

Setting realistic expectations for weight loss after laparoscopic sleeve gastrectomy

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Abstract

Introduction: Despite the clinical benefits of bariatric surgery, some patients have experienced disappointment with their weight loss. Setting realistic expectations is the key to success.

Aim: To develop a specific prediction calculator to estimate the expected body mass index (BMI) at 1 year after laparoscopic sleeve gastrectomy (LSG).

Material and methods: A retrospective analysis was performed to study 211 patients after primary LSG. Nine baseline variables were analyzed. Least angle regression (LARS) was employed for variable selection and to build the predictive model. External validation was performed on a dataset of 184 patients. To test the accuracy of the model, a Wilcoxon signed-rank test was performed between BMI estimates and the observed BMI. A linear logistic equation was used to construct the online predictive calculator.

Results: The model included three variables – preoperative BMI ($\beta = 0.023$, $p < 0.001$), age ($\beta = 0.005$, $p < 0.001$), and female gender ($\beta = 0.116$, $p = 0.001$) – and demonstrated good discrimination ($R^2 = 0.672$; adjusted $R^2 = 0.664$) and good accuracy (root mean squared error of estimate, RMSE = 0.124). The difference between the observed BMI and the estimated BMI was not statistically significant (median = 0.737 (–2.676, 3.254); $p = 0.223$). External validation confirmed good performance of the model.

Conclusions: The study revealed a useful predictive model for estimating BMI at 1 year after LSG. The model was used for development of the PREDICT BMI calculator. This tool allows one to set realistic expectations of weight loss at one year after LSG.

Key words: obesity, laparoscopic sleeve gastrectomy, bariatric surgery, sleeve gastrectomy, weight loss, expectations.

Introduction

Bariatric surgery is the most effective treatment of obesity and related diseases [1]. Several procedures are currently offered to patients. Laparoscopic sleeve gastrectomy (LSG) is the most commonly used in North America and Europe [2–4]. Despite the significant clinical benefits from surgery some patients were disappointed with the weight loss due to

unrealistic expectations. This leads to an abandonment of weight loss goals and may negatively influence the long-term outcome [5, 6]. Setting realistic expectations is an important aspect of the preoperative education. It is a key to successful treatment [5, 7]. However, there is currently no clinically useful tool to estimate the expected body mass index (BMI) in patients after LSG.

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Aim

The purpose of this study is to develop a specific prediction calculator for estimation of the expected BMI at 1 year after LSG.

Material and methods

The data of 211 patients were retrospectively collected from medical records. All patients completed 1-year follow-up. Obese patients undergoing primary LSG from January 2011 to September 2015 were included. The outcome of the study was defined as the BMI at 1 year after the initial procedure. The independent demographic variables were: gender, race, age, preoperative body mass index, and smoking status. Examined comorbidities included diabetes mellitus type II, hypertension, obstructive sleep apnea, and dyslipidemia (Table I). Weight loss was expressed as change in BMI (Δ BMI), total weight loss (TWL), and percentage of excess weight loss (%EWL).

Ethical statement

All procedures involving human participants were performed 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.

Statistical analysis

Data were analyzed using SAS University Edition software (SAS Institute Inc., Cary, NC, USA). Least

angle regression (LARS) was employed for variable selection. This new model selection algorithm, developed by Efron *et al.*, relates to the classic model selection method known as forward selection but instead of including variables at each step, the estimated parameters are increased in a direction equiangular to each one's correlations with the residual [8]. Initially, the BMI at 1 year after surgery (dependent variable) was transformed by logarithmic transformation. The data were then split into a training (65%) and testing set (35%). In addition, the external data set was employed for external validation. The model was developed using a hybrid method and the average square error (ASE) over the validation data as a selection criteria. Goodness of fit was assessed by ASE. To test the accuracy of the predictive model, the Wilcoxon signed-rank test was performed between estimated BMI and BMI observed 1 year after surgery. A linear logistic equation was used to construct the online predictive calculator (www.predictbmi.com). It is also available as the app for iOS.

Results

Table I presents the descriptive characteristics of 211 patients. The median age of patients was 45 (Q1: 38, Q3: 54) years and median BMI was 45.3 (41.2, 52.2) kg/m² at the time of surgery. The median postoperative BMI was 33.6 (29.4, 38.8) kg/m². The median %EWL was 58.6 (43.6, 73.3) %. The median Δ BMI was 13.5 (10.2, 17.5) kg/m² and the median

Table I. Independent variables included to the analysis

Characteristic	Study sample (n = 211)	Validation sample (n = 183)	Definition
	Median (Q1, Q3) or %		
Age [years]	45 (38, 54)	38 (31, 48)	–
Gender, female	85.8%	54.9%	–
Preoperative BMI [kg/m ²]	45.3 (41.2, 52.3)	46.6 (41.2, 52.1)	Calculated based on the preoperative weight and height
Hypertension	69%	48.4%	Hypertension requiring medication
Diabetes type 2	34.4%	17.4%	Diabetes type requiring medication or controlled by diet
OSA	79%	4.9%	Obstructive sleep apnea requiring CPAP therapy
Arthritis	66.2%	NA	History of arthritis before surgery
Dyslipidemia	52.7%	9.8%	History of dyslipidemia before surgery
Smoking status	46.92%	NA	History of current or former smoking

n – number of patients, Q1 – first quartile, Q3 – third quartile, BMI – body mass index, OSA – obstructive sleep apnea, CPAP – continuous positive airways pressure, NA – not available.

Table II. Weight loss outcome in studied sample

Variable	Median (Q1, Q3)	Range/IQR	Definition
% Excess weight loss	58.6 (43.6, 73.7)	1.8–136.3/30.1	100% × (initial BMI – nadir BMI) / (initial BMI – a), with reference point a = 25
Total weight loss	32.6 (25.4, 43.5)	2.3–91.2/18.1	Initial weight – postoperative weight [kg]
Change in BMI	13.5 (10.2, 17.5)	5.0–40.3/7.3	Initial BMI – postoperative BMI [kg/m ²]

Q1 – first quartile, Q3 – third quartile, IQR – interquartile range, BMI – body mass index, OSA – obstructive sleep apnea, CPAP – continuous positive airways pressure.

Table III. Excess weight loss categories in studied sample

Excess weight loss category	N (%)
EWL < 30%	19 (9)
30% < EWL < 50%	59 (28)
EWL > 50%	133 (63)

n – numbers of patients, EWL – excess weight loss.

TWL was 32.7 (25.4, 43.5) kg (Table II). Sixty-three percent of patients achieved EWL > 50% at 1 year after surgery (Table III).

Model development

Nine variables were analyzed. The model included three variables: age, preoperative BMI and gender (Table IV). All predictors were significant: preoperative BMI ($\beta = 0.023, p < 0.001$), age ($\beta = 0.005, p < 0.001$), and female gender ($\beta = 0.116, p = 0.001$).

The linear regression equation was as follows: $\log_{10} \text{BMI} = 2.111 + (0.005 \times \text{age}) + (0.023 \times \text{preoperative BMI}) + (0.116 \times \text{female gender})$.

The model was significant ($p < 0.001$) and explains 67% of weight loss ($R^2 = 0.672$; adjusted $R^2 = 0.664$). The root of the mean standard error of the estimate was 0.124. Figure 1 shows the progression of the ASE separately for the training, validation, and test data. The desirable behavior is present where the ASE for the training, validation, and test data all decrease monotonically with the selection terminating at the step beyond which the test and validation errors would begin to grow. The difference in ASE between training and testing data sets was -0.005 and that between training and validation data sets was -0.007 . The median estimated BMI was 33.0 (30.0, 39.0) kg/m². The difference between the observed BMI and the estimated BMI was not statistically significant (median = 0.737 ($-2.676, 3.254$); $p = 0.223$).

Table IV. Comparison of observed and estimated BMI after surgery in studied sample (n = 211)*

1-year postoperative BMI	Mean ± SD	Median (IQR)
Observed	34.8 ± 7.6	33.7 (9.4)
Estimates	34.9 ± 6.9	33.0 (9.0)

BMI – body mass index, n – numbers of patients, SD – standard deviation, IQR – interquartile range. *Wilcoxon signed-rank $p = 0.719$.

External validation

The validation sample included 184 patients. All patients underwent LSG as a primary bariatric procedure in a European high volume bariatric center between January 2013 and December 2015. 55% were female. Median age was 38.5 (31.5, 48.0) years. The median BMI was 46.7 (41.6, 52.1) kg/m². The median BMI at 12 months after surgery was 31.3 (26.9, 35.2) kg/m². The median %EWL was 71.6 (58.6, 88.6) %.

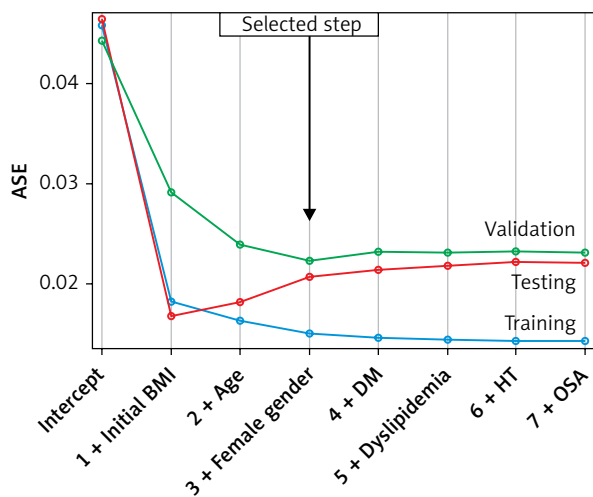


Figure 1. Model selection. The average square errors (ASE) separately for the training, validation, and test data

BMI – body mass index, DM – diabetes type 2, HT – hypertension, OSA – obstructive sleep apnea.

The median Δ BMI was 14.9 (12.0, 18.9) kg/m² and the median TWL was 43.5 (35.0, 56.6) km. 87.5% of patients achieved EWL > 50% at 1 year after surgery. The median expected BMI estimated by the model was 32.0 (28.0, 36.0) kg/m². The difference between the 1-year post-surgery estimated BMI and the BMI observed 1 year after surgery was not statistically significant (median: -0.223 (-3.506, 2.667); $p = 0.160$). The final model accurately predicted the 1-year post-surgery BMI.

Online calculator

The linear regression equation was the basis for development of the online calculator called PREDICT BMI. It provides information about expected BMI and weight loss at 1 year after surgery. Weight loss is calculated indirectly from expected BMI. A free version of the calculator is available at <http://www.predictbmi.com>.

Some examples of the expected BMI using the PREDICT BMI are as follows:

- A 32-year old female patient with BMI 46.9 kg/m². Expected BMI at 1 year after surgery would be 28.9 kg/m².
- A 30-year old male patient with BMI 37.0 kg/m². Expected BMI at 1 year after surgery in 22.5 kg/m².
- A 54-year old female patient with BMI 46.3 kg/m². Expected BMI at 1 year after surgery would be 31.9 kg/m².

Discussion

Bariatric surgery is a very effective treatment of obesity and related comorbidities [9].

Due to the rising prevalence of obesity, bariatric surgery has become very popular in many countries. Several procedures are currently offered to bariatric patients. The LSG is the most popular [2]. The method is relatively safe and feasible as a primary and revisional procedure [10, 11]. In spite of high clinical efficacy, many patients are disappointed with the effects. The expectations regarding weight loss after surgery are greater than the results expected by the surgeons [5]. Communication between the patient and the bariatric surgeon is very important as it influences the whole treatment process. Setting realistic expectations may be the key to success [7].

We proposed a prediction model of the BMI at 1 year after surgery in patients who are scheduled for LSG. The predictive model was developed using

an LARS algorithm. This new statistical approach is a better option for variable selection than the widely used stepwise regression or similar selection methods which are not recommended in the literature [12]. The presented model included three variables. Age, preoperative BMI and female gender were associated with the BMI at 12 months after the procedure. All predictors were statistically significant in analysis of variance. The model was validated on an external dataset and showed good performance. The simplicity of the proposed model makes it easy to use. On the basis of the model we developed a calculator, which can be used for estimation of weight loss. Using this calculator a bariatric surgeon can set a realistic expectation regarding weight loss.

Previous studies focused on predictive factors for weight loss after bariatric surgery and proved the significance for all factors included in the model [13–16]. The negative correlation between preoperative BMI and weight loss has been well described [17]. There is evidence for a negative association between age and weight loss after surgery [14, 15, 18–20]. Female gender was found in many studies to be a negative predictor for weight loss after surgery [15, 19, 21, 22].

The number of studies presenting prognostic models for expected weight loss after surgery is limited. Goulart *et al.* presented the same idea for a prognostic model for bariatric patients. Their model was developed based on data derived from 152 patients after LSG and included age and preoperative BMI. That model explained 64% of weight loss [23]. However, the model was not validated on an external dataset.

The presented study has several limitations. First, the variability in bariatric patients is high.

In order to make a simple model and avoid overfitting, we limited the number of factors in our analysis. We did not include in variable selection important predictors such as onset of obesity, socioeconomic status, functional status, eating habits and psychological disorders.

Second, the weight loss is affected by surgical factors such as the bougie size, distance from pylorus and the completeness of resection of the fundus. Those factors were not included in the model. Inclusion of the above factors would make it more complex. Some of them would also be difficult for objective assessment.

Third, the calculator addresses the issue of expected weight loss, but many patients have unrealistic expectations about their body image after sur-

gery [23]. Thus, the estimation should be followed by a physician's comment about that.

Finally, there is a certain risk of misinterpretation of estimations. Thus, we recommend using the calculator for setting a weight loss goal after surgery and informing the patient that the final result depends on his compliance with postoperative recommendations regarding diet and physical activity.

Despite those limitations, the PREDICT BMI calculator can be very useful in clinical practice. This user-friendly tool allows one to answer an important question asked by the patient: "How much weight will I lose?". The estimation of postoperative BMI and expected weight loss provides the answer and can be useful for motivational purposes.

Conclusions

We have presented a predictive model for estimating BMI at 1 year after LSG. The model includes the following factors: age, gender, preoperative BMI. The PREDICT BMI calculator developed based on this model allows for the estimation of patients' BMI at 1 year after surgery and the setting of realistic expectations. It is essential to emphasize that the estimation is only indicative and the final result is dependent on the patient's adherence to dietary and physical activity recommendations after surgery. The ability to set realistic expectations is the key for satisfaction after surgery. Once a realistic goal is set, the patient can be encouraged to attain it.

Conflict of interest

The authors declare no conflict of interest.

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