JOURNAL OF PLASTIC SURGERY AND HAND SURGERY
2022, VOL. 56, NO. 6, 326–334
https://doi.org/10.1080/2000656X.2020.1788043

ARTICLE

Retrospective analysis of the predictive factors associated with good surgical outcome in brachioplasty in massive weight loss patients

Paolo Marchica[a], Franco Bassetto[a], Chiara Pavan[b], Massimo Marini[b], Alfredo M. Raimondi[b], Caterina Gardener[a], Martina Grigatti[a], Andrea Pagani[a], Tito Brambullo[a], Michele Zocchi[a] and Vincenzo Vindigni[a]

[a]Clinic of Plastic Surgery, University of Padua, Padua, Italy; [b]Department of Psychiatry, University of Padua, Padua, Italy

ABSTRACT

Background: Upper arm lift is a widespread body contouring procedure, but no globally accepted guidelines exist in selecting patients and, due to comorbidity and heterogeneity of them, it is difficult to identify predictive factors of good surgical outcome. The authors review the team's experience of 56 brachioplasty performed in massive weighs loss patients.

Methods: Data of 56 consecutive arm lifts were reviewed for preoperative, perioperative and postoperative variables and outcomes (complications, scarring, wound healing, revision surgery, need for blood transfusion, satisfaction, etc.). Surgical technique and postoperative care are described. A statistical analysis was performed to identify relationship between possible predictive factors and outcomes. Furthermore, an evaluation of different employed wound management devices was conducted.

Results: Follow-up ranged from 6 to 36 months (mean 20.1 months). Outcomes summary is reported (overall complication rate 50%, poor scarring rate 25%, delayed wound healing rate 26.8%, revision surgery rate 37.5%, need for blood transfusion rate 8.9%, satisfaction rate 71.4%) and statistical investigation evidenced the role of prior plastic surgery BMI and the associated change in BMI before and after weight loss, just prior brachioplasty, and the modality of weight loss.

Conclusion: The authors' technique resulted in positive outcomes overall, considering the difficulty in dealing with the problems of MWL patients. Based on our results, we aim to suggest to perform brachioplasty in patient with the lower achievable BMI (preferably <30kg/m2) to reduce the negative effect of unmodifiable factors as diabetes, modality of weight loss, a wide ΔBMI, and other well-known negative predictive factors.

Abbreviations: BMI: body mass index; MWL: massive weight loss; BAPRAS: British Association of Plastic, Reconstructive and Aesthetic Surgeons; GCP: good clinical practice; WL: weight loss; sNPWT: single-use negative pressure wound therapy; DWH: delayed wound healing; VSS: Vancouver scar scale; MSS: Manchester scar scale; I.V.: intravenous; VTE: venous thromboembolism; kg: kilograms; m^2: square meter; g: grams; mg: milligrams; dL: deciliter; yo: years old; pts: patients; SG: sleeve gastrectomy; LAGB: laparoscopic adjustable gastric banding; GB: gastric bypass; IGB: intragastric balloon; Hb: hemoglobin; NR: normal range; F: French; wks: weeks

ARTICLE HISTORY
Received 29 February 2020
Revised 6 June 2020
Accepted 22 June 2020

KEYWORDS
Brachioplasty; body contouring surgery; arm lift; massive weight loss; obesity; BMI; postbariatric surgery

Introduction

Body contouring surgery is a continuous developing discipline due to the intrinsic complexity of massive weight loss (MWL) patients and a common address of reconstructive surgeons is necessary. Latest BAPRAS recommendations suggest a BMI $\leq$30.0 kg/m^2, weight stability of 12 months and significant functional disturbance (both physical and psychological), as general criteria for body contouring surgery [1]. Nevertheless there are not guidelines for each procedure.

Upper arm lift developed since 1930s and nowadays modern techniques are based on works by Pascal-Le Louarn [2] and Gusenoff-Rubin [3].

MWL patients are complex candidates to all surgeries because of comorbidities due to their metabolic condition and weight history [4,5], thus a scientific approach in select brachioplasty patient is needed. Song [6], El Khatib [7] and Abboud [8] described different type of 'bat wing' deformity, depending on grade of ptosis, adiposity, skin excess and tone, thus different patients can be addressed to fit procedures. However, there are not any studies that recommend which patients are ideal candidates to arm lift.

Our work aims to provide tools to select the patient, trying to foresight postoperative outcomes, based on preoperative, perioperative and postoperative variables that could influence the final result.

Materials and methods

The sample

A retrospective analysis was conducted on all MWL patients underwent brachioplasty from 2016 to 2018. Requirements of the Declaration of Helsinki as well as principles of GCP were taken into consideration. Patients gave full consent to use their personal data. Institutional review board approval was obtained before conducting the study.

CONTACT Paolo Marchica paolomarchica91@gmail.com Clinic of Plastic Surgery, University of Padua, Via Nicolò Giustiniani, 2, Padua, PD, 35128, Italy
This work has been presented at Italian Society of Plastic Surgery annual national meeting 2019 (SICPRE 2019, 26–28 Setpember, Palermo, Italy).

Data were obtained from patients' charts and phone surveys were performed to complete follow-up.

Our sample included 56 women that obtained surgical or non-surgical weight loss (WL) and presented themselves to our attention because of visible and unpleasant upper arm deformity. Each individual patient was preoperatively graded according to the Pittsburgh classification [6] (severity ranged from grade 2–3), subsequently estimating the extent of resections. Surgery inclusion criteria were a stable weight condition for at least 6 months and stabilized, not life-threatening, medical or psychiatric comorbidities. Skin infections, presence of lymphedema and venous or arterial insufficiency as well were considered as exclusion criteria. BMI variation before WL and before plastic surgery (ΔBMI) $>5\,kg/m^2$ was required prior performing surgery [1].

All patients had different comorbidities and medical (smoking history, diabetes mellitus, hypothyroidism, threated with hormone replacement therapy and anemia were the main considered issues) and psychiatric history. Weight history was evaluated and considered for the analysis, and patients were grouped by interval of preoperative plastic surgery BMI [9]: Ideal ($BMI < 25$), Overweight ($25 \leq BMI < 30$), Obese ($30 \leq BMI < 35$), Morbidly Obese ($35 \leq BMI < 40$).

A preoperative plastic surgery $BMI = 30 kg/m^2$ was considered as cut-off to group patient in hypothetic ideal candidates ($BMI < 30$) and non-ideal candidates ($BMI \geq 30$). Total ΔBMI and cut-off of $15\,kg/m^2$ were considered as well.

Preoperative hemoglobin and bilirubin serum values and their relationship with outcomes were investigated. Concurrent lipoaspiration and other body contouring procedures (abdominoplasty, mastoplasty, thigh lift, trunk lipoaspiration and cervicofacial rhytidectomy) were considered.

Different postoperative dressing were randomly use to treat surgical wounds, depending on surgeons' choice and patients were distinguished in three groups: conventional sterile taping Steri-Strip™ (3 M, Two Harbors, MN, USA), Zip® Surgical Skin Closure System (ZipLine Medical, Campbell, CA) and PICO™ Single Use Negative Pressure Wound Therapy System or sNPWT (PICO™; Smith & Nephew, Hull, UK).

All patients followed the same postoperative prescription in using elastocompressive upper limb garments for subsequent 3 months and started treating scars with massotherapy and topical self-drying silicone gel products 30 days after surgery.

The outcomes

Primary outcomes were identified in complications, distinguishing among majors and minors (majors: severe postoperative anemia requiring transfusion, permanent lymphedema, early revision surgery within a month, thromboembolism, sepsis, death; minors: seroma, hematoma, skin infection, wound dehiscence, poor scarring as scar hypertrophy, asymmetry and scar retractions, paresthesia, transient lymphedema) and delayed wound healing or DWH (need for dressing beyond three weeks). Secondary outcomes were length of hospital stay, time of drains removal, need for revision surgery and blood transfusion, scar quality (scar assessment was carried out with Vancouver Scar Scale, or VSS [10], and Manchester Scar Scale, or MSS [11], time to return to normal activities (more or less than 30 days), and general satisfaction about surgery.

Data were recorded and statistical analyses were performed using a 2-tailed Fisher Exact Test for binary and categorical data or one-way ANOVA test for ordinal data. *p*-values < 0.05 were considered statistically significant [Office 365 MS Excel for Mac OS X, V. 16.30 (19101301); IBM SPSS Statistics V26 for Mac] and *p*-values <0.1 were taken into consideration to identify weaker relationships even if not statistically significant.

Figure 1. Preoperative evaluation, frontal view, abducted arms.

Figure 2. Preoperative evaluation, back view, abducted arms.

Operative technique

Pre-operative marking is carried out in upright position with abducted arms, first marking the future scar site that falls more posteriorly than Pascal-Le Louarn technique [2], from the medial epicondyle of the humerus to the caput longum triceps brachii insertion point in the axilla. No consensus about the scar position exists [12]. Afterwards due to downwards and upwards skin traction and pinch test of the skin, superior and inferior incision lines are marked on antero-medial and postero-medial aspects of the arm, and an axillary Z-plasty is drawn, if the scar extends to the chest wall, to minimize the risk of scar retraction.

Surgery is carried on with the patients in supine position and abducted arms, in general anesthesia and orotracheal intubation. Preoperatively, Cephazolin I.V. 1 g is used as antibiotic prophylaxis. If needed (grade 2b and 3 deformity) [7], traditional arm wet lipoaspiration is performed. First superior incision is made, dissecting up to the superficial fascia, respecting the deep adipose tissue which protects the deep fascia, on which run the medial cutaneous sensory nerves. Dissection is carried on towards the postero-medial aspect of the arm and second incision line is determined

Figure 3. Postoperative result, frontal view, abducted arms.

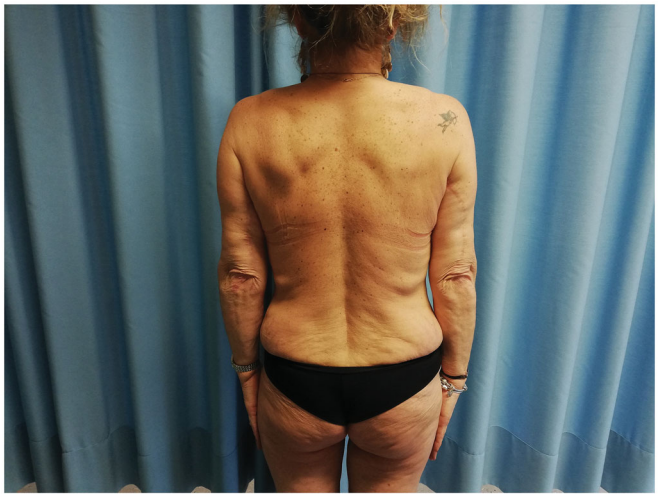

Figure 4. Postoperative result, back view, adducted arms.

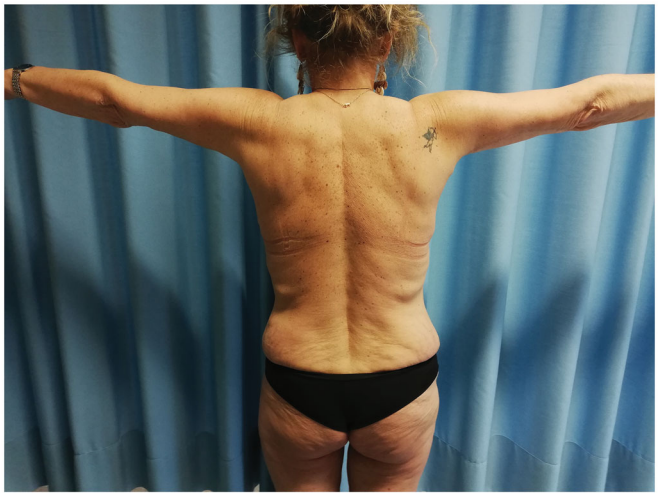

Figure 5. Postoperative result, back view, abducted arms.

in order to establish the excess of skin. Once the brachial skin excess is resected, the wound margins are faced together, to assess the tension and perform eventual changes. A silicone drainage (15-19F) is placed *in situ* in all procedures and all closures are done in three layers in superficial fascia and in the deep dermis with #3/0 resorbable thread simple buried dermal sutures and running subcuticular sutures with #4/0 resorbable thread (Monosyn®, B. Braun Surgical, S.A., Rub., Barcelona, Spain).

Contralateral resection is performed by comparing the arms. Postoperative dressing devices are applied (Steri-Strip™, Zip®, PICO™) with arm compressive garments.

A clinical case is reported in Figures 1–5, respectively the preoperative evaluation (Figures 1 and 2) and postoperative result at 1 year (Figures 3–5).

Results

The following tables summarize the results of our retrospective analysis (Tables 1–5).

Demographics data indicated a mean age of 49.39 years old, average prior WL weight and BMI of 118.25 kg and 44.40 kg/m^2, and average prior plastic surgery weight and BMI of 73.73 kg and 27.71 kg/m^2, with a mean ΔBMI of 16.69 kg/m^2. 51.8% had history of smoking but only 19.6% continued smoking at the time of surgery. Investigated comorbidities revealed 8.9% of patients affected by diabetes mellitus, 26.8% suffered of hypothyroidism, and 30.4% had chronic multifactorial anemia (mean serum Hb of 12.46 g/L). 26.8% patients suffered had psychiatric history.

Almost all patient received upper limb lipoaspiration (85.7%) and 48.2% had a concomitant body contouring procedure, with mastoplasty predominance.

Different postoperative wound management devices were randomly applied by the surgeons: 25% of patients received Steri-Strip™ for two weeks, 37.5% was treated with PICO™ for first postoperative week, while 37.5% received Zip® for three weeks. All patients followed postoperative prescriptions (elastocompressive upper limb garments and massotherapy).

Follow-up ranged from 6 to 36 months (mean 20.1 months). Mean hospital stay was 1.86 days, with 19.6% patients that prolonged the hospitalization beyond 2 days. Mean drainage holding time almost coincided with the length of hospital stay (1.75 days).

Overall complication rate was 50%, 39.3% patients had minor complications only (poor scarring 25% (Figure 6), dog ears 12.5%, transient paresthesia 1.8%, seromas 5.4%) and just 10.7% patients had major events associated (3.6%) or not (7.1%) with minor issues (severe anemia with consequent need for blood transfusion 8.9%, and one case of early revision within a month because of important surgical wound dehiscence 1.79%).

73.2% of surgical wounds healed in less than 3 weeks, while 26.8% patients presented delay in wound healing and needed more than 3 weeks to heal. Revision surgery rate was 37.5% but almost all reintervention were late revision procedures because of poor scarring. Average time to return to normal daily activities was 30.55 days (32.1% patients needed less than 30 days).

Mean VSS [10] and MSS [11] scores were 4.29/13 and 7.79/16 and final average satisfaction of the patients, ranged from 0 (the worst) to 10 (the best), was 6.63/10, demonstrating that brachioplasty procedures overall results were positive from the point of view of both the surgeon and the patients (71.4% patients satisfied).

Relationships between primary and secondary outcomes and possible predictive factors were investigated and are summarized in Table 6 (statistically significant *p*-values are bolded and underlined, while *p*-values <0.1 close to the significant threshold are underlined only). Many of these did not reveal a significant relationship ($p > 0.05$), although some of these variables are known risk factor in literature (e.g. smoking history, active smokers [13], Hb value diagnostic for anemia [14].

Table 1. Patient demographics/Preoperative factors.

Patient demographics/preoperative factors	
No. of patients	56
Age (Years)	49.39 ± 9.99
Prior WL weight (kg)	118.25 ± 16.21
Prior WL BMI (kg/m^2)	44.40 ± 5.88
Prior plastic surgery weight (kg)	73.73 ± 11
Prior plastic surgery BMI (kg/m^2)	27.71 ± 4.22
BMI group (kg/m^2)	41 pts BMI $<$ 30 (73.2%) 15 pts BMI $\geq$ 30 (26.8%) • BMI $<$ 25 (18 pts, 32.1%) • 25 $\leq$ BMI $<$ 30 (23 pts, 41.1%) • 30 $\leq$ BMI $<$ 35 (10 pts, 17.9%) • 35 $\leq$ BMI $<$ 40 (5 pts, 8.9%) • BMI $>$ 40 (0 pts, 0%)
BMI change between before wl and before plastic surgery or ΔBMI (kg/m^2)	16.69 ± 5.48
WL modality	Surgical WL 43 pts (76.8%) • 24 SG • 3 LAGB • 15 GB • 1 IGB Non-surgical WL 13 pts (23.2%)
Smoking history	Yes–29 pts (51.8%) No–27 pts (48.2)%
Active smokers	Yes–11 pts (19.6%) No–45 pts (80.4%)
Diabetes mellitus	Yes–5 pts (8.9%) No–51 pts (91.1%)
Hypothyroidism (treated with hormone replacement therapy)	Yes–15 pts (26.8%) No–41 pts 73.2%)
Anemia ($<$12g/l, all causes)	Yes–17 pts (30.4%) No–39 pts (69.6%)
Psychiatric disorder	Yes–15 pts (26.8%) • 4 anxiety disorder • 7 depressive disorder • 4 alimentary disorder No–41 pts (73.2%)
Lab test (preoperative serum values)	
HB (G/L) NR $\geq$ 12	12.46 ± 1.47
Total bilirubin (mg/dL), NR $<$ 17.1	9.19 ± 5.19
Direct bilirubin (mg/dL), NR $<$ 3.4	3.74 ± 1.78
Indirect bilirubin (mg/dL) NR $<$ 13.7	5.44 ± 3.57

WL: weight loss; BMI: body mass index; kg: kilograms; m^2: square meter; mg: milligrams; dL: deciliter; yo: years old; pts: patients; SG: sleeve gastrectomy; LAGB: laparoscopic adjustable gastric banding; GB: gastric bypass; IGB: intragastric balloon; Hb: hemoglobin; NR: normal range.

Table 2. Perioperative factors.

Perioperative factors	
No. of patients	56
Associated lipoaspiration	Yes – 48 pts (85.7%) No – 8 pts (14.3%)
Other associated body contouring plastic surgery procedures	Yes – 27 pts (48.2%) • 6 abdominoplasty • 14 mastoplasty • 3 thigh lift • 3 trunk lipoaspiration • 1 cervicofacial rhytidectomy) No – 29 pts (51.8%)

Pts: patients.

Table 3. Postoperative factors/postoperative wound and scar managements.

Postoperative factors/postoperative wound and scar managements	
No. of patients	56
Elastocompressive upper limb garments (I class)	56 pts (100%)
Massotherapy and topical self-drying silicone gel products	56 pts (100%)
ZIP® Surgical Skin Closure System (3 WKS)	14 pts (25%)
PICO^{TM} SNPWT (1WK)	21 pts (37.5%)
Conventional sterile taping (Steri-Strip^{TM}) (2 wks)	21 pts (37.5%)

Pts: patients; wks: weeks; sNPWT: single use negative pressure wound therapy.

Table 4. Postoperative outcomes.

Postoperative outcomes	
No. of patients	56
Length of hospital stay (days)	1.86 ± 1.27 • 11 pts ≥2 (19.6%) • 45 pts < 2 (80.4%)
Time of drains removal (days)	1.75 ± 1.23
Complications (pts)	28 (50%)
Need for blood transfusion (pts)	Yes–5 (8.9%) No–51 (91.1%)
Delayed wound healing or DWH (pts)	15 ≥ 3wks (26.8%) 41 < 3wks (73.2%)
Need for revision surgery (pts)	Yes–21 (37.5%) • 1 early revision for surgical wound dehiscence requiring reintervention (1.8%) No–35 (62.5%)
Time to return to normal daily activities (days)	30.55 ± 18.8 • 18 pts < 30 (32.1%) • 38 pts ≥30 (67.9%)
Scars evaluation	
VSS (Vancouver scar scale)	4.29 ± 2.82/13
MSS (Manchester scar scale)	7.79 ± 2.05/16
Satisfaction	6.63 ± 2.71/10 • 16 pts < 6 (28.6%) • 40 pts ≥ 6 (71.4%)

Pts: patients; DWH: delayed wound healing; wks: weeks.

Table 5. Postoperative outcomes: complications.

Postoperative outcomes: complications	
No. of patients	56
Complications (pts)	28 (50%)
Poor scarring (hypertrofic scar, scar retraction, asimmetry)	14 (25%)
Dog ears	7 (12.5%)
Paresthesia	1 (1.8%)
Seroma	3 (5.4%)
Severe anemia requiring blood transfusion	5 (8.9%)
Wound dehiscence requiring early reintervention	1 (1.8%)
No complication (pts)	28 (50%)
Minor complications only (pts)	22 (39.3%)
Major complications only (pts)	4 (7.1%)
Minor and major complications associated (pts)	2 (3.6%)

Pts: patients.

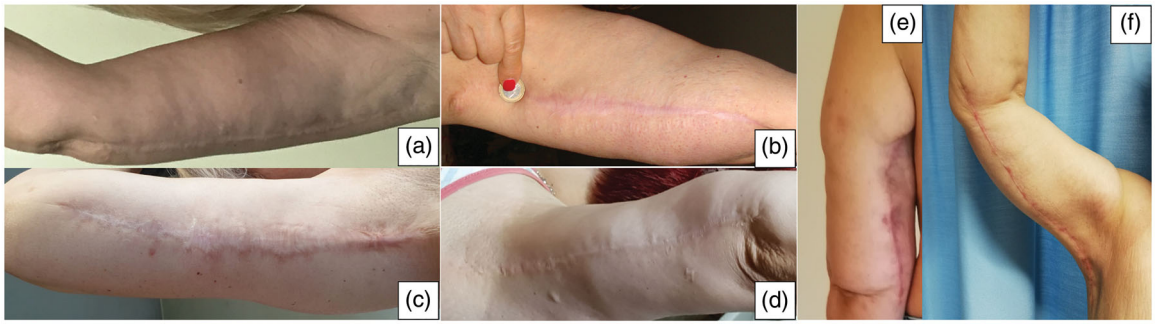

Figure 6. Outcome: scarring. The scars are described and assessed with Vancouver Scar Scale (VSS 0–13; best 0, worse 13) and Manchester Scar Scale (MSS 5–16; best 5, worse 16): 6a normotrophic normochromic scar VSS1, MSS 5; 6 b slightly hypochromic and diastatic scar VSS 4, MSS 8 (a 1 euro coin is placed near the scar to allow for an estimation of the size); 6c hypochromic and diastatic scar VSS 7, MSS 11; 6d normochromic, slightly diastatic scar VSS 1, MSS 6; 6e hyperchromic and hypertrophic scar VSS 10, MSS 14; 6f slightly hyperchromic and hypertrophic scar VSS 7, MSS 9.

Some of the investigated factors revealed a weak relationship with some of the outcomes (p-value > 0.05 but < 0.1, near to the threshold value): primary outcomes e.g. prior plastic surgery BMI $> 30 kg/m^2$ and other concomitant body contouring procedures related to complications; BMI group prior plastic surgery, ΔBMI and diabetes mellitus related to poor scarring; prior plastic surgery BMI $> 30 kg/m^2$ related to DWH; secondary outcomes e.g. ΔBMI $> 15 kg/m^2$ related to the need for revision surgery; ΔBMI $> 15 kg/m^2$ related to need for blood transfusion.

Finally, a statistically significant difference ($p < 0.05$) emerged for factors as prior plastic surgery BMI related to poor scarring (patients with BMI $> 30 kg/m^2$ seem to be negatively influenced in scarring process), prior plastic surgery weight and BMI and WL modality related to DWH (the higher the weight and BMI, the longer is the DWH, and surgical WL modality related to a bad outcome). Secondary outcomes as time to return to daily normal activities was associated to higher prior plastic surgery weight and BMI, with the same trend of DWH. Need for revision surgery

Table 6. *p*-Values obtained performing 2-tailed Fisher exact test or one-way ANOVA test between primary and secondary outcomes and possible predictive factors.

	Outcomes						
Factors	Complications (yes/no)	Complications by gravity (minor/ major/no complications)	Poor scarring (yes/no)	Delayed wound healing (<3wks/≥3wks)	Time to return to normal daily activities (<30days/ ≥3days)	Need for revision surgery (yes/no)	Need for blood transfusion (yes/no)
Age	0.158	0.163	0.351	0.926	0.180	0.111	0.209
Age cut-off 50 years	0.403	0.406	0.216	1.000	0.233	0.165	0.645
Menopause	0.227	0.293	0.489	0.735	0.338	0.212	1.000
Prior WL weight	0.779	0.493	0.295	0.274	0.142	**0.047**	0.674
Prior WL BMI	0.336	0.514	0.546	0.368	0.146	0.119	0.406
Prior plastic surgery weight	0.895	0.477	0.393	**0.009**	**0.028**	0.850	0.298
Prior plastic surgery BMI	0.949	0.540	0.202	**0.018**	**0.024**	0.535	0.480
Prior plastic surgery BMI cut-off 30	0.547	0.100	**0.037**	0.085	0.202	0.534	0.309
BMI group prior plastic surgery	0.390	0.223	0.057	0.295	0.183	0.729	0.373
BMI change between before wl and before plastic surgery (ΔBMI)	0.279	0.164	0.100	0.413	0.877	**0.030**	0.148
ΔBMI cut off 15	0.587	0.201	0.213	0.125	0.155	0.092	0.071
WL modality	0.528	0.534	0.274	0.730	1.000	0.201	1.000
WL modality by type	0.624	0.773	0.231	**0.048**	0.378	0.402	1.000
Smoking history	1.000	0.222	0.542	0.552	0.779	1.000	0.185
Active smokers	1.000	0.889	0.711	0.461	1.000	1.000	1.000
Diabetes mellitus	0.352	0.213	0.094	1.000	0.652	0.352	1.000
Hypothyroidism (treated with hormone replacement therapy)	0.547	0.683	0.307	0.735	0.524	1.000	1.000
Anemia (<12g/L, all causes)	0.562	0.157	0.317	0.755	0.763	1.000	0.634
Anemia grade	0.325	0.204	0.292	0.721	0.931	0.464	0.136
Psychiatric disorder	0.227	0.191	0.489	1.000	0.751	0.764	0.113
Type of psychiatric disorder	0.422	0.237	0.608	1.000	1.000	0.534	0.053
Lab test (preoperative serum values)							
HB (g/L) NR ≥ 12	0.865	0.207	0.241	0.971	0.773	0.615	0.156
Total bilirubin (mg/dL)	0.138	0.284	0.986	0.986	0.731	0.795	0.305
Total bilirubin (mg/dL) Cut-off NR <17.1	0.180	0.495	1.000	1.000	0.665	0.637	1.000
Direct bilirubin (mg/dL)	0.189	0.340	0.821	0.941	0.727	0.967	0.291
Direct bilirubin (mg/dL) Cut-off NR < 3.4	0.377	0.532	0.741	0.501	0.751	0.762	0.635
Indirect bilirubin (mg/dL)	0.145	0.310	0.942	0.998	0.757	0.704	0.353
Indirect bilirubin (mg/dL) cut-off NR < 13.7	1.000	1.000	0.473	1.000	0.532	1.000	1.000
Associated upper limb lipoaspiration	0.252	0.190	0.664	1.000	1.000	1.000	1.000
Other concomitant body contouring plastic surgery procedures	0.162	0.106	0.626	0.826	0.906	0.126	0.212
Time of drains removal	0.925	0.402	0.890	0.729	0.838	0.627	**0.036**
Post-operative wound management devices (all compared)	0.348	0.164	0.097	0.161	0.159	0.537	0.424
ZIP® surgical skin closure system vs. all devices	0.355	0.081	0.732	0.082	0.113	0.532	0.316
PICO™ single use negative pressure wound therapy system vs. all devices	1.000	0.851	0.113	0.534	1.000	0.264	1.000
Conventional sterile taping steri-strip™ vs. all devices	0.269	0.193	0.056	0.534	0.143	0.777	0.352
SATISFACTION	0.341	0.610	0.054	**0.002**	0.428	**0.003**	0.278

WL: weight loss; BMI: body mass index; NR: normal range.
Statistically significant *p*-values are bolded and underlined. *p*-values <0.1 close to the significant threshold are underlined only.

seemed to be influenced by prior weight loss weight and a larger ΔBMI. Finally need for blood transfusion showed association with time of drains removal (the earlier the drains were removed, the higher was the risk of need for blood transfusion).

No relationship emerged between psychiatric history and the outcomes, while satisfaction was surely influenced by a DWH ($p < 0.05$) and probably by a poor scarring and need for revision surgery, with p-values near to threshold value ($p < 0.1$). Finally, no relationships emerged between satisfaction (cut-off 6/10) and associated procedures, except lipoaspiration ($p > 0.05$).

The study of post-operative wound management devices performed with 2-tailed Fisher Exact Test (Table 6) revealed that no statistically significant differences were found between the use of one of the devices and the outcomes ($p > 0.05$). Only a weak relationship (p-value > 0.05, but < 0.1, near to the threshold value) has been found as regard the use of Zip® and preventing DWH and the use of Steri-Strip™ and scarring, but we cannot affirm the superiority of these devices over the others, rather a trend of superiority of the single outcome DWL in our sample, not applicable to a general population.

Discussion

Despite the increasing request of brachioplasty and wide scientific literature, there is not a gold standard brachioplasty technique that shows significantly improved outcomes and predictive final outcomes factors have not yet been identified.

Most frequent complications include poor scarring [15], edema and lymphedema [15], seromas [16–18], infection [15], underresection [16], common in MWL patients (surgical or dietary and physical exercise induced WL [19,20]. Major issues are less frequent such as venous thromboembolism (VTE), severe anemia, sepsis and death [21]. No consensus exists in literature in distinction among major and minor complication [15–19]. We preferred define as majors, the life threatening events, such as severe anemia requiring blood transfusion, sepsis, VTE, and early revision surgery within a month, and minors the aforementioned seroma, hematoma, skin infection, wound dehiscence, poor scarring as scar hypertrophy, asymmetry and scar retractions, paresthesia, transient lymphedema, and finally the need for late revision surgery, because often due to a visible unpleasant scar, contrariwise to other hidden body contouring surgical scar, such as the abdominoplasty.

We reported a complication rate of 50% (in literature ranged from 22% to 56% [2,21–23]. Such a wide range of percentage may be attributed to an unambiguous definition of complications. Poor scarring rate (25%) may appear high and a wide range of unpleasant scars has been evidenced in literature. Such a disparity may be due to the subjective nature used to diagnose a scar as hypertrophic or more generally poor [22].

Some authors stated that complications rate increases with a prior plastic surgery BMI $> 30 kg/m^2$ [9], and also with a high prior WL BMI and resultant ΔBMI [24], thus considering BMI a predictive factor as regard complications. More specifically, Gusenoff et al. [3] found that change in BMI was a significant predictor of infection. Not all the surgeons found the same association, both for prior WL BMI and prior plastic surgery BMI [25]. Nemerofsky [26], indeed, did not found any relationship between preoperative BMI and outcomes, but they have identified the ΔBMI as a predictive factor (the greater the ΔBMI, the higher results the complications rate).

Being now established that obese patients have high levels of systemic inflammation [27] and high levels of proinflammatory mediators can negatively influence the healing process [28], it is possible to hypothesize that related-obesity systemic inflammation may be in relation to pathological scarring. A certain role of BMI has been established in pathological wound healing, even if patients undergo bariatric surgery and their BMI persists to be within the obese category [29].

We found a weak relationship between complications distinguished by gravity and a BMI $> 30 kg/m^2$, while a stronger association has been found between prior plastic surgery weight and BMI and scarring and DWH. The higher ΔBMI could be considered a predictive factor of need for revision surgery, risk of severe anemization and a weaker predictor of poor scarring.

Surgical MWL patients are usually considered more at risk than non-surgicals [22,25]. Malabsorption, and consequently lack of nutrients, indeed could represent an explanation for the higher rate of complications and poor healing in surgical ones, and a nutritional supplementation is helpful in reducing issues [5,30]. However Gusenoff [31] observed higher complication rates in non-surgical MWL patients, probably due to dietary, metabolic or psychosocial issues and combined surgery. Furthermore, a histological study [32] revealed that despite the inflammatory changes in skin of MWL patients, the differences between surgical and non-surgical group are not enough to explain different outcomes. In our opinion, WL modality could influence the complications and physiological process of wound healing and consequently a normal scarring, based on normal acknowledge of physiology [33] especially causing a delay when a surgical approach leads to weight loss, despite no statistically significant results have been obtained.

Although anemia is a well-known negative predictor in wound healing [34], we did not find any influence on the considered outcomes, as happened with smoking.

Our revision rate was higher than all rates (37.5%) reported in literature, that ranged from 0% to 21% [3,21,22], perhaps due to surgical technique, to scar final position (indeed some patients prefers a bicipital groove scar) that results in a more visible scar and, thus, a lower threshold for aesthetic revisions, and finally to scar-specific complications. Scar location continues to be a debated topic, but a medially based straight scar is the most aesthetically acceptable option when performing a brachioplasty, then a curved posteromedial scar [12].

None of the reviewed articles quantified how long the DWH might have been considered and some authors generically discuss about healing delay without reference to time from surgery [35]. Literature distinguishes between acute and chronic wounds based on the histopathology and molecular biology and the cut-off of 3–4 weeks [36]. We considered the healing time of three weeks within physiological limits to define where a DWH occurred, but this data is not comparable to that of other authors.

No correlation was obtained between the outcomes and associated lipoaspiration, similarly to Gusenoff et al. [3] and Bossert et al. [37].

None of the other independent variables were found associated with complications, poor scarring, DWH and secondary outcomes, maybe due to the small sample size and the overlapping of positive and negative influence of the different factors that heterogeneity of the sample entailed. The same interpretation can be provided regarding the weak relationships (indicated as p-value close to the threshold value, $p > 0.05$ but < 0.1) between the factors and the outcomes.

Abboud et al. [8] strongly stated that in mild–moderate ptosis (grade 1–3), an adequate result is achieved by powered-assisted liposuction, consequent fat grafting and injection. According to El

Khatib [7], in mild ptosis (grade 1–2a) the liposuction approach is the recommended treatment, but in our opinion to extend the use of liposuction to moderate ptosis (thus beyond the grade 2a of El Khatib) may lead to unsatisfying results, because as declared by the same Abboud, patients who underwent revision surgery, were the ones with the worse arm deformities (3 b) considered in its study, thus it may seem a forcing extending a liposuction-only approach to this class of patients. In addition, the author excluded grade 4 patients from his analysis and thus obtained such a low complication and revision rate (2.1% and 9.5%). Therefore, we support the role of excisional therapy for moderate and severe deformities, even if a less invasive approach is advisable for less severe conditions.

All of our patients underwent a surgical excision approach because their deformities were incompatible with a liposuction-only treatment (over 2a grade [7]/3b grade [8]). We did not consider the need to perform lipofilling to lift and thicken the skin of the posteromedial region, as the result was achieved through simple excision.

Not a comparison exists in literature between Zip®, PICO™ and Steri-Strip™. Although no statistically significant results emerged in our analysis, we may suggest the use of Zip® to improve the wound healing process or the use of Steri-Strip™ and sterile taping to improve the scarring process, compared to other devices aware that this prompt is only the result of the trend obtained in our sample.

Conclusion

It is extremely difficult to identify every single predictor that plays a role in leading the investigated outcomes, due to the size and heterogeneity of our sample and to the overlapping of positive and negative influence of all considered factors, but some of these seem to be more involved in conditioning the final result, such as prior plastic surgery BMI, ΔBMI, the modality of WL and diabetes mellitus.

Hence, in our opinion, surgeons should prefer to perform brachioplasty in patients with the lower achievable BMI (preferably $<30 kg/m^2$) to reduce the negative effect of unmodifiable factors as diabetes, modality of weight loss and a wide ΔBMI, according to what observed in our study, and other well-known negative predictive factors (e.g. age, smoking history, chronic anemia or concomitant plastic surgery procedures). The role of liposuction still remains debated. Finally, it is not possible to define a gold standard device between Zip®, PICO™ or Steri-Strip™. A larger and more homogeneous sample could provide more reliable results.

Ethical approval

Requirements of the Declaration of Helsinki as well as principles of GCP were taken into consideration. Patients gave full consent to use their personal data. Institutional review board approval was obtained before conducting the study.

Disclosure statement

None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this manuscript. No funding was received for this article.

Prof. Franco Bassetto has to declare the relevant financial activities outside the submitted work, during the 36 months prior to publication:

- Klox: fees for consultancy and investigator
- Smith and Nephew: fees for consultancy and investigator
- Urgo Medical: fees for consultancy and advisory board
- Acelity: fees for consultancy
- Medtronic: fees for consultancy
- Rigenera: fees for consultancy
- Molnlycke: fees for consultancy
- Sofar: fees for investigator

ORCID

Paolo Marchica https://orcid.org/0000-0002-2108-2979

References

[1] BAPRAS. UK Commissioning guide: Massive Weight Loss Body Contouring. London: British Association of Plastic, Reconstructive and Aesthetic Surgeons, The Royal College of Surgeons of England; 2017 [accessed 2020 Jan 5]. Available from: http://www.bapras.org.uk/docs/default-source/commissioning-and-policy/2017–draft-for-consultation–body-contouring-surgery-commissioning.pdf?sfvrsn=0

[2] Pascal JF, Le Louarn C. Brachioplasty. Aesthetic Plast Surg. 2005;29:423–429.

[3] Gusenoff JA, Coon D, Rubin JP. Brachioplasty and concomitant procedures after massive weight loss: a statistical analysis from a prospective registry. Plast Reconstr Surg. 2008; 122:595–603.

[4] Pitanguy I, Gontijo de Amorim NF, Radwanski HN. Contour surgery in the patient with great weight loss. Aesthetic Plast Surg. 2000;24:406–411.

[5] Agha-Mohammadi S, Hurwitz DJ. Nutritional deficiency of postbariatric surgery body contouring patients: what every plastic surgeon should know. Plast Reconstr Surg. 2008; 122:604–613.

[6] Song AY, Jean RD, Hurwitz DJ, et al. A classification of contour deformities after bariatric weight loss: the Pittsburgh Rating Scale. Plast Reconstr Surg. 2005;116:1535–1544.

[7] El Khatib HA. Classification of brachial ptosis: strategy for treatment. Plast Reconstr Surg. 2007;119:1337–1342.

[8] Abboud MH, Nicolas M, Abboud NM, Dibo SA. Brachioplasty by power-assisted liposuction and fat transfer: a novel approach that obviates skin excision. Aesthet Surg J. 2016;36:908–917.

[9] Au K, Hazard SW, 3rd, Dyer AM, et al. Correlation of complications of body contouring surgery with increasing body mass index. Aesthet Surg J. 2008;28:425–429.

[10] Sullivan T, Smith J, Kermode J, et al. Rating the burn scar. J Burn Care Rehabil. 1990;11:256–260.

[11] Beausang E, Floyd H, Dunn KW, et al. A new quantitative scale for clinical scar assessment. Plast Reconstr Surg. 1998; 102:1954–1961.

[12] Shermak MA. Aesthetic refinements in body contouring in the massive weight loss patient: part 2. Arms. Plast Reconstr Surg. 2014;134:726e.

[13] Coon D, Tuffaha S, Christensen J, et al. Plastic surgery and smoking: a prospective analysis of incidence, compliance, and complications. Plast Reconstr Surg. 2013;131:385–391.

[14] WHO. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Vitamin and Mineral Nutrition Information System. Geneva: World Health Organization; 2011 [accessed 2020 Jan 5]. Available from: http://www.who.int/vmnis/indicators/haemoglobin

[15] Regnault P. Brachioplasty, axilloplasty, and pre-axilloplasty. Aesthetic Plast Surg. 1983;7:31–36.
[16] Lockwood T. Brachioplasty with superficial fascial system suspension. Plast Reconstr Surg. 1995;96:912–920.
[17] Abramson DL. Minibrachioplasty: minimizing scars while maximizing results. Plast Reconstr Surg. 2004;114:1631–4. Discussion 1635–7.
[18] Temourian B, Malekzadeh S. Rejuvenation of the upper arm. Plast Reconstr Surg. 1998;102:545–551. Discussion 552–3.
[19] Michaels JV, Coon D, Rubin JP. Complications in postbariatric body contouring: postoperative management and treatment. Plast Reconstr Surg. 2011;127:1693–1700.
[20] Toy JW, Rubin JP. Post-bariatric reconstruction. In: Neligan PC, Rubin JP, editors. Plastic surgery. Vol. 2, 4th ed. London: Elsevier; 2017. p. 709–730.
[21] Sisti A, Cuomo R, Milonia L, et al. Complications associated with brachioplasty: a literature review. Acta Biomed. 2018; 88:393–402.
[22] Zomerlei TA, Neaman KC, Armstrong SD, et al. Brachioplasty outcomes: a review of a multipractice cohort. Plast Reconstr Surg. 2013;131:883–889.
[23] Duscher D, Pollhammer MS, Wenny R, et al. Barbed sutures in body-contouring: outcome analysis of 695 procedures in 623 patients and technical advances. Aesthetic Plast Surg. 2016;40:815–821.
[24] Coon D, Gusenoff JA, Kannan N, et al. Body mass and surgical complications in the postbariatric reconstructive patient: analysis of 511 cases. Ann Surg. 2009;249:397–401.
[25] Breiting LB, Lock-Andersen J, Matzen SH. Increased morbidity in patients undergoing abdominoplasty after laparoscopic gastric bypass. Dan Med Bull. 2011;58:A4251.
[26] Nemerofsky RB, Oliak DA, Capella JF. Body lift: an account of 200 consecutive cases in the massive weight loss patient. Plast Reconstr Surg. 2006;117:414–430.
[27] De Luca M, Angrisani L, Himpens J, et al. Indications for surgery for obesity and weight-related diseases: position statements from the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO). Obes Surg. 2016;26:1659–1696.
[28] Nagaraja S, Chen L, DiPietro LA, et al. Computational analysis identifies putative prognostic biomarkers of pathological scarring in skin wounds. J Transl Med. 2018;16:32.
[29] Pierpont YN, Dinh TP, Salas RE, et al. Obesity and surgical wound healing: a current review. ISRN Obes. 2014;2014: 638936.
[30] Agha-Mohammadi S, Hurwitz DJ. Enhanced recovery after body-contouring surgery: reducing surgical complication rates by optimizing nutrition. Aesth Plast Surg. 2010;34: 617–625.
[31] Gusenoff JA, Coon D, Rubin JP. Implications of weight loss method in body contouring outcomes. Plast Reconstr Surg. 2009;123:373–376.
[32] Fearmonti RM, Blanton M, Bond JE, et al. Changes in dermal histomorphology following surgical weight loss versus diet-induced weight loss in the morbidly obese patient. Ann Plast Surg. 2012;68:507–512.
[33] Demidova-Rice TN, Hamblin MR, Herman IM. Acute and impaired wound healing: pathophysiology and current methods for drug delivery, part 1: normal and chronic wounds: biology, causes, and approaches to o care. Adv Skin Wound Care. 2012;25:304–314.
[34] Heughan C, Grislis G, Hunt TK. The effect of anemia on wound healing. Ann Surg. 1974;179:163–167.
[35] Hurwitz DJ, Holland SW. The L brachioplasty: an innovative approach to correct excess tissue of the upper arm, axilla, and lateral chest. Plast Reconstr Surg. 2006;117:403–11. Discussion 412–3.
[36] Dreifke MB, Jayasuriya AA, Jayasuriya AC. Current wound healing procedures and potential care. Mater Sci Eng C Mater Biol Appl. 2015;48:651–662.
[37] Bossert RP, Dreifuss S, Coon D, et al. Liposuction of the arm concurrent with brachioplasty in the massive weight loss patient: is it safe? Plast Reconstr Surg. 2013;131: 357–365.