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GUIDELINES

Weight Loss Reporting: Predicted Body Mass Index After Bariatric Surgery

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Abstract BMI and %EBMIL are the most accurate methods for comparing results of patients after bariatric surgery. %EBMIL is based on BMI 25 as a constant end-point for all patients, but BMI 25 is easily achieved by patients with BMI<50, whereas it is not so feasible for patients with BMI>50. We were prompted to obtain by statistical methods a mathematical formula able to calculate the final BMI (FBMI) 3 years after the operation, dependent on the initial or preoperative BMI (IBMI) of a multicenter group of morbid obese patients operated with different bariatric techniques. We also obtained a specific formula for each bariatric procedure of this group of patients. We propose the name *Predicted BMI* for the value obtained with these formulas and its application in the %EBMIL instead of the constant value of BMI 25. We have analyzed the IBMI and FBMI of a multicenter group of 7,410 patients, subjected to different bariatric procedures with a minimum follow-up of 36 months. Statistical methods with a linear regression model have been used to obtain the two types (global and specific) of Predicted BMI. We first obtained a general formula of $\mathrm{PBMI} = \mathrm{IBMI} \times 0.4 + 11.75$ for the total population of patients, and a second specific formula for each bariatric technique: $\mathrm{PBMI} = \mathrm{IBMI} \times 0.43 + 13.25 + \text{technique\_correction\_adjustment}$. Predicted BMI and its application to the %EBMIL may result in a more rational comparison of results of bariatric patients, bariatric techniques, and groups of bariatric surgeons. Predicted BMI may advance the BMI that each patient would probably achieve after surgery.

Keywords Bariatric surgery · Body mass index
Predicted BMI · Weight loss reporting · Obesity surgery

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Introduction

Bariatric parameters like the ideal body weight (IBW), the Excess Body Weight (Preoperative weight−IBW), the % Excess Weight Loss (%EWL), and the Body Mass Index (BMI) are different methods for reporting weight loss after obesity surgery [1].

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Nevertheless, Deitel [2, 3] recommended the use of the Percentage of the Excess BMI Loss ($\%EBMIL = \frac{(Initial\_BMI - Final\_BMI)}{(Initial\_BMI - 25)} 100$), as a more objective method to present weight loss results in clinical studies of bariatric surgery. Greenstein [4] reported that Xavier Pi Sunyer, Chairman of the National Institute of Health, recommended establishing the value of BMI 25 as the cutoff point to define overweight and also the BMI 25 as the end point for obese patients after bariatric surgery. But, this score of BMI 25 is easily achieved by morbidly obese (MO) patients with a BMI<50, whereas is not feasible for the super-obese (SO) individuals with BMI>50.

After calling attention on the disparity of results between MO and SO patients [5], we developed a mathematical formula [6] considering the IBMI and the FBMI of a group of 135 MO patients operated on with Bilio-Pancreatic Diversion/Duodenal Switch (BPD/DS). In this preliminary work, the algorithm obtained was: $PBMI = IBMI \times 0.33 + 14$.

In our experience with over 1,378 bariatric patients [7], we, and other authors as Marceau [6] (Table 1), observed that reaching good or excellent results is fairly easy after operating MO patients but is uncommon with SO ones, even when the drop in the BMI values after surgery is much greater. In order to achieve a more accurate system for weight loss reporting (WLR), we have coordinated a multicentre study with 7,410 obese patients operated with different bariatric techniques with the aim of obtaining the proposed predicted BMI.

Patients and Methods

We analyzed retrospectively the IBMI (range 35–70) and FBMI of a group of 7,410 patients with a follow-up of more than 3 years, operated on with different techniques in different countries and by the surgeons listed in Acknowledgements (one in Canada, two in the USA, one in Colombia, one in Greece, one in Italy, one in Germany, and 16 in Spanish bariatric units). Distribution of patients according to the different bariatric techniques is shown in Table 2. Statistical methods with a linear regression model have been used in order to obtain a formula that calculates the individualized postoperative BMI for each patient. Two types of formulas were obtained: (1) Predicted BMI suited for all individuals independent of the technique and (2) Predicted BMI adjusted to each specific technique.

Table 1 Changes in FBMI According to IBMI in Marceau 898 Patients

IBMI	40–45	45–50	50–55	55–60	60–65
n 898	221	244	206	146	81
BMI >3 years	26.27	28.66	30.6	31.76	34.33
ST	3.11	3.97	4.64	5.27	6.53
Drop in the BMI	16.3	18.8	21.9	25.7	28.2

Table 2 Distribution of 7,410 Patients According to Bariatric Techniques

		Number
AGB	Adjustable gastric band	1,026
GB	Gastric band non-adjustable	82
SG	Sleeve gastrectomy	128
VBG	Vertical banded gastroplasty	179
BGBP	Banded gastric bypass	682
GBP	Gastric bypass	2,083
Mini-GBP	Mini-gastric bypass	686
BPD/Scopinaro	BPD/scopinaro	280
BPD/Larrad	BPD/larrad	173
BPD/DS	BPD/duodenal switch	2,091
Total		7,410

Results

The relationship between IBMI and FBMI after a 3-year follow-up and the regression line in 7,410 patients is shown in Fig. 1. Table 3 shows the linear regression model coefficients in 7,410 patients. Figure 2 shows the different regression lines depending on various surgical techniques, Table 4 shows the regression model coefficients for each bariatric technique, and Table 5 the FBMI Algorithms according to different bariatric techniques. Figure 3 shows the Changes in mean IBMI and mean FBMI with the different techniques.

Thus, if BMI is the dependent variable, the algorithm to obtain the predicted BMI for the global group of patients should be: $PBMI = IBMI \times 0.4 + 11.75$.

On the other hand, the specific formula adjusted for each bariatric procedure is $PBMI = IBMI \times 0.43 + 13.25 +$ Technique_Adjustment.

If we use the predicted BMI adjusted for each technique, the Mini-GBP patients have to deduct eight points, BPD/DS-5.2, BPS/Scopinaro-3.6, BGBP-4.6, SG-2.3, and AGB add 3.7 points. We propose the name predicted BMI for these formulas since it represents the expected or final BMI that a subject should achieve after a bariatric procedure.

Then, to evaluate the %EBMIL, the constant value of BMI 25 should be substituted for the Predicted BMI. Thus, %EBMIL for a given individual should be:

$$\%EBMIL = \frac{(Initial\_BMI - Final\_BMI)}{(Initial\_BMI - PBMI)} 100.$$

Mean %EBMIL, using the PFBMI instead of the constant value of BMI 25, of this group of patients was 99.48 (range 96.75–110.46).

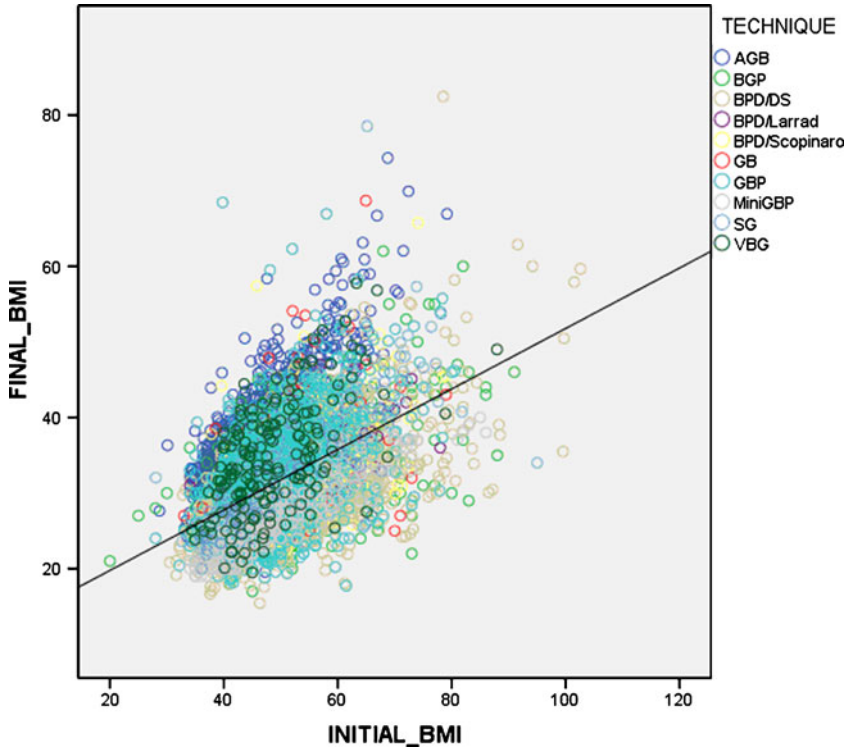

Fig. 1 Linear Regression Analysis in 7,410 Patients PBMI = IBMI × 0.4 + 11.75

Discussion

More than 344,000 individual MO patients are operated every year worldwide (>220,000 in the USA/Canada); however, weight loss measurement has not been standardized [8]. In 1959, the Metropolitan Life Insurance Company released tables of the IBW, called the "desirable" weights for each height, based on collected insurance data for longevity [9]. In 1983, the same company released the "ideal" weights for greatest longevity (or for lowest mortality) [10]. The middle values of all frames of height and weight tables are generally used.

In 1994, the American Society for Bariatric Surgery (ASBS) Committee on Standards for Reporting Results published a review to be considered by surgeons for WLR on bariatric surgery patients [11]. In 1997, the same committee [12] strongly recommended the utilization of the metric system and the BMI to classify obesity, and it was approved in General Assembly plenary session by the ASBS membership. This committee defined the %EBMIL as the percentage of BMI units a patient has lost from the beginning of treatment to follow up, relative to a BMI of 25 recommending that the use of %EBMIL may become the standard to present weight loss data in clinical studies.

Height is important to calculate the IBW, but height is not really taken into account to calculate the %EWL as $\%EWL = \frac{(Initial\_weight - Final\_weight)}{(initial\_weight - IBW)} 100$ [5]. %EWL is still popular in the literature, but we question its value since height is so important in the evaluation of the MO patient. %EBMIL, on the contrary, compares BMI (height and weight) instead of weight only, and this is the reason why BMI and %EBMIL are recommended as the best parameters for WLR [2].

Dixon [1] retrieved 65 surgical and 36 nonsurgical reports and concluded that "current methods" of WLR are not ideal and recommended that BMI values are more accurate for comparing obesity between individuals of all heights.

Baltasar [5] compared and analyzed two real MO and SO patients and concluded that the use of the Predicted BMI will make comparison of results more rational.

Table 3 Linear Regression Model Coefficients in 7,410 Patients

Parameter	B	Std. error	*t*	Sig.	95% Confidence interval		Partial eta squared
					Lower bound	Upper bound	
Intercept	11.75	.39	29.66	.00	10.98	12.53	.10
IMC0	.40	.008	50.02	.00	.38	.41	.25

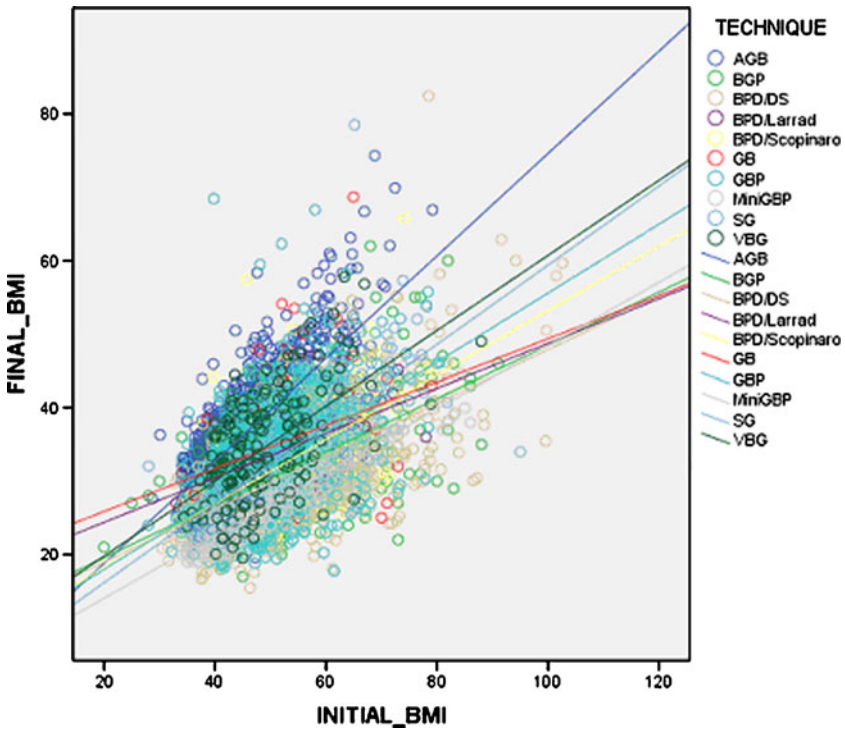

Fig. 2 Linear Regression Analysis in 7,410 Patients According to Different Bariatric Techniques PBMI = IBMI × 0.43 + 13.25 + Technique_Adjustment

Table 4 Linear Regression Model Coefficients in 7,410 Patients According to Different Bariatric Techniques

Parameter estimates

Dependent variable: FBMI

Parameter	B	Std. error	*t*	Sig.	95% Confidence interval		Partial eta squared
					Lower bound	Upper bound	
Intercept	13.25	.49	26.75	.00	12.28	14.22	.09
All categories	.43	.01	63.34	.00	.42	.45	.35
AGB	3.72	.39	9.35	.00	2.94	4.50	.01
BGBP	−4.61	.41	−11.18	.00	−5.42	−3.80	.017
BPD/DS	−5.27	.38	−13.78	.00	−6.02	−4.52	.025
BPD/Larrad	−1.80	.52	−3.44	.00	−2.82	−.77	.002
BPD/Scopinaro	−3.67	.47	−7.81	.00	−4.60	−2.75	.01
GBand (nonadj)	−.543	.65	−.82	.40	−1.82	.74	.00
GBP	−3.02	.38	−7.90	.00	−3.77	−2.27	.00
MiniGBP	−8.06	.41	−19.55	.00	−8.86	−7.25	.049
SG	−2.37	.56	−4.16	.00	−3.48	−1.25	.00
VBG	0[a]						

Obs: 95%CI for PBMIall is applied to the multiplication factor (0.435); for other equations, it relates to the final addition. VBG: No difference regarding PBMIall

AGB adjustable gastric banding, *BGPB* banded Roux-en-Y gastric bypass, *BPD*/*DS* duodenal switch, *BPD*/*Larrad* Larrad BPD, *BPD*/*Scopinaro* Scopinaro BPD, *GBand* (*nonadj*) nonadjustable gastrisc banding, *GBP* gastric by-pass, *SG* sleeve gastrectomy, *VBG* vertical banded gastroplasty

Table 5 PFBMI Algorithms According to Different Bariatric Techniques

Modality	Coefficient (95% CI)	Equation
All 0.43	0.43 (0.42 0.45)	PBMIall = IBMI × 0.43 + 13.25
AdjGB	3.72 (2.94 4.50)	PBMIagb = IBMI × 0.43 + 16.97
BandGPbypass	−4.61 (−5.42 −3.80)	PBMIbgp = IBMI × 0.43 + 8.64
BPD/DS	−5.27 (−6.02 −4.52)	PBMIds = IBMI × 0.43 + 7.97
BPD/Larrad	−1.80 (−2.82 −0.77)	PBMIlarrad = IBMI × 0.43 + 11.45
BPD/Scopinaro	−3.67 (−4.60 −2.75)	PBMIscop = IBMI × 0.43 + 9.57
GBand (non adj)	−0.54 (−1.82 0.74)	PBMIgb = IBMI × 0.43 + 12.71
GBP	−3.02 (−3.77 −2.27)	PBMIgbp = IBMI × 0.43 + 10.23
MiniGBP	−8.06 (−8.87 −7.25)	PBMImgbp = IBMI × 0.43 + 5.19
SG	−2.37 (−3.48 −1.25)	PBMIsg = IBMI × 043 + 10.88

AdjGB adjustable gastric banding, *Gband* nonadjustable gastric banding, *BandGPbypass* Banded Roux-en-Y gastric bypass, *BPD/DS* biliopancreatic diversion/duodenal switch, *GBP* gastric bypass, *SG* sleeve gastrectomy, *CI* confidence interval

Obs: 95%CI for PBMIall is applied to the multiplication factor (0.43); for other equations, it relates to the final addition; VBG: No difference regarding PBMIall

General equation: PBMI=IBMI×0.43 + technique adjustment

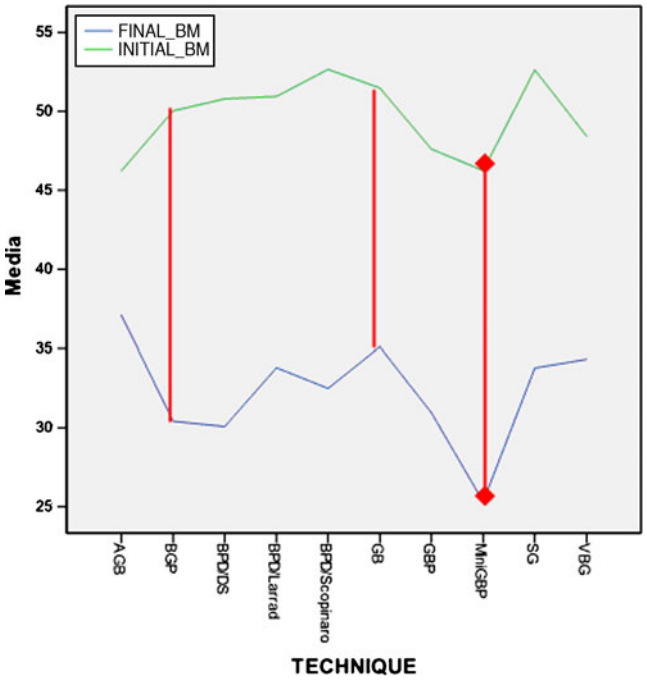

Fig. 3 Changes in Mean IBMI and Mean FBMI with the Different Techniques. *Red lines* Show Differences between IBMI and FBMI for each Bariatric Technique

%EBMIL is based on the acceptance of BMI 25 as the upper limit of normal BMI and also the goal for all bariatric patients. According to our experience with bariatric patients, we wondered whether this goal BMI should be considered a constant score for all patients and all degrees of morbid obesity or, on the contrary, the FBMI should be individualized according to the IBMI in order to achieve a rational comparison of results.

With this new formula, the aim of any bariatric patient at follow-up should be %EBMIL=100%. If the %EBMIL results are above this value, it indicates that her/his result is better than predicted, while, on the other hand, if a patient has a %EBMIL below 100, results are worse than predicted. Similarly, mean %EBMIL=100 may be useful for the comparison of different bariatric surgeons and institutions, independently of race, country, or social backgrounds, as well as for the comparison of different bariatric techniques.

Figure 3 shows the differences between mean IBMI and FBMI for the different surgical techniques. As shown, the mini-GBP seems to reach the lowest FBMI, but the truth is that those patients started with lower IBMI.

This study is based on 7,410 patients, but if institutions as the Surgical Review Corporation that has been developed by the American Society of Metabolic and Bariatric Surgery, the Bariatric Surgery Center of Excellence, the Bariatric Outcomes Longitudinal Database, or the European Centers of Excellence would proceed to make a study with a very large number of patients, a more accurate assessment of all bariatric patients could be made using the %EBMIL based on the predicted BMI.

Conclusions

The results of our study suggest that individualization with the proposed predicted BMI to replace the actual BMI 25 figure in the %EBMIL may result in a more rational comparison of results between bariatric patients, different bariatric techniques, and also different groups of bariatric surgeons.

Further studies are to be made with larger series of patients and different bariatric centers with enough follow-up to better define a predicted BMI universally accepted for all degrees of morbid obesity. Another interest of the predicted BMI is the possibility of advancing the BMI that each patient would probably achieve after surgery.

The bariatric surgical societies should try to find a more objective form to evaluate results for all types of patients

and operative techniques independently of the social status, racial background, country, or surgical institutions.

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