	0.4	4.34 [1.40, 13.49]
Cleveland et al (2013)	33	272	20	540	2.0	3.28 [1.92, 5.60]
Hanwright et al (2013)	232	3,636	428	9,350	36.0	1.39 [1.19, 1.63]
Garvey et al (2012)	16	700	0	0		Not estimable
Greco et al (2007)	22	62	6	118	0.6	6.98 [2.99, 16.31]
Moran et al (2001)	1	30	0	170	0.0	16.55 [0.69, 397.00]
Total (95% CI)		9,504		30,244	100.0	1.91 [1.75, 2.07]
Total reop	894		1,325			



Abbreviations: CI, confidence interval; RR, risk ratio.
Heterogeneity $Chi^2 = 49.44$, df = 8 ($p < 0.00001$); $I^2 = 84\%$.
Test for overall effect: $Z = 15.24$ ($p < 0.00001$).

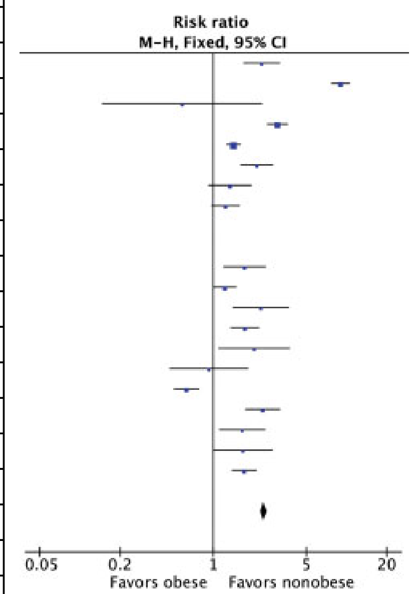
Table 6 Subgroup analysis of surgical complications in obese versus nonobese women

Surgical complication	Studies	Patients		RR (95% CI)	*p*-Value	Heterogeneity *p*-Value
		Obese	Nonobese			
Fat necrosis	9	1,430	2,227	1.65 [1.31–2.07]	<0.0001	0.07
Hematoma	9	771	2,356	1.05 [0.72–1.52]	0.82	0.006
Hernia	10	1,383	2,620	1.67 [1.15–2.43]	0.007	0.36
Partial flap failure	7	1,237	2,034	1.60 [1.06–2.41]	0.03	0.68
Seroma	10	816	2,717	1.96 [1.57–2.45]	<0.00001	0.002
Total flap failure	7	640	2,210	1.97 [1.34–2.91]	0.0006	0.21
Wound dehiscence	4	4,540	9,798	2.51 [1.80–3.52]	<0.00001	0.0007
Wound infection	13	533	11,216	2.34 [2.03–2.69]	<0.00001	0.0001

Abbreviations: CI, confidence interval; RR, risk ratio.

Table 7 Forest plot for surgical complications (SC) in autologous reconstruction

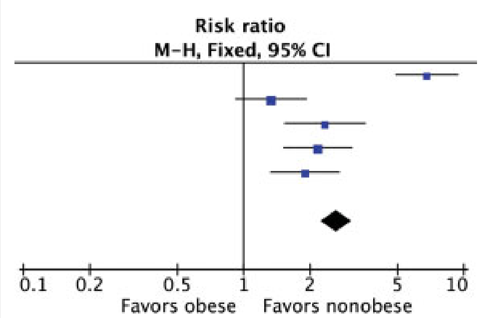
Study	Obese		Nonobese		Weight	RR
	SC	Total	SC	Total	%	M-H Fixed, 95% CI
Sinha et al (2016)	26	29	28	72	1.9	2.31 [1.68, 3.16]
Huo et al (2016)	523	549	135	1,274	9.6	8.99 [7.66, 10.56]
Alipour et al (2016)	2	14	11	45	0.6	0.58 [0.15, 2.33]
Massenburg et al (2015)	298	2,433	179	4,422	14.9	3.03 [2.53, 3.62]
Fischer et al (2014a)	178	272	249	540	19.6	1.42 [1.25, 1.61]
Nguyen et al (2014)	36	175	58	376	4.3	1.33 [0.92, 1.94]
Ozturk et al (2014)	47	63	42	119	3.4	2.11 [1.59, 2.80]
Nelson et al (2014)	39	57	61	110	4.9	1.23 [0.97, 1.57]
Ireton et al (2013)	13	21	0	0		Not estimable
Momeni et al (2012)	9	28	0	0		Not estimable
Ochoa et al (2012)	47	165	42	253	3.9	1.72 [1.19, 2.48]
Yezhelyev et al (2012)	65	103	90	174	4.0	1.22 [0.99, 1.50]
Seidenstuecker et al (2011)	18	79	48	479	1.6	2.27 [1.40, 3.70]
Appleton et al (2010)	32	39	50	105	3.2	1.72 [1.34, 2.21]
Wan et al (2010)	15	103	22	306	1.3	2.03 [1.09, 3.75]
Rossetto et al (2010)	8	39	37	167	1.6	0.93 [0.47, 1.83]
Greco et al (2007)	36	62	109	118	8.8	0.63 [0.51, 0.78]
Selber et al (2006)	38	80	85	420	3.2	2.35 [1.74, 3.16]
Spear et al (2005)	16	30	55	170	1.9	1.65 [1.11, 2.46]
Moran et al (2001)	32	114	18	107	2.2	1.67 [1.00, 2.79]
Chang et al (2000)	40	64	240	654	5.0	1.70 [1.37, 2.11]
Total (95% CI)		4,519		9,911	100.0	2.41 [2.27, 2.55]
Total SC	1,518		1,559			



Abbreviations: CI, confidence interval; RR, risk ratio.
Heterogeneity Chi^2 =598.15, df = 18 ($p < 0.00001$); $I^2 = 97\%$.
Test for overall effect: $Z = 29.70$ ($p < 0.00001$).

Table 8 Forest plot for surgical complications (SC) in implant reconstruction

Study	Obese		Nonobese		Weight	RR
	SC	Total	SC	Total	%	M-H Fixed, 95% CI
Wink et al (2014)	97	374	47	1,229	15.3	6.78 [4.88, 9.42]
Nguyen et al (2014)	36	175	58	376	25.6	1.33 [0.92, 1.94]
Fischer et al (2013b)	38	2,390	47	6,915	16.8	2.34 [1.53, 3.58]
Fischer et al (2013a)	51	3,741	68	10,844	24.3	2.17 [1.52, 3.12]
McCarthy et al (2007)	28	108	106	776	18.0	1.90 [1.32, 2.73]
Total (95% CI)		6,788		20,140	100.0	2.64 [2.25, 3.09]
Total SC	250		326			



Abbreviations: CI, confidence interval; RR, risk ratio.
Heterogeneity Chi^2 =48.97, df = 4 ($p < 0.00001$); $I^2 = 92\%$.
Test for overall effect: $Z = 12.01$ ($p < 0.00001$).

Despite a higher occurrence of DVT and PE being mentioned in the reviewed articles, numerical data were not sufficient to be used in the meta-analysis. It is recommended that obese patients with multiple comorbid conditions should be monitored closely for postoperative medical complications and should receive appropriate mechanical and pharmacological venous thromboembolic prophylaxis with weight-adjusted dosages calculated for the latter.[45] One study found that

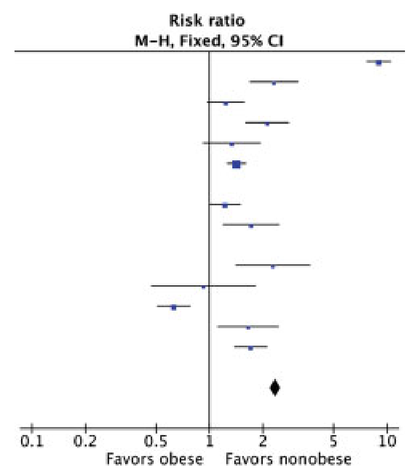
Table 9 Subgroup analysis of surgical complications in nonobese women versus Class I, Class II, and Class III obese women

Obesity class	Patients		RR (95% CI)	*p*-Value	Heterogeneity *p*-Value
	Obese	Nonobese			
Class I (30–34.9 kg/m^2)	2,899	13,533	1.32 [1.15–1.50]	<0.0001	0.68
Class II (35–39.9 kg/m^2)	1,181	13,533	1.84 [1.56–2.17]	<0.00001	0.02
Class III (>40 kg/m^2)	837	13,533	1.66 [1.36–2.03]	<0.00001	0.25

Abbreviations: CI, confidence interval; RR, risk ratio.

Table 10 Forest plot for sensitivity analysis of surgical complications (SC)

Study	Obese		Nonobese		Weight	RR
	SC	Total	SC	Total	%	M-H Fixed, 95% CI
Huo et al (2016)	523	549	135	1274	12.8	8.99 [7.66, 10.56]
Sinha et al (2016)	26	29	28	72	2.5	2.31 [1.68, 3.16]
Nelson et al (2014)	39	57	61	110	6.6	1.23 [0.97, 1.57]
Ozturk et al (2014)	47	63	42	119	4.6	2.11 [1.59, 2.80]
Nguyen et al (2014)	36	175	58	376	5.8	1.33 [0.92, 1.94]
Fischer et al (2014a)	178	272	249	540	26.3	1.42 [1.25, 1.61]
Garvey et al (2012)	391	700	0	0		Not estimable
Yezhelyev et al (2012)	65	103	90	174	10.6	1.22 [0.99, 1.50]
Ochoa et al (2012)	47	165	42	253	5.2	1.72 [1.19, 2.48]
Momeni et al (2012)	9	28	0	0		Not estimable
Seidenstuecker et al (2011)	18	79	48	479	2.1	2.27 [1.40, 3.70]
Rossetto et al (2010)	8	39	37	167	2.2	0.93 [0.47, 1.83]
Greco et al (2007)	36	62	109	118	11.8	0.63 [0.51, 0.78]
Spear et al (2005)	16	30	55	170	2.6	1.65 [1.11, 2.46]
Chang et al (2000)	40	64	240	654	6.8	1.70 [1.37, 2.11]
Total (95% CI)		2,415		4,506	100.0	2.36 [2.22, 2.52]
Total SC	1,479		1,194			



Abbreviations: CI, confidence interval; RR, risk ratio.
Heterogeneity Chi^2 =569.76, df = 12 ($p < 0.00001$); $I^2 = 98\%$.
Test for overall effect: $Z = 26.63$ ($p < 0.00001$).

medical complications were more likely to occur in patients undergoing pedicled TRAM reconstruction than latissimus and free flap reconstruction, suggesting that this increased risk may be due to either a selection bias, as patients prone to thrombotic events were more likely to undergo pedicled flap reconstruction, or due to the fact that perioperative anticoagulants are more routinely used in patients undergoing free tissue transfer.[16]

Length of Postoperative Hospital Stay

Despite the increase in postoperative complications, the mean length of postoperative hospital stay for obese women was comparable with studies of nonobese patients. The length of stay in the obese population varied from 4.2[23] to 7 days,[43] lengths of stay which are comparable with studies in nonobese populations.[35,40]

Reoperation

Overall, the rate of reoperation was higher in the obese population. This is not surprising given the increased occurrence of surgical complications in obese patients. One study differentiated between reconstruction types, reporting that free flap patients had the highest rate of reoperation, followed by TRAM flaps, tissue expander and, last latissimus flaps.[16]

Patient Satisfaction

Despite a higher occurrence of complications, obese women achieved equivalent postoperative satisfaction scores to the comparison group,[18] and reported similar satisfaction levels in terms of decision-making prior to surgery and also surgical outcome.[44] A significant decrease in aesthetic satisfaction was seen in obese women undergoing expander and implant reconstructions, reported to be due to the challenge in achieving symmetry to a native large volume contralateral breasts.[38]

Implications for Clinical Practice

To minimize the occurrence of the complications mentioned in this meta-analysis and provide better care for obese women, we recommend that clinicians counsel patients with a BMI > 30 regarding the high risk of complications and to

Table 11 Summary of RRs for the primary outcomes in obese versus nonobese women

Outcome	Studies	Patients		RR (95% CI)	*p*-value	Heterogeneity *p*-Value
		Obese	Nonobese			
Surgical complications	29	20,061	51,307	2.29 [2.19–2.39]	<0.00001	<0.00001
Fat necrosis	9	1,430	2,227	1.65 [1.31–2.07]	<0.0001	0.07
Hematoma	9	771	2,356	1.05 [0.72–1.52]	0.82	0.006
Hernia	10	1,383	2,620	1.67 [1.15–2.43]	0.007	0.36
Partial flap failure	7	1,237	2,034	1.60 [1.06–2.41]	0.03	0.68
Seroma	10	816	2,717	1.96 [1.57–2.45]	<0.00001	0.002
Total flap failure	7	640	2,210	1.97 [1.34–2.91]	0.0006	0.21
Wound dehiscence	4	4,540	9,798	2.51 [1.80–3.52]	<0.00001	0.0007
Wound infection	13	533	11,216	2.34 [2.03–2.69]	<0.00001	0.0001
Autologous reconstruction	21	4,519	9,911	2.59 [2.44–2.75]	<0.00001	<0.00001
Implant reconstruction	5	6,788	20,140	2.64 [2.25–3.09]	<0.00001	<0.00001
Medical complications	6	8,343	21,814	2.80 [2.41–3.26]	<0.00001	<0.00001
Reoperation	11	9,504	30,244	1.91 [1.75–2.07]	<0.00001	<0.00001

Abbreviations: CI, confidence interval; RR, risk ratio.

consider weight loss with delayed reconstruction as an option. The literature regarding breast reconstruction following weight loss is not robust, requiring surgeons to utilize good clinical judgment in making individual patient recommendations in the setting of oncologic considerations. It should be emphasized that obesity should not be considered a contraindication for reconstructive breast surgery. Previous research suggests that the preoperative weight loss not only facilitates reconstruction and enhances outcomes[26] but also improves postreconstructive satisfaction in obese women.[66] Research has shown that the dilated perforators seen in obesity exist even after weight reduction and can consequently be harvested during surgery to supply a less bulky and robust flap.[67,68] It has also been suggested that the decreased fat in the flap leads to lower risk of fat necrosis[69] and the decreased density of the flaps seen in weight loss patients allows for easier perforator dissection and flap mobilization.[26]

Strengths and Limitations

The strengths of this systematic review and meta-analysis are that it is noncommercial, with strict inclusion and exclusion criteria; it assessed the methodological quality of the studies using the GRADE criteria, and performed a sensitivity analysis to provide more robust conclusions. A study protocol was published a priori following peer-review and we have reported in line with the PRISMA criteria.[9,70] At the time of writing, this review was the largest and most comprehensive review of the effect of obesity on breast reconstruction, analyzing the most recent studies including two from 2016.

There are several limitations to our work. Most importantly, only nonrandomized studies, which carry inherent biases such as selection bias, met the inclusion criteria. All studies were case series with an LoE of 4 and approximately half of the studies were of low or very low quality. This may weaken the strength of this review. It should be noted that the majority of discussions around case series revolve around their relevance to a potential cause–effect relationship.[71] By respecting the limitations of these studies and accepting them for what they are, we can learn a great deal from such evidence.[72] Our search criteria excluded unpublished data and abstracts and this could add to publication bias.

Unfortunately, only eight papers offered data on implant reconstruction, but these did not, however, distinguish between the different kind of implants. This would be a great future research question. This review did not provide a distinction between immediate and delayed reconstruction as the included papers either analyzed immediate and delayed reconstruction as a single group or did not clearly state whether reconstruction was immediate or delayed. Finally, autologous reconstruction, which includes TRAM, LDM, DIEP, and SIEA flaps, was analyzed as a single group as data for each flap individually were limited. These techniques have varying characteristics and consequently there is heterogeneity in the effect of obesity on each type, resulting in biased observations.

Assessing if different implants have a different relationship to obesity would be a useful research question to address. The impact of breast size would also be interesting to assess. Obesity has known hormonal and nutritional dimensions and given the strength of the effect shown in our meta-analysis, obesity is likely an independent risk factor. However, despite studies not controlling for breast size, breast size itself may be a confounder in this analysis and certainly could be another independent risk factor. Future studies could provide an answer for this question.

Implications for Future Research

This review and meta-analysis highlight the need for carefully assessing obese patients prior to reconstructive breast surgery but also highlight the need for further research. The majority of papers in this review investigated the group of obese women as a whole. The subgroup analysis of the different classes of obesity found that the Class II patients had higher surgical complication rates than the Class III patients. Current research on the reasons behind this is lacking and future research would ideally classify obesity into the different WHO classes, providing more specific information on the 30 to 35, 35 to 40, and > 40 BMI groups, helping to clarify the reasons and allowing for more tailored risk profiling. BMI was categorized into distinct group ranges but it is likely to be a continuous variable as far as risk is concerned. Ultimately identification of a "threshold" level of obesity would be ideal and this could be the subject of future research.

Furthermore, this review found that obese women were more likely to experience surgical complications during both implant and autologous reconstruction in comparison to nonobese women. Direct comparison of the two types of procedures was not possible in this review as the numerical data was limited. Future studies specifically aimed at comparing implant and autologous reconstruction are necessary to provide a more accurate comparison of the two procedures.

As previously mentioned, all the studies in this review were case series, which are known to suffer from methodological and reporting issues.[73] Issues with the reporting of surgical case series were highlighted in a systematic review of autologous fat grafting for breast reconstruction where the majority of studies failed to provide information about patient demographics and prior treatment.[74]

In the drive to improve the quality of research in clinical practice, various reporting guidelines for different study types have been developed, such as for case reports[75] and systematic reviews.[70] Examples include the CONSORT statement[76,77] and the STROBE guidelines.[78] Case series should be reported in line with recently published expert consensus guidelines such as the PROCESS guidelines.[79] There are a variety of outcome measures reported in case series and an agreement on a core set of outcome measures to report would help future researchers aggregate studies.

The lack of high-quality research underscores the need for authors to adhere to stringent reporting guidelines. All research should be registered before recruiting patients.[80] With the launch of the Research Registry, surgeons are encouraged to prospectively register their research and to submit a protocol, which will undergo peer review allowing them to enhance their work.[74]

Conclusion

According to this meta-analysis, obese women were more likely to experience surgical and medical complications and had a higher chance of returning to the operating room. Given the high rates of complications in patients undergoing breast reconstruction with a BMI over 30, careful counseling about the risks and possible delay in reconstruction until weight loss has occurred should be considered.

Conflict of Interest

None of the authors have any conflicts of interest, relevant to this article, to declare.

References

1 WHO. Obesity and overweight Fact sheet N°311, WHO [Internet]. WHO; 2015. http://www.who.int/mediacentre/factsheets/fs311/en. Accessed July 24, 2017

2 Cancer Research UK. Breast cancer incidence statistics [Internet]. Cancer Research UK; 2014. http://www.cancerresearchuk.org/health-professional/cancer-statistics/statistics-by-cancer-type/breast-cancer/incidence-invasive. Accessed July 24, 2017

3 American Cancer Society. Cancer facts & figures 2012. [Internet]. ACS; 2012. https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/annual-cancer-facts-and-figures/2012/cancer-facts-and-figures-2012.pdf. Accessed Jan 4, 2018

4 American Society of Plastic Surgeons. Reconstructive plastic surgery statistics [Internet]. ASPS; 2011. https://www.plasticsurgery.org/documents/News/Statistics/2011/reconstructive-procedure-trends-2011.pdf. Accessed July 24, 2017

5 Davies K, Allan L, Roblin P, Ross D, Farhadi J. Factors affecting postoperative complications following skin sparing mastectomy with immediate breast reconstruction. Breast 2011;20(01):21–25

6 Byrne TK. Complications of surgery for obesity. Surg Clin North Am 2001;81(05):1181–1193, vii–viii

7 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(06):1886–1892

8 Higgins JPT, Green S (editors). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011] [Internet]. The Cochrane Collaboration, 2011. http://handbook.cochrane.org/ Accessed July 24, 2017

9 Panayi A, Agha RA, Sieber BA, Orgill DP. Impact of obesity on outcomes in breast reconstruction: a systematic review protocol. Int J Surg Protocols 2016;2:1–4

10 Guyatt GH, Oxman AD, Vist GE, et al; GRADE Working Group. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ 2008;336(7650):924–926

11 Moher D, Cook DJ, Eastwood S, Olkin I, Rennie D, Stroup DF. Improving the quality of reports of meta-analyses of randomised controlled trials: the QUOROM statement. Quality of reporting of meta-analyses. Lancet 1999;354(9193):1896–1900

12 World Health Organization. Obesity: Preventing and Managing the Global Epidemic. WHO Technical Report Series 894. Geneva: WHO; 2000

13 Nguyen KT, Hanwright PJ, Smetona JT, Hirsch EM, Seth AK, Kim JY. Body mass index as a continuous predictor of outcomes after expander-implant breast reconstruction. Ann Plast Surg 2014;73(01):19–24

14 Fischer JP, Wes AM, Tuggle CT III, Serletti JM, Wu LC. Risk analysis of early implant loss after immediate breast reconstruction: a review of 14,585 patients. J Am Coll Surg 2013;217(06):983–990

15 Chang DW, Wang B, Robb GL, et al. Effect of obesity on flap and donor-site complications in free transverse rectus abdominis myocutaneous flap breast reconstruction. Plast Reconstr Surg 2000;105(05):1640–1648

16 Hanwright PJ, Davila AA, Hirsch EM, et al. The differential effect of BMI on prosthetic versus autogenous breast reconstruction: a multivariate analysis of 12,986 patients. Breast 2013;22(05):938–945

17 Huo J, Smith BD, Giordano SH, Reece GP, Shih YT. Post-mastectomy breast reconstruction and its subsequent complications: a comparison between obese and non-obese women with breast cancer. Breast Cancer Res Treat 2016;157(02):373–383

18 Sinha S, Ruskin O, D'Angelo A, McCombe D, Morrison WA, Webb A. Are overweight and obese patients who receive autologous free-flap breast reconstruction satisfied with their postoperative outcome? A single-centre study. J Plast Reconstr Aesthet Surg 2016; 69(01):30–36
19 Alipour S, Omranipour R, Akrami R. Obesity should not prevent from TRAM flap breast reconstruction in developing countries. Indian J Surg 2015;77(Suppl 2):341–344
20 Massenburg BB, Sanati-Mehrizy P, Ingargiola MJ, Rosa JH, Taub PJ. Flap failure and wound complications in autologous breast reconstruction: a national perspective. Aesthetic Plast Surg 2015;39(06):902–909
21 Mennie JC, Mohanna PN, O'Donoghue JM, Rainsbury R, Cromwell DA. Donor-site hernia repair in abdominal flap breast reconstruction: a population-based cohort study of 7929 patients. Plast Reconstr Surg 2015;136(01):1–9
22 Selber JC, Wren JH, Garvey PB, et al. Critical evaluation of risk factors and early complications in 564 consecutive two-stage implant-based breast reconstructions using acellular dermal matrix at a single center. Plast Reconstr Surg 2015;136(01):10–20
23 Fischer JP, Nelson JA, Sieber B, et al. Free tissue transfer in the obese patient: an outcome and cost analysis in 1258 consecutive abdominally based reconstructions. Plast Reconstr Surg 2013;131 (05):681e–692e
24 Fischer JP, Nelson JA, Au A, Tuggle CT III, Serletti JM, Wu LC. Complications and morbidity following breast reconstruction—a review of 16,063 cases from the 2005-2010 NSQIP datasets. J Plast Surg Hand Surg 2014;48(02):104–114
25 Nelson JA, Fischer JP, Yan C, et al. The impact of obesity on abdominal wall function after free autologous breast reconstruction. Microsurgery 2014;34(05):352–360
26 Ozturk CN, Kundu N, Bernard S, Cooper K, Ozturk C, Djohan R. Breast reconstruction with abdominal-based free flaps in high body mass index population: postoperative complications and impact of weight loss. Ann Plast Surg 2014;72(01):13–22
27 Wink JD, Fischer JP, Nelson JA, Serletti JM, Wu LC. Direct-to-implant breast reconstruction: an analysis of 1612 cases from the ACS-NSQIP surgical outcomes database. J Plast Surg Hand Surg 2014;48(06):375–381
28 Fischer JP, Nelson JA, Serletti JM, Wu LC. Peri-operative risk factors associated with early tissue expander (TE) loss following immediate breast reconstruction (IBR): a review of 9305 patients from the 2005-2010 ACS-NSQIP datasets. J Plast Reconstr Aesthet Surg 2013;66(11):1504–1512
29 Ireton JE, Kluft JA, Ascherman JA. Unilateral and bilateral breast reconstruction with pedicled TRAM flaps: an outcomes analysis of 188 consecutive patients. Plast Reconstr Surg Glob Open 2013; 1(02):1–7
30 Garvey PB, Villa MT, Rozanski AT, Liu J, Robb GL, Beahm EK. The advantages of free abdominal-based flaps over implants for breast reconstruction in obese patients. Plast Reconstr Surg 2012;130 (05):991–1000
31 Momeni A, Ahdoot MA, Kim RY, Leroux E, Galaiya DJ, Lee GK. Should we continue to consider obesity a relative contraindication for autologous microsurgical breast reconstruction? J Plast Reconstr Aesthet Surg 2012;65(04):420–425
32 Ochoa O, Chrysopoulo M, Nastala C, Ledoux P, Pisano S. Abdominal wall stability and flap complications after deep inferior epigastric perforator flap breast reconstruction: does body mass index make a difference? Analysis of 418 patients and 639 flaps. Plast Reconstr Surg 2012;130(01):21e–33e
33 Yezhelyev M, Duggal CS, Carlson GW, Losken A. Complications of latissimus dorsi flap breast reconstruction in overweight and obese patients. Ann Plast Surg 2013;70(05):557–562
34 Seidenstuecker K, Munder B, Mahajan AL, Richrath P, Behrendt P, Andree C. Morbidity of microsurgical breast reconstruction in patients with comorbid conditions. Plast Reconstr Surg 2011;127 (03):1086–1092
35 Appleton SE, Ngan A, Kent B, Morris SF. Risk factors influencing transfusion rates in DIEP flap breast reconstruction. Plast Reconstr Surg 2011;127(05):1773–1782
36 Rossetto LA, Abla LEF, Vidal R, et al. Factors associated with hernia and bulge formation at the donor site of the pedicled TRAM flap. Eur J Plast Surg 2010;33(04):203–208
37 Wan DC, Tseng CY, Anderson-Dam J, Dalio AL, Crisera CA, Festekjian JH. Inclusion of mesh in donor-site repair of free TRAM and muscle-sparing free TRAM flaps yields rates of abdominal complications comparable to those of DIEP flap reconstruction. Plast Reconstr Surg 2010;126(02):367–374
38 Atisha DM, Alderman AK, Kuhn LE, Wilkins EG. The impact of obesity on patient satisfaction with breast reconstruction. Plast Reconstr Surg 2008;121(06):1893–1899
39 Greco JA III, Castaldo ET, Nanney LB, et al. Autologous breast reconstruction: the Vanderbilt experience (1998 to 2005) of independent predictors of displeasing outcomes. J Am Coll Surg 2008;207(01):49–56
40 Mehrara BJ, Santoro TD, Arcilla E, Watson JP, Shaw WW, Da Lio AL. Complications after microvascular breast reconstruction: experience with 1195 flaps. Plast Reconstr Surg 2006;118(05):1100–1109, discussion 1110–1111
41 Selber JC, Kurichi JE, Vega SJ, Sonnad SS, Serletti JM. Risk factors and complications in free TRAM flap breast reconstruction. Ann Plast Surg 2006;56(05):492–497
42 Spear SL, Ducic I, Cuoco F, Taylor N. Effect of obesity on flap and donor-site complications in pedicled TRAM flap breast reconstruction. Plast Reconstr Surg 2007;119(03):788–795
43 Moran SL, Serletti JM. Outcome comparison between free and pedicled TRAM flap breast reconstruction in the obese patient. Plast Reconstr Surg 2001;108(07):1954–1960, discussion 1961–1962
44 Kulkarni AR, Katz S, Hamilton AS, Graff JJ, Alderman AK. Patterns of use and patient satisfaction with breast reconstruction among obese patients: results from a population-based study. Plast Reconstr Surg 2012;130(02):263–270
45 Fischer JP, Sieber B, Nelson JA, et al. Comprehensive outcome and cost analysis of free tissue transfer for breast reconstruction: an experience with 1303 flaps. Plast Reconstr Surg 2013;131(02):195–203
46 Ducic I, Spear SL, Cuoco F, Hannan C. Safety and risk factors for breast reconstruction with pedicled transverse rectus abdominis musculocutaneous flaps: a 10-year analysis. Ann Plast Surg 2005; 55(06):559–564
47 Nelson JA, Chung CU, Fischer JP, Kanchwala SK, Serletti JM, Wu LC. Wound healing complications after autologous breast reconstruction: a model to predict risk. J Plast Reconstr Aesthet Surg 2015;68 (04):531–539
48 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(07): 586–591
49 Garvey PB, Buchel EW, Pockaj BA, Gray RJ, Samson TD. The deep inferior epigastric perforator flap for breast reconstruction in overweight and obese patients. Plast Reconstr Surg 2005;115 (02):447–457
50 Jandali S, Nelson JA, Sonnad SS, et al. Breast reconstruction with free tissue transfer from the abdomen in the morbidly obese. Plast Reconstr Surg 2011;127(06):2206–2213
51 Fischer JP, Nelson JA, Kovach SJ, Serletti JM, Wu LC, Kanchwala S. Impact of obesity on outcomes in breast reconstruction: analysis of 15,937 patients from the ACS-NSQIP datasets. J Am Coll Surg 2013;217(04):656–664
52 Fischer JP, Wes AM, Kanchwala S, Kovach SJ. Effect of BMI on modality-specific outcomes in immediate breast reconstruction (IBR)—a propensity-matched analysis using the 2005-2011 ACS-NSQIP datasets. J Plast Surg Hand Surg 2014;48(05):297–304
53 Fischer JP, Wes AM, Tuggle CT, Serletti JM, Wu LC. Risk analysis and stratification of surgical morbidity after immediate breast reconstruction. J Am Coll Surg 2013;217(05):780–787

54 Cleveland EC, Fischer JP, Nelson JA, et al. Optimizing the fascial closure: an analysis of 1261 abdominally based free flap reconstructions. Ann Plast Surg 2013;71(03):255–260
55 Fischer JP, Cleveland EC, Nelson JA, et al. Breast reconstruction in the morbidly obese patient: assessment of 30-day complications using the 2005 to 2010 National Surgical Quality Improvement Program data sets. Plast Reconstr Surg 2013;132(04): 750–761
56 OCEBM Levels of Evidence Working Group The Oxford 2011 levels of evidence [Internet] Oxford Centre for Evidence-Based Medicine (2011), p. 5653. http://www.cebm.net/index.aspx?o=5653. Accessed 24 July, 2017
57 Enser M, Avery NC. Mechanical and chemical properties of the skin and its collagen from lean and obese-hyperglycaemic (ob/ob) mice. Diabetologia 1984;27(01):44–49
58 Goodson WH III, Hunt TK. Wound collagen accumulation in obese hyperglycemic mice. Diabetes 1986;35(04):491–495
59 Xing L, Culbertson EJ, Wen Y, Robson MC, Franz MG. Impaired laparotomy wound healing in obese rats. Obes Surg 2011;21(12): 1937–1946
60 Mraz M, Haluzik M. The role of adipose tissue immune cells in obesity and low-grade inflammation. J Endocrinol 2014;222(03): R113–R127
61 Scheflan M, Kalisman M. Complications of breast reconstruction. Clin Plast Surg 1984;11(02):343–350
62 Pierpont YN, Dinh TP, Salas RE, et al. Obesity and surgical wound healing: a current review. ISRN Obes 2014;2014:638936
63 Wilson JA, Clark JJ. Obesity: impediment to wound healing. Crit Care Nurs Q 2003;26(02):119–132
64 Lambert DM, Marceau S, Forse RA. Intra-abdominal pressure in the morbidly obese. Obes Surg 2005;15(09):1225–1232
65 Sauerland S, Korenkov M, Kleinen T, Arndt M, Paul A. Obesity is a risk factor for recurrence after incisional hernia repair. Hernia 2004;8(01):42–46
66 Larson KE, Ozturk CN, Kundu N, Cooper KR, Bernard S, Djohan R. Achieving patient satisfaction in abdominally based free flap breast reconstruction: correlation with body mass index subgroups and weight loss. Plast Reconstr Surg 2014;133(04): 763–773
67 Shayan R, Rozen WM, Bernard S, Corlett RJ, Ashton MW, Taylor GI. Perforator dilatation induced by body weight gain is not reversed by subsequent weight loss: implications for perforator flaps. Plast Reconstr Surg 2008;122(06):1765–1772
68 Wechselberger G, Haug M, Schoeller T, Nehoda H, Piza-Katzer H. Breast reconstruction facilitated by vertical banded gastroplasty. Obes Surg 2000;10(05):460–464
69 Nahabedian MY, Momen B, Galdino G, Manson PN. Breast reconstruction with the free TRAM or DIEP flap: patient selection, choice of flap, and outcome. Plast Reconstr Surg 2002;110(02): 466–475, discussion 476–477
70 Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 2009;6(07):e1000097
71 Jenicek M. Clinical case reports and case series research in evaluating surgery. Part II. The content and form: uses of single clinical case reports and case series research in surgical specialties. Med Sci Monit 2008;14(10):RA149–RA162
72 Agha RA, Orgill DP. Evidence-based plastic surgery: its rise, importance, and a practical guide. Aesthet Surg J 2016;36(03):366–371
73 Agha RA, Fowler AJ, Lee SY, et al. Systematic review of the methodological and reporting quality of case series in surgery. Br J Surg 2016;103(10):1253–1258
74 Agha RA, Fowler AJ, Herlin C, Goodacre TE, Orgill DP. Use of autologous fat grafting for breast reconstruction: a systematic review with meta-analysis of oncological outcomes. J Plast Reconstr Aesthet Surg 2015;68(02):143–161
75 Gagnier JJ, Kienle G, Altman DG, Moher D, Sox H, Riley D; CARE Group. The CARE guidelines: consensus-based clinical case report guideline development. J Clin Epidemiol 2014;67(01):46–51
76 Turner L, Shamseer L, Altman DG, et al. Consolidated standards of reporting trials (CONSORT) and the completeness of reporting of randomised controlled trials (RCTs) published in medical journals. Cochrane Database Syst Rev 2012;11(11):MR000030
77 Turner L, Shamseer L, Altman DG, Schulz KF, Moher D. Does use of the CONSORT statement impact the completeness of reporting of randomised controlled trials published in medical journals? A Cochrane review. Syst Rev 2012;1:60
78 Agha RA, Lee SY, Jeong KJ, Fowler AJ, Orgill DP. Reporting quality of observational studies in plastic surgery needs improvement: a systematic review. Ann Plast Surg 2016;76(05):585–589
79 Agha RA, Fowler AJ, Rajmohan S, Barai I, Orgill DP; PROCESS Group. The PROCESS statement: preferred reporting of case series in surgery. Int J Surg 2016;36:319–323
80 WMA Declaration of Helsinki - Ethical Principles for Medical Research Involving Human Subjects. http://www.who.int/bulletin/archives/79%284%29373.pdf. Accessed 24 July, 2017