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Expected body mass index after bariatric surgery

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A B S T R A C T

Introduction: The body mass index (BMI) is the most practical method to measure and compare obesity between individuals. The Percentage of Excess BMI Loss (PEBMIL) is used to present results in operated patients and is based on the premise that a BMI-25 is the final aim, on being the upper limit in normal subjects. It is possible to achieve a BMI-25 in morbid obese (MO) patients with initial low BMIs (<50) but it is rare in overweight (OW) patients with a BMI >50. Expected BMI (EBMI) would be that which should be reached by all subjects depending on their initial BMI.
Objective: The objective of this study is to search for, using statistical methods, a formula based on clinical evidence that can identify the EBMI depending on the initial BMI.
Patients and method: We analysed the initial and final BMI in a group of 135 MO patients, operated on using the duodenal switch procedure and with a follow up of over 3 years. A linear regression method has been used to obtain a formula that could calculate the EBMI of each patient operated on.
Results: We obtained an algorithm in which EBMI = Initial BMI #x 0.33+14. If we apply the individualised EBMI instead of the BMI-25, the median PEBMIL was 99.48 (range, 76.75–110.46).
Conclusion: This result suggests that the application of an individual EBMI is a more reliable estimate of the success or failure of bariatric operations.

Índice de masa corporal esperable tras cirugía bariátrica

Palabras clave:
Cirugía bariátrica
Índice de masa corporal esperable

R E S U M E N

Introducción: El índice de masa corporal (IMC) es el método más práctico para medir y comparar la obesidad entre diferentes individuos. El porcentaje perdido del exceso de IMC (PPEIMC) se utiliza para presentar los resultados de los pacientes operados y se basa en la premisa de que un IMC de 25 es el objetivo final, al ser el límite superior de individuos normales. Alcanzar un IMC de 25 es posible en pacientes obesos mórbidos con IMC inicial

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Porcentaje de índice de masa corporal perdido
Exceso en el índice de masa corporal

bajo (<50), pero es poco frecuente en pacientes superobesos con IMC superior a 50. El IMC esperable (IMCE) sería aquel que deberían alcanzar todos los individuos de acuerdo con su IMC inicial.
Objetivo: El objetivo de este trabajo es buscar por métodos estadísticos una fórmula, basada en hechos clínicos, que identifique el IMCE de acuerdo con el IMC inicial.
Pacientes y método: Se ha analizado el IMC inicial y final de un grupo de 135 pacientes operados de obesidad mórbida con la técnica del cruce duodenal con un seguimiento superior a 3 años. Se ha utilizado un método estadístico de regresión lineal para obtener una fórmula que calcule el IMCE de cada paciente operado.
Resultado: Se ha obtenido un algoritmo en el que el IMCE=IMC inicial#x0,33+14. Si se aplicaba el IMCE individualizado en vez de la constante del IMC de 25, el PPEIMC mediano era de 99,48 (rango: 76,75 a 110,46).
Conclusión: Este resultado evidencia que la aplicación individual del IMCE estima con mayor fiabilidad el éxito o fracaso de las operaciones bariátricas.

Introduction

More than 300 000 obese patients undergo surgical procedures yearly. The weight-loss measuring parameters currently in use are quite varied: *a)* the percentage of excess weight loss (%EWL), which is based on ideal weight (an approximate body mass index [BMI] of 23) depending on size (these measurements come from tables that Metropolitan Life Insurance of New York[1] developed in the 1940s for white individuals at a medium to high economic level etc, but in this system, weight above an ideal level is independent rather than height-related; *b)* the "treatment range" for obesity if individuals drop a certain percentage given by Rheinhold criteria; *c)* "changes in weight" given by the Swedish Obesity Study[2] (SOS), without taking height into account; and *d)* the percentage of excess BMI loss (%EBMIL).

In 1994, the Standards Committee for Reporting Results of the American Society for Bariatric Surgery (ASBS) published a review for evaluation by bariatric surgeons.[3] In 1997, the Standards Committee created guides with the published results including a BMI-based classification that was approved by Society members, but EWL continued to be used as a measurement method.[4] %EWL, is still the most widely-used measurement in medical literature, even though it does not take the individual's height into account. In the publication Obesity Surgery, it is beginning to be replaced by %EBMIL (percentage of excess body mass index loss, also known as PEBMIL).

Currently, BMI (described by Quetelet, the Napoleonic-era Belgian mathematician) is considered by heath professionals and even the general population to be the correct method for comparing obesity among individuals of different weights and heights. Since 2003, %EBMIL (initial BMI–final BMI/initial BMI–25) ×100 has been considered more objective than %EWL for presenting results for bariatric patients in clinical studies.[5-7]

Xavier Pi Sunyer, Professor of Medicine at Columbia University at New York,[8,9] recommended that the division between normal weight and overweight individuals be drawn at a BMI of 25. This measurement is the main part of our debate, since if an obese person wonders about the goal weight he/she should expect after surgery clinicians have difficulty answering. Or rather, they do not know how to respond because there may be several answers: Is weight the most important parameter? Shouldn't the clinical assessment of the patient's health be more important? For clinicians, the clinical parameter is the most important and serves as a treatment base, since if they are able to treat diabetes, reduce high blood pressure, prolong life, treat cholesterol and triglyceride levels, improve joint function in a patient, etc. they are obviously meeting their treatment goal.

However, when presenting weight loss results and not clinical aspects, %EBMIL does not evaluate all obese patients equally; reaching a BMI of 25 in super-obese patients (SO)[7] is very difficult, as well as dangerous to their health, as losing so much weight would probably be accompanied by malnutrition. In table 1 we see how the final BMI for Marceau's patients depends on their initial BMI and varies significantly among the 898 patients in the series. The authors of this article have called attention to this problem in an article published in Obesity Surgery.[7]

Choosing a final BMI of 25 as a goal is the keystone of this debate, and our objective in this study is to look for an expected BMI (EBMI) that would reflect realistic expectations

Table 1 – Change in final body mass index according to initial body mass index in Marceau's group of 898 patients

Initial BMI	40 to 45	45 to 50	50 to 55	55 to 60	60 to 65
n: 898	221	244	206	146	81
BMI >3 years	26.27	28.66	30.6	31.76	34.33
SD	3.11	3.97	4.64	5.27	6.53
Lost BMI	16.3	18.8	21.9	25.7	28.2

Source: personal letter from P. Marceau sent for the purpose of this study
BMI indicates body mass index; SD, standard deviation

for each individual depending on his or her initial BMI at the time of operation.

Patients and methods

Over a 3-year follow-up period, initial BMI (between 35 and 70) and final BMI were analysed in 135 patients who had undergone the duodenal switch procedure. We used a statistical model with independent linear regression with respect to any variable other than initial BMI in order to obtain a formula to personalise EBMI and %EBMIL, and replace the idea of a final BMI of 25 with EBMI.

We use the term "expected," which is a verbal adjective from "expect," meaning "regard as likely to happen." Origin Latin *exspectare*, "to look out for," according to the *Compact Oxford English Dictionary*. [See "*esperable*" «*Que se puede esperar (del lat. sperabilis); tener esperanza de conseguir lo que se desea*», in the *Diccionario de la Academia Española de la Lengua*].

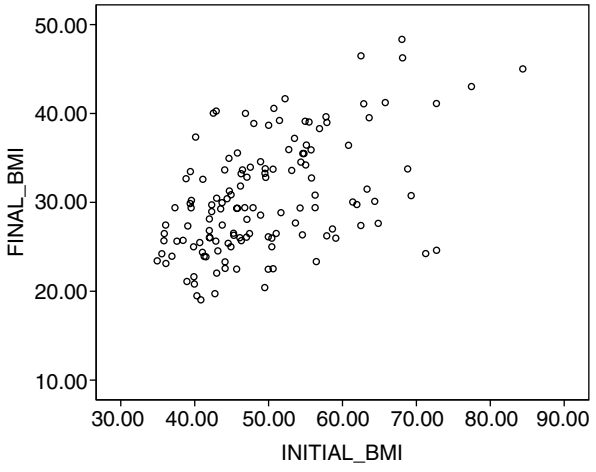

Figure - Relationship between initial body mass index and that after follow-up in 135 patients.

Results

Figure shows the relationship between initial and final BMI in this patient group, and Table 2, Table 3, and Table 4 show the linear regression analysis coefficients. Therefore, if BMI is the dependent variable, the algorithm for obtaining EBMI shall be:

$$\text{EBMI} = \text{initial BMI } X + C \rightarrow \text{EBMI} = 0.33 \times \text{initial BMI} + 14$$

Therefore, the "constant" BMI value of 25 should be replaced by the personalised EBMI which depends upon the BMI at the time of the operation. In conclusion, the probable %EBMIL (E-%EBMIL) or corrected %EBMIL would be:

$$\text{E-\%EBMIL} = [\text{initial BMI} - \text{final BMI}/\text{initial BMI} - (0.33 \cdot \text{initial BMI} + 14)] \times 100$$

If we use EBMI instead of a set BMI of 25, the mean E-%EBMIL for this patient group was 99.48 (range: 96.75 to 110.46) (Table 5).

Table 5 shows the distribution of one of Marceau's patient groups to which the EBMI and the E-%EBMIL have been applied. Here, we can see the comparison between the lost BMI and the EBMI and obtain relative error differences ranging from 1% to 6%. Furthermore, by comparing the %EBMIL based on a BMI of 25 with E-%EBMIL, we can see that the results for the group with a BMI between 40 and 45 are 12.12% better than expected, and observe that for other patients, the improvements exceeding expectations were between 1.1% and 5.6%.

Table 2 – Linear regression model

R	DC	Adjusted for DC	Standard error of the estimate
0.50[a]	0.25	0.25	5.48

DC indicates determination coefficient; R, correlation coefficient.
[a]Predictors: constant, initial body mass index.

Table 3 – Linear regression model variance analysis[b]

Model	Square-root sum	DL	Mean square	F	Significance
1					
Regression	1391.54	1	1391.54	46.28	0.000a
Residual	3998.45	133	30.06		
Total	5389.99	134			

DL indicates degree of liberty; F, F-test.
[a]Predictors: constant, initial body mass index.
[b]Dependent variable: initial body mass index.

Table 4 – Linear regression model-Coefficients[a]

Model		Non-standard coefficients		Standard coefficients	t	Significance
		B	Standard error	Beta	B	TE
1	Constant	**C=13.98**	2.47		5.65	0.000
	Initial BMI	**X=0.33**	0.04	0.50	6.80	0.000

BMI indicates body mass index; TE, typical error.
[a]Dependent variable: final body mass index.

Table 5 – Differences between lost body mass index and expected body mass index, and between percentage of excess body mass index lost based on a BMI of 25 and the expected percentage of excess body mass index lost for Marceau's patient group

Average point	42.5	47.5	52.5	57.5	62.5
Initial BMI	**40 to 45**	**45 to 50**	**50 to 55**	**55 to 60**	**60 to 65**
n:898	221	244	206	146	81
BMI >3 years	26.27	28.66	30.6	31.76	34.3
SD	3.11	3.97	4.64	5.27	6.53
Lost BMI	16.3	18.8	21.9	25.7	28.2
Expected BMI	28.025	29.675	31.325	32.975	34.63
Mean BMI - Marceau	26.27	28.66	30.6	31.76	34.3
Difference in BMI	1.755	1.015	0.725	1.215	0.295
(relative error), %	6	3	2	4	1
%EBMIL at BMI=25	92.743	83.733	79.636	79.2	75.12
%EBMIL with EBMI	112.12	105.69	103.42	104.95	101.1

BMI indicates body mass index; %EBMIL,: percentage of excess body mass index lost; E-%EBMIL, expected percentage of excess body mass index loss; SD, standard deviation.

Discussion

In our own experience with 1321 patients who underwent bariatric surgery, and in that of other authors,[1,10] it can be observed that achieving good or even excellent results is not difficult when operating on morbidly obese patients. However, it is very rare in patients with super-obesity, because a BMI of 25 is almost impossible for them to reach.[1,7]

The uncorrected %EBMIL based on a final BMI of 25 cannot be the same as that used by the EBMI for all bariatric patients. The authors of this article do not believe that EBMI should be a constant fixed value; instead, it should be personalised and depend on the initial BMI, regardless of age, race and social status.[7]

Another interesting point regarding using EBMI would be that it would be useful for all types of bariatric interventions. It is well-known that certain procedures are performed in subjects with lower BMIs (tubular gastrectomies, gastric banding, vertical gastroplasty, etc), others in subjects with middle-ranging BMIs (gastric bypass), and still others, such as biliopancreatic derivations (BPDs) in subjects with high BMIs. And it is obvious that when the %EBMIL is used, the patients with the lowest BMI benefit statistically. With the E-%EBMIL in use, all patients should come as close as possible to a 100% value for all intervention types; those exceeding 100% would experience excellent results, and those below 100% would be needing improvement. Using uncorrected %EBMIL, we read that ring gastric bypasses reach a value of 55%, gastric bypasses 65% and BPDs, more than 70%, regardless of the initial BMI. Therefore, we note that the dispersion in the results is not favourable for comparing the bariatric techniques themselves. The E-%EBMIL measurement will serve for comparing results between both different surgeons and bariatric centres and different bariatric techniques.

Conclusions

The final assessment of the surgical result must be clinical. The weight-loss results, which are important for measuring success or failure in obesity surgery, are more important statistically speaking, although they may be even more

important in the patient's subjective point of view ("I had the operation to lose weight"). BMI is the best tool for evaluating obesity; however, a final BMI as 25 as a common goal for all subjects complicates this assessment. A personalised form of EBMI, based on initial BMI, rationalises the results that are obtained, independently from race, age, sex, procedure used and centre in question if we use an E-%EBMIL adjusted for each patient's expected progress according to the initial BMI.

For this reason, our project is formulated in three phases: *a)* alert practitioners that the concept of a BMI of 25 is inexact, as in our publication in Obesity Surgery;[7] *b)* evaluate a series of patients undergoing the same procedure in order to find an EBMI formula dependent on initial BMI (the current study); and *c)* launch a multi-centre project to increase the number of individuals providing results and correct our formula using the data from a larger number of cases.

This study shows preliminary results based on a three-year follow-up study in 135 patients who underwent a duodenal switch procedure. We need larger patient numbers in order to analyse different techniques and centres with long-term follow up, and in order to define the best resulting formula. Nevertheless, the fact that the mean value of the E-%EBMIL for these patients approaches 100% suggests that these results are consistent. A definitive EBMI algorithm based on a larger patient series, which is now in its initial phase, will be necessary. For now, if it is worth the study, bariatric societies should evaluate this formula and if possible, accept or improve on it.

REFERENCES

1. Marceau P, Biron S, Hould FS, et al. Duodenal switch: Long-Term Results. Obes Surg. 2007;17:1421–30.
2. Sjostrom L, Narbro K, Sjostrom CD, et al. Effects of bariatric surgery on mortality in Swedish obese subjects. N Engl J Med. 2007;357:741–52.
3. Standards Committee. American Society for Bariatric Surgery. Standards for reporting results. Obes Surg. 1994;4:56–65.
4. Standards Committee, American Society for Bariatric Surgery. Guidelines for reporting results in bariatric surgery. Obes Surg. 1997;7:521–2.
5. Deitel M, Greenstein RJ. Recommendations for reporting weight loss [editorial]. Obes Surg. 2003;13:159–60.
6. Deitel M, Gawdat K, Melissas J. Reporting weight loss 2007. Obes Surg. 2007;17:565–8.
7. Baltasar A, Deitel M, Greenstein RJ. Weight loss reporting. Obes Surg. 2008;18:761–2.
8. Greenstein RJ. Reporting weight loss. Obes Surg. 2007;17:1275–6.
9. Kuczmarski RJ, Flegal KM. Criteria for definition of overweight in transition: Background and recommendations for the United States. Am J Clin Nutr. 2000;72:1074–81.
10. Baltasar A, Bou R, Bengochea M, Serra C, Pérez N. Mil operaciones bariátricas. Cir Esp. 2006;79:349–55.