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ORIGINAL CONTRIBUTIONS

Post-bariatric Abdominoplasty: Identification of Risk Factors for Complications

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Abstract

Purpose The aim was to evaluate the complication rate after abdominoplasty procedures performed in a high volume post-bariatric center and to identify predictors of complications.

Material and Methods A retrospective analysis was performed and included all abdominoplasty procedures performed between January 2011 and December 2019. Complications classified according to the Clavien-Dindo classification were documented and potential risk factors were statistically evaluated.

Results A total of 898 patients were included. Overall complication rate was 29.8%. Type I complications (minor wound problems) occurred in 15.8% (n = 140). Type II complications requiring medical intervention occurred in 10% (n = 90). Five patients had deep venous thrombosis or pulmonary embolism; others received antibiotic treatment for wound infections. In total 42 type III complications occurred in 36 patients, with re-intervention for wound problems (n = 16), seroma (n = 16), umbilical necrosis (n = 4), and bleeding (n = 6). The weight of tissue resected ($p < 0.001$), the interval between bariatric and body contouring surgery ($p < 0.05$), preoperative BMI ($p < 0.05$), male gender ($p < 0.05$), diabetes mellitus type 2 ($p = 0.05$), and smoking ($p < 0.05$) were important predictors for developing complications.

Conclusion In this large retrospective post-bariatric abdominoplasty series, the overall complication rate is low compared to other published series as a consequence of our completely standardized approach and technique. Our analysis shows a significant linear correlation between the amount of skin tissue resected and postoperative complications. Moreover, the longer the interval between bariatric surgery and abdominoplasty, the higher the complication rate. High preoperative BMI, diabetes mellitus type 2, smoking, and male gender were identified as independent significant risk factors for complications.

Keywords Post-bariatric · Abdominoplasty · Body contouring

Introduction

Due to the increased prevalence of obesity and the steep rise of bariatric surgery the last decade, functional reconstructive surgery after massive weight loss or post-bariatric surgery has emerged radically. Statistics of the American Society of Plastic Surgeons show that 55.245 body contouring procedures were performed after massive weight loss in the USA in 2016 [1].

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The removal of excess skin leads to improvements in a patient's appearance and enhanced physical, psychological, and social health and well-being. Complications are associated in 80% of patients undergoing post-bariatric surgical procedures as reported in literature [2, 3]. Abdominoplasty is a widespread body contouring procedure with the aim to remove excess skin and fat from the abdominal wall in order to create a more esthetical body shape with increased quality of life for the patient. Medical literature data related to this specific topic is scarce and usually only focuses on reporting complication rates among different types of post-bariatric surgery with most often limited patient records [4–6]. The aim of the present study was to assess the complication rate of post-bariatric abdominoplasty surgery performed in a high volume post-bariatric center and to identify risk factors for complications.

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Materials and Methods

Patient and Data Collection

This is a retrospective analysis of a database of consecutive patients operated on with abdominoplasty after massive weight loss after bariatric surgery at the department of Bariatric & Post-Bariatric Surgery AZ Sint-Jan Brugge-Oostende AV, Belgium. Body contouring was offered to patients with a documented stabilized weight at least 1 year after initial bariatric surgery. Included patients underwent one of four types of abdominoplasty: standard or extended abdominoplasty, circumferential lower body lift, or fleur-de-lys abdominoplasty (inverted T-shape). No liposuction was performed in combination with these surgeries. Surgery was performed by a single surgeon (SVC), or under his direct supervision, in a standardized fashion from April 2011 to December 2019.

Patient data were collected from the hospital's electronic medical record. The collected data included patient demographics, type of body contouring surgery, body mass index (BMI) at time of bariatric surgery, BMI prior to bariatric surgery, BMI at time of abdominoplasty, time interval between initial bariatric procedure and abdominoplasty, length of hospital stay (LOS), smoking history, diabetes mellitus, and amount of tissue resected. All smoking patients were advised to stop smoking at least 1 month before surgery; patients that smoked within the 1-month timeframe before surgery were considered smokers in the analysis.

Complications were classified according to the modified Clavien-Dindo classification. Recorded complications included wound dehiscence (requiring local wound care and/or multiple clinical visits), wound infections treated with antibiotics, seroma formation, hematoma, deep venous thrombosis (DVT) or pulmonary embolism (PE), bleeding (requiring blood transfusion), return to operating room, and death.

Statistical Analysis

Descriptive statistics were performed depending on variables' type and distribution. Continuous variables were described as means ± standard deviation (SD), while categorical variables were reported with the number of patients and percentages. All variables were non-normally distributed, which was confirmed by the Kolmogorov-Smirnov test. To compare continuous variables between groups, the Mann-Whitney *U* test was performed. For comparison of categorical variables, Fisher's exact test was used. Variables with a *p*-value lower than 0.1 after simple logistic regression analysis were included in the multivariate analysis. For the latter, a logistic regression was performed using the enter selection procedure and the results were presented as odds ratio (OR) with 95% confidence interval 95% CI).

$P \leq 0.05$ was considered to indicate statistical significance (two-tailed test).

The statistical Package for Social Sciences (SPSS version 26.0.0.0; IBM SPSS statistics, IBM Corporation, Armonk, NY, USA) was used for the statistical analysis.

Results

A total of 898 patients were included in our study. Mean age was 43 years ± 11.4. The majority was female (n = 788; 87.8%). Patients either underwent Roux-en-Y gastric bypass (RYGB) (n = 792; 88.2%) or sleeve gastrectomy (SG) (n = 106, 11.8%). Mean BMI of patients before weight loss surgery was 42.4 kg/m^2 ± 6.4. Mean BMI at time of body contouring surgery was 27.4 kg/m^2 ± 6.4 with an average weight reduction of 40.6 kg ± 15.8. Most patients underwent the standard abdominoplasty procedure (n = 744; 82.9%); circumferential lower body lift was performed in 135 patients (15%) and fleur-de-lys abdominoplasty in 19 patients (2.1%). Mean time between initial bariatric surgery and body contouring surgery was 44 months ± 38.9. During surgery an average of 1.969 g ± 1.509.8 g was resected. Mean LOS was 3.6 days. Smokers (n = 196; 21.8%) were included in our series. Diabetes mellitus type 2 (DM2) was present in 4.7% (n = 42) of cases (Table 1).

A total of 283 complications was reported in 268 patients. Overall patient complication rate was 29.8% (n = 268). Superficial wound dehiscence and seroma formation were most frequent and occurred in respectively 14.6% (n = 131) and 8.7% (n = 79) of all patients. DVT and PE were seen in 5 cases (0.6%) and only needed medical treatment. Surgical re-intervention for complications was needed in 4.1% of cases (n = 36). This was done under local or general anesthesia respectively in 2.4% and 1.6%. There were no life-threatening complications or deaths in our series (Table 2).

Complications were graded using the Clavien-Dindo classification. Patients could have multiple complications but were allocated according to the complication with the highest grade. Minor complications requiring local wound care or consequential aspirations of seroma (Clavien-Dindo grade I) were most common (n = 142/283; 50.2%). Complications requiring antibiotic treatment or blood transfusions (Clavien-Dindo grade II) occurred in 31.8% (n = 90/283). Grade III complications were noted in 12.7% (n = 36/283); these were treated under local (n = 22/283; 7.8%) or general anesthesia (14/283; 4.9%). There were no grade IV complications.

Statistical analysis revealed that gender, smoking, DM2, BMI at time of abdominoplasty, amount of tissue resected, and time interval between bariatric surgery and abdominoplasty was all significantly associated with increased complication rate (Table 3). Male patients had a significantly higher complication ratio compared to the female

Table 1 Demographics

Variable	Total (n = 898)
Age (y)	
Mean	43.4
Median	43
SD	11.4
Sex, n (%)	
Male	110 (12.2)
Female	788 (87.8)
Smoking, n (%)	
Yes	196 (21.8)
No	582 (64.8)
Missing	120 (13.4)
Diabetes, n (%)	
Yes	42 (4.7)
No	799 (89.0)
Missing	57 (6.3)
Hospital stay (days)	
Mean	3.6
Median	3
SD	1.2
Resected weight, median (g)	
Mean	1969.3
Median	1625
SD	1509.8
BMI at time of bariatric surgery (kg/m^2)	
Mean	42.4
Median	40.9
SD	6.4
BMI at time of abdominoplasty (kg/m^2)	
Mean	27.5
Median	26.7
SD	5.1
Weight reduction before abdominoplasty (kg)	
Mean	40.4
Median	40
SD	15.8
Interval between bariatric surgery and abdominoplasty (months)	
Mean	42.3
Median	27
SD	38.9

population ($p = 0.047$). Smoking was associated with a higher risk for complications ($p = 0.031$). Complications were significantly higher in patients with DM2 (p = 0.049). A higher BMI at time of abdominoplasty and higher amount of resected tissue are both significantly associated with a higher complication rate (p = 0.006 and p < 0.001 respectively). Finally, a significant higher complication rate was noted when patients had a longer time interval between their initial bariatric surgery and the abdominoplasty (p = 0.01).

Conclusion

Due to the increasing prevalence of obesity, bariatric surgery is still on the rise. As a consequence the demand for the so-called post-bariatric procedures is exponentially growing. Despite the massive weight loss, many patients are not yet satisfied with their new body and removal of this excess skin and fat seems to be the final step in their process of fighting obesity. Often the emotional aspect is just as, or even more, important than the physical aspect when applying for body contouring surgery. However, patients undergoing body contouring surgery in a post-bariatric setting are at a 60 to 87% greater risk of complications [7–10]. Overall complication rate for patients undergoing post-bariatric surgery ranges from 20 to 66% in literature [11]. Even with the high risk of morbidity, the benefit outweighs the risk for many patients.

Comparing complications rates between different studies are challenging due to a lack of standardization in the reporting methods. In the present retrospective study, the Clavien-Dindo (CD) classification was used to document and grade complications in a uniform manner [12–14]. This classification system is generally accepted for reporting complications in the area of general and other fields of surgery. It is known to be a validated therapy-oriented classification system for complications, ranking adverse events by severity with avoidance of confusing terms [14].

An overall complication rate of 29.5% was reported in our series which is consistent to other published series [3, 15–17]. Most complications were graded type I (50.2%) and thus "minor" of nature.

The most frequent type I complication was wound dehiscence (27.6%). Moreover, wound dehiscence was the most common overall complication and occurred in 14.6% of all cases. This frequency is relatively low compared to the overall 22–30% wound dehiscence rate reported in literature [5]. The majority could be treated with local therapy (type I).

Seroma formation is a frequent encountered problem following abdominoplasty. Since a large dissection area is created during this procedure the problem of dead space arises, making it prone to seroma formation. The prevalence of seroma ranges from 5 to 43% [18]. The seroma rate in our series was 8.8% with the use of two spiral aspiration drains. The majority of patients is discharged with one drain, which is removed after one week when output is < 30 cc/24 h. Several other surgical strategies have been proposed to reduce the risk of seroma formation including preservation of the Scarpa fascia, scalpel dissection below the fascia, and the use of sutures to obliterate the dead space between the Scarpa fascia and the muscle fascia [19, 20]. However, a recent meta-analysis on 4295 patients showed no

Table 2 Characteristics of patients and surgery

	Complications (n = 268)	No complications (n = 630)	p-value	Test
Age (y)			0.354	Mann-Whitney U
Mean	43.9	43.1		
Median	44	43		
SD	11.7	11.2		
Smoking, n (%)			0.049	Fisher's exact
Yes	71 (7.9)	125 (13.9)		
No	167 (18.6)	415 (46.2)		
Missing	30(3.3)	90(10.0)		
Diabetes type 2, n (%)			0.050	Fisher's exact
Yes	18 (2,0)	24 (2,7)		
No	229 (25.5)	570 (63.5)		
Missing	21(2.3)	36 (4.0)		
Hospital stay (days)			0.897	Mann-Whitney U
Mean	3.65	3.53		
Median	3	3		
SD	1.4	1.1		
Resected weight, median (g)			<0.001	Mann-Whitney U
Mean	2364.5	1799.5		
Median	1871	1491		
SD	1874.8	1287.7		
BMI at time of bariatric surgery (kg/m^2)			0.289	Mann-Whitney U
Mean	43.2	42.1		
Median	40.9	40.9		
SD	7.1	6.0		
BMI at time of abdominoplasty (kg/m^2)			0.008	Mann-Whitney U
Mean	28.4	27.2		
Median	27.3	26.4		
SD	5.6	4.8		
Weight reduction before abdominoplasty (kg)			0.439	Mann-Whitney U
Mean	40.2	40.5		
Median	40	40		
SD	17.9	14.8		
Interval between bariatric surgery and abdominoplasty (months)			0.002	Mann-Whitney U
Mean	47	40		
Median	30	26		
SD	43.7	36.4		

difference in complications nor seroma rate between the previously mentioned techniques [21].

The prevalence of other complications in our series, such as hematoma and umbilical ischemia, was low compared to literature. The majority of these complications was graded type I or II. Importantly, DVT and PE was observed in only 0.6% (n = 5) of all patients even though no low molecular weight heparin (LMWH) is administered postoperatively. All of these patients had normal laboratory coagulation levels and none of them was known with pre-existing coagulation disorders. All were non-smokers. These findings are very low compared to other studies, reporting a prevalence of DVT and PE in 2–9% [5]. As a preventive strategy, patients wear graduated compressive stockings (per- and postoperative) and are repeatedly advised to move their legs on a regular basis while still in bed. LMWH is only administered when indicated in high-risk patients. In the still very obese patients (BMI > 50kg/m^2), intermittent pneumatic compression is applied.

Male gender is independently associated with an increased risk of complications following post-bariatric abdominoplasty. Using multivariate regression to adjust for the effect of other patient factors (smoking, diabetes, age,

Table 3 Logistic regression analysis of risk factors for complications after abdominoplasty

Variable	Adjusted OR (95% CI)	*p*-value
Gender (male)	1.631 (1.006–2.643)	0.047
Smoking (yes)	1.534 (1.040–2.264)	0.031
Diabetes type 2 (yes)	2.150 (0.996–4.642)	0.049
BMI at time of abdominoplasty (kg/m^2)	1.049 (1.014–1.086)	0.006
Interval (months)	1.005 (1.001–1.009)	0.01

BMI before body contouring surgery, time interval, and specimen weight), male gender still remains an independent risk factor for complications. Although the mechanism of this finding is not well understood, this finding is in accordance to the study of Donato et al. [22].

Cammarata et al. demonstrated that advanced age (≥ 65 years) is an independent risk factor for wound and overall complications [23]. Analysis of our series could not confirm those findings and advanced age could not be withheld as an independent risk factor for complications.

Many studies have reported the effects of smoking on wound healing. It is generally accepted that smoking negatively influences wound healing due to vasoconstriction and hypoxemia, although there are still many controversies on this topic [3, 5, 17, 24–27]. Table 4 shows an overview of studies demonstrating the role of smoking on wound healing in abdominoplasty. When interpreting the results, one should always keep in mind the included number of patients and the proportion of smokers in that specific population. In our series of 898 patients with 21.8% (n = 196) active smokers, smokers have a significantly higher risk for wound complications after abdominoplasty. Preoperatively patients are advised to quit smoking but surgery is not refused in case of failure. As a consequence, smokers are extensively informed and warned for this higher complication risk. The present study is the only one so far with a significant high number of post-bariatric patients undergoing abdominoplasty that demonstrates a negative impact of smoking on wound healing. In contrast, Neaman et al. showed no impact of smoking on wound healing in 1008 patients undergoing cosmetic abdominoplasty. However, in those series, the proportion of smokers was only 10.7% (n = 108) and also included patients that quit within 3 months before surgery. Additionally, only 10.6% of patients were post-bariatric, not mentioning the proportion of smokers in this subgroup. More uniform and larger studies are necessary to confirm or reject that post-bariatric smokers behave differently and are at higher risk for wound healing-related complications.

Obese patients have a seven fold higher risk for developing diabetes in comparison to healthy people [28]. It is widely demonstrated that DM2 influences microvascularization leading to poorer tissue perfusion and lower exchange of nutrients. This makes DM2 an independent and modifiable risk factor for poor wound healing and surgical site infections [28, 29]. Previous studies already showed a significant increase in wound complications for diabetic patients undergoing abdominoplasty [28, 30]. Our results are consistent with these findings and show a significant higher risk for complications in wound healing after abdominoplasty in patients with DM2. Therefore, it is imperative in these patients to obtain and optimize blood sugar control pre- and postoperatively.

Bariatric procedures are an effective way for obese patients to obtain massive weight loss in a small period of time. Consequently, this leads to abundant residual skin and fatty tissue which is the cause for many physical and emotional problems [9, 10]. In our center, patients undergoing post-bariatric surgery should wait at least 12 months after their initial bariatric surgery and have a stabilized weight for at least 3 months. Nevertheless, many patients remain overweight (BMI > 25 kg/m^2) after achieving their minimum weight. Our findings reveal that wound complications are directly proportional to the pre-abdominoplasty BMI. Many reports already illustrated that patients with a higher preoperative

Table 4 Overview of complications in smokers in literature

Authors	Year	*N*	*N* (%) smokers	Significance
Gravante et al.	2007	73	38 (52.05%)	$p < 0.0001$
Hensel et al.	2001	199	37 (18.6%)	$p < 0.05$
Manassa et al.	2002	132	71 (53.8%)	$p < 0.01$
Momeni et al.	2009	139	48 (34.5%)	NS
Neaman et al. and Hansen et al.	2007	206	38 (18.4%)	$P = 0.049$
Neaman et al.	2013	1008	108 (10.7%)	NS
Samra et al.	2010	161	27 (16.8%)	NS

BMI are at higher risk for complications in wound healing [9, 29, 31–36]. To date, there is no consensus whether patients should be selected according to their preoperative BMI.

In close relationship to pre-abdominoplasty BMI is the resected weight of the specimen. This is probably due to the fact that patients with a higher preoperative BMI also have a larger pannus size. The present results indicate that a higher resection weight is significantly associated with a higher risk for complications, consistent to other authors [9, 36–38]. On the other hand, no correlation was found between wound healing complications and pre-bariatric BMI or maximal weight loss.

As a new finding in literature, a strong significant correlation between wound healing complications and the interval between the initial bariatric procedure and the abdominoplasty was found. Statistical analysis revealed that patients waiting longer for post-bariatric surgery (after initial stabilized weight) are at higher risk for developing wound problems. This has not been demonstrated before. Currently, we have no clear explanation for this surprising finding but it is hypothesized that when patients wait longer for their post-bariatric procedure their nutritional status might be compromised, especially if in-hospital follow-up had ended. Patients had either a RYGB or a SG, both prone to the development of nutritional deficiencies. We found no significant statistical difference between RYGB and SG in the occurrence of complications. All patients are advised to take nutritional supplements. Future checkups routinely include blood tests checking for nutritional deficits. It is well documented that nutrition is imperative in the wound healing process. Despite their small sample size, Austin et al. found that preoperative protein supplementation for patients undergoing abdominoplasty was associated with 0% complications compared to 21% in their control group [39]. This conclusion was also supported by the findings of Agha-Mohammadi et al. [40].

Standardized blood tests are implemented in our preoperative workup but only focusing on the most common deficits (iron, vitamin B-complex, folic acid). However, a large number of other vitamins, minerals, and proteins (e.g., vitamin A, C, E, zinc, copper, selenium, albumin …) play an important role in the wound healing process [40]. Since our preoperative nutritional assessment at this time was incomplete, we were not able to further investigate the impact of nutritional deficiencies. In view of the importance of these findings, nutritional data on patients will be collected and analyzed for future research.

Post-bariatric surgery is becoming a separate surgical subspecialty. The amount of publications related to post-bariatric surgery in general is increasing. Uniform reporting methods (e.g., Clavien-Dindo) need to be considered urgently in order to be able to compare the different results. Only then surgeons will be able to draw the exact conclusions and to deliver the best possible care.

Post-bariatric surgery is performed both by general and plastic-reconstructive surgeons. It is important that every surgeon decides in good conscience whether they are able to perform the procedure to meet the patients' expectations. Post-bariatric surgery is not strictly cosmetically in nature but also has a functional aim and both groups of surgeons should not compete but rather work in symbiosis together. In the meantime, reimbursement criteria are necessary to help the post-bariatric patient to afford those functional and reconstructive procedures.

This study is subject to the inherent limitation of any retrospective study. Additionally, patient satisfaction and quality of life were not investigated.

In conclusion, this current study is to our knowledge the largest retrospective analysis of exclusively post-bariatric abdominoplasty cases. Male gender, smoking, DM2, BMI at time of abdominoplasty, amount of tissue resected, and time interval between bariatric surgery and abdominoplasty were all identified as risk factors for complications. Surgeons should take these risk factors into consideration when counseling patients preoperatively and optimize where possible.

Declarations

Ethics Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent does not apply.

Conflict of Interest The authors declare no conflict of interest.

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