Prospectively Validated Pre-Operative Prediction of Weight and Co-Morbidity Resolution in Individual Patients Comparing Five Bariatric Operations

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ABSTRACT

Background: No method predicts, pre-operatively, post-operative bariatric surgery outcomes in individual patients. Decisions for/against surgery and operation choice remain subjective. Only 1% of qualifying patients embrace bariatric surgery.

Objective: To predict pre-operatively, and validate prospectively, weight and co-morbidity resolution in individual patients after open (RYGB) and laparoscopic (LRYGB) gastric bypass, laparoscopic adjustable gastric band (LAGB), sleeve gastrectomy (SG), and bilio-pancreatic diversion/duodenal switch (BPD/DS).

Design: Retrospective analysis

Setting: Surgical Review Corporation BOLD database, 2007-2010

Participants: 166,601 patients who had RYGB (n=5,389), LRYGB (n=83,059), LAGB (n=67,514), SG (n=8,966), or BPD/DS (n=1,673)

Interventions: None

Main Outcomes and Measures: Patients were randomized into modeling (n=124,053) and validation (n=42,548) groups. From pre-operative data, multivariate linear and logistic regression predicted weight and co-morbidities at 2, 6, 12, 18, and 24 months post-operatively. Model fit was examined by r-squared and ROC/AUC and predicted versus observed results via Pearson correlation coefficient and Sensitivity/Specificity.

Results: Follow-up at 2/24 months was 120,909/11,014 for Modeling and 41,528/3,703 for Validation. Weight models r-squared was 0.910, 0.813, 0.725, 0.638, and 0.613 at 2, 6, 12, 18, and 24 months, respectively. Categorical ROC/AUC was 0.617 to 0.949 for 24 month predictions. Continuous Pearson Coefficients were 0.969/0.811 at 2/24 months. Co-morbidity resolution median 24 month Sensitivity/Specificity were 79.2%/ 97.42%.

Conclusions: Prospectively validated pre-operative models predict, in individual patients, weight and obesity co-morbidities two years in advance for RYGB, LRYGB, LAGB, SG or BPD/DS. This advance knowledge facilitates choosing which operation is best for each individual and may encourage more patients to choose bariatric surgery.

Introduction: Morbid obesity affects 6.3% of the US population,[1, 2] with weight-related medical problems doubling their medical expenses.[3] From the 2012 US Census,[4] over 19.8 million Americans meet NIH criteria for bariatric surgery.[5] Nevertheless, only about 0.97% of those who qualify for bariatric operations actually undergo surgery [6] and benefit from its weight loss and resolution of co-morbidities.[7] The relative efficacy of different operations may be debated,[8] but the minimal penetration of bariatric surgery into the morbidly obese population leaves millions disabled. Characteristics of operative patients are understood, [9] but why patients decide against bariatric surgery remains unknown. Certainly variation in health insurance coverage for bariatric surgery and accompanying financial concerns are contributing factors [10]. Patient lack of knowledge and concerns over outcomes and complications may contribute. [11, 12]. Among obese patients who declined bariatric surgery, Fung and associates found fear of complications (51%), not needing weight loss surgery (32%), fear of surgery (24%), and costs (20%) to be the principal reasons against operation [13]. The open question is how to calm those concerns and encourage more patients to embrace surgical weight loss.

The lack of validated outcomes predictions for individual morbidly obese patients may be another factor that discourages patients from having weight loss surgery. Calculators predicting the relatively rare complications of bariatric surgery [14,15,16] and non-validated weight loss calculators [17] are reported. Nevertheless, prospectively validated predictions for bariatric surgery, applicable to individuals and comparing future results of the most common operations are not available. Thus, in counseling patients about bariatric surgery, physicians can reference only the published results for each operation, not individual outcomes. Ultimately, the choice of whether or not to have weight loss surgery, and which procedure to undergo, are left, subjectively, to the patient.

The present study hypothesized that the Systemic Mediator Associated Response Test (SMART) methodology could predict individual bariatric surgery outcomes from pre-operative clinical data. Previous, SMART models predicted qualitative and quantitative results in septic patients,

[18] and identified cohorts within failed clinical trials among which study drugs reduced septic mortality. [19] The objective of the present study, then, was to determine whether or not outcomes from the most frequently performed bariatric operations could be predicted in individual patients from pre-operative data, and then validated prospectively in a separate population.

Methods: With the approval of the Data Access Committee of the Surgical Review Corporation (SRC) and of the Institutional Review Board of Our Lady of Lourdes Medical Center, Camden, N.J., HIPAA-compliant data from the SRC's Bariatric Outcomes Longitudinal Database (BOLD) [20] on 166,601 patients who had undergone primary bariatric surgery between June 1, 2007 and December 31, 2010, and who had had at least one post-operative follow-up visit was analyzed. Business and validation rules were built into BOLD to flag or reject potential errors at the point of data entry, as well as automated data quality reports to identify unacceptable trends after data capture. In addition, pre-operative data, post-operative complications, and deaths entered into BOLD were verified 100% on-site by SRC monitors. Long term follow-up information was verified by random chart reviews in at least 15% of the cases.[20] Revisional operations were excluded from the present study. In the overall population, 5,389 patients underwent RYGB, 83,059 had LRYGB, 8,966 received SG, 67,514 had LAGB, and 1,673 had BPD/DS (BPD and BPD/DS combined). Subjects were randomized into a modeling group (n = 124,053) or a validation group (n = 42,548). Pre-operative BOLD parameters with <5% missing data (n=46) were screened as independent variables. Categorical pre-operative variables subcategorized by severity of illness in BOLD using semi-numerical scales of 1 to 5 or 1 to 4, etc. were included in the statistical mix. Continuous dependent variables included weight and weight loss. Dichotomous dependent variables included diabetes mellitus, hypertension, obstructive sleep apnea (OSA), liver disease, cholelithiasis, gastro-esophageal reflux disease (GERD), congestive heart failure (CHF), abdominal hernia, surgeon/support group follow-up and adverse events, as defined by the Surgical Review Corporation's BOLD reporting definitions. [20] From a General Estimating Equation platform, multivariate linear regression identified pre-operative independent variables that predicted weight and weight loss at 2, 6, 12, 18 and 24 months for each operation. Multivariate logistic regression identified pre-operative independent parameters predicting co-morbidities at 2, 6, 12, 18 and 24 months for each operation, and adverse events at 0-6, and 0-12 months. All models were built using forward selection. Only independent variables with interaction coefficients $p<0.10$ were included in the models. Low-incidence variables causing quasi-complete separation of data points were not used. The coefficient of determination (r^2) tested model fit for continuous dependent variables. Receiver Operating Characteristics/Area Under the Curve (ROC/AUC) examined dichotomous model fit. [21] Modeling was performed for each operation for each dependent variable at each observation point.

Linear models were tested by comparing validation group predicted values to the observed outcomes using Pearson correlation coefficients. Logistic models were validated by sensitivity and specificity. [21]

Results: Pre-operative variables that were screened as weighted independent variables (n=46) and those included in the final prognostic models (n=26) are listed in Table 1.

Model fit for continuous and dichotomous dependent variables and validation results are displayed in Table 2. For weight/weight loss, r^2 values were 0.910, 0.813, 0.725, 0.638, and 0.613 in baseline models that predicted these continuous dependent variables at 2, 6, 12, 18, and 24 months post-operatively, respectively. ROC AUC for dichotomous dependent variables ranged from 0.985 for cholelithiasis at 2 months to 0.599 for Surgeon Follow-up/Support group attendance at 12 months. Models for the complications of nausea and vomiting, intra-abdominal complications, and organ failure and sepsis were not successful because low event rates caused a quasi-separation of points. Grouping all occurrences of these adverse events into an Any AE category resulted in an ROC AUC of 0.683 for both the 0-6 month and 6-12 month periods.

Weight/weight loss models were validated at 2, 6, 12, 18, and 24 months after surgery with Pearson Correlation Coefficients of 0.959, 0.932, 0.875, 0.837, and 0.811, respectively. Validation of dichotomous models included median sensitivity of 79.2% (range 25.0% to 98.30%) and median specificity of 97.42%% (range 80.27% to 99.99%). For Any Adverse Event, specificity for both 0-6 months and 6-12 months was 99.92% but sensitivity was only 0.52% and 0.51%, respectively, for those intervals.

Discussion: This investigation describes a method that predicts, from pre-operative clinical data, in individual patients, what weight/weight loss and the presence or absence of the most serious obesity co-morbidities will be up to twenty-four months in advance following RYGB, LRYGB, LAGB, SG, or BPD/DS. These results individualize the choice of bariatric operation for morbidly obese patients. Weight/weight loss were validated at clinically useful accuracy. Diabetes mellitus was predicted with a 24 month specificity of 93.97%, and clinically applicable sensitivities. Hypertension prognostications had consistently high sensitivity/specificity. Obstructive sleep apnea models achieved specificities greater than 90% through 24 months. Pre-operative predictions of liver disease also carried strong validation results, as did cholelithiasis models through 24 months. Presence/absence of GERD was forecast well from pre-operative data. Abdominal hernia models had excellent sensitivity and specificity. In spite of high specificities, low event rates for congestive heart failure, any adverse event, and surgeon follow-up/support group attendance limited sensitivity in those models. Our review of the literature indicates that the prospectively validated predictions of weight/weight loss and of the presence or resolution of obesity co-morbidities in individual patients described here, comparing results from five different operations, have not been reported previously and represent a significant advance in the field of bariatric surgery. These predictive engines will enable physicians and morbidly obese patients to individualize objectively the choice of bariatric operation.

While previous reports described clinical formulae, [22] quartile regression curves, [23] artificial neural networks, [24] and other correlations [25] to predict weight/weight loss, most applied to only one operation, were not validated prospectively, and used databases less comprehensive for each patient a pre-operative baseline than BOLD. Baseline weight/weight loss models in the present investigation achieved Pearson correlation coefficients of 0.959, 0.932, 0.875, 0.837, and 0.811 at 2, 6, 12, 18, and 24 months post-operative, respectively. The results here, for the first time, enable data-based, individualized choice of weight loss operation.

Type II diabetes mellitus afflicts 28-52% of bariatric patients, [26, 27] and improves with weight loss. [28, 29] Knowing, in addition, what diabetes resolution will be comparing five operations could increase patients' confidence in choosing bariatric surgery. In the current analysis, Type II diabetes in individual patients was predicted accurately up to 24 months in advance. Diabetes sensitivity ranged from 98% to 60%, with specificity consistently above 91%. Previous studies associated diabetes control with post-operative weight loss, [28] and various clinical parameters, but did not predict individual outcomes. [29] The prognostic models reported here enable Type II diabetes patients to know what their relative risk of diabetes persistence/resolution will be following bariatric surgery up to 24 months in advance, comparing future results from five weight loss operations.

Arterial hypertension resolves frequently following bariatric surgery. [30, 31] However, prior to the present investigation, remission or persistence of hypertension after any weight loss procedure was not predicted, but, rather, only associated statistically with baseline parameters and post-operative weight loss. [30, 31] In the current report, prospectively validated models predicted the risk of hypertension for individual patients up to 24 months in advance, comparing outcomes for RYGB, LRYGB, SG, LAGB and BPD/DS. Sensitivity/specificity were 92.44%/85.21% at 2 months and 79.56%/79.3% at 24 months. These models will enable individual hypertensive patients to choose objectively which procedure will control her/his high blood pressure most effectively.

Obstructive sleep apnea affects more that 40% of bariatric patients, [27] and often resolves following weight loss surgery. [32] However, post-operative outcomes predictions do not apply to individuals. Models that predicted OSA in the present paper performed well, with all ROC/ACU values 0.827 and higher, and sensitivity/specificity ranging from 73.99%/93.6% at 2 months, to 50.76%/90.95% at 24 months. Our review of the literature indicates that such validated advance knowledge of OSA persistence/resolution in individual bariatric surgery patients has not been reported previously, and is an important finding of this study.

Non-alcoholic fatty liver disease and non-alcoholic steatohepatitis involve 7-16% of bariatric surgery patients. [26, 27] While liver disease may resolve with weight loss, results vary between RYGB, LRYGB, LAGB, SG, and BPD/DS (31), adding decisional uncertainty for patients regarding which operation to undergo. For these patients, the liver disease models presented here add objectivity to the choice of bariatric procedure, with median sensitivity/specificity at 84.79%/98.41%. Thus, although the diagnosis of liver disease in BOLD was clinical only, as liver biopsies were not required on all patients, the prognostic models here provide individual weight-related liver dysfunction patients with clinically significant guidance regarding its resolution by operation type.

At surgery, 9-31% of bariatric patients have gallstones, [26, 27] and the incidence increases with post-operative weight loss. [33] However, pre-operative factors that predict the incidence of cholelithiasis following weight loss operations are not established. In this investigation, pre-operative cholelithiasis models were validated at sensitivity/specificity above 86.93%/97.21% through 24 months, providing a reliable means of identifying patients most at risk for gallstone formation. This advance knowledge could facilitate the decision of whether or not to perform incidental cholecystectomy at the time of primary bariatric surgery, or, for high risk patients without gallstones at operation, medical prophylaxis.

GERD is diagnosed pre-operatively in 35-52% of patients who undergo bariatric surgery. [26, 27] Resolution of GERD is excellent with RYGB/LRYGB, and DS, variable with LAGB, but GERD may increase following SG. [34] Our review of the literature suggests that the present investigation is the first to predict relative risk of GERD in individual patients after weight loss procedures. While sensitivity drifted below 50% at 12 months, specificity actually increased in the 12-24 month models. Considering the inter-procedure variation of bariatric surgeries regarding post-operative GERD, the advance knowledge presented in this study may enable patients to compare the GERD effects of each technique in their individual cases.

At least 8% of bariatric surgery patients have pre-existing inguinal and ventral abdominal wall hernias. How and when to repair these defects continues to be debated. However, the incidence of abdominal hernia can increase following bariatric surgery to 50% and higher [33] The prognostic models reported here provide patients and surgeons reliable pre-operative predictions of abdominal hernia development in individuals, comparing the five most common weight loss procedures. With ROC/AUC's all 0.921 and higher, and sensitivity/specificity consistently at clinically useful levels, these findings can facilitate objective pre-operative bariatric surgery planning regarding relative risk of abdominal hernia.

Congestive heart failure affects up to 9% of bariatric surgery patients pre-operatively. [26] Although weigh loss logically should ameliorate CHF severity, the rate of CHF following bariatric surgery can increase to over 22%. [33] The ability to identify before surgery the individuals most at risk for CHF months and years after weight loss operations certainly could assist in pre-operative planning and peri-surgical management. In the present work, CHF ROC/AUC model fit was excellent. However, although specificity was above 99%, low event rates kept sensitivities in the 40% range and below. Nevertheless, these results are the first reported predictions of CHF in bariatric surgery.

Close long-term follow-up with bariatric surgeons and staff and regular support group attendance help to optimize surgical outcomes. In the present investigation, pre-operative modeling ROC/AUC's were 0.620 and under, Specificity was above 99%, but Sensitivity was <1%. In this modeling, then, one knows before surgery who will not follow-up, but not who are the compliant patients. Perhaps this at least identifies pre-operatively patients who need the most encouragement for follow-up compliance.

Modeling for adverse events yielded ROC/AUC of 0.683, high Specificity, and Sensitivity less than 1%, leaving the identities of problem-free patients clear, but not those at highest risk of complications. Fortunately, complications after bariatric surgery have been addressed by previous authors. Sarela et al developed the Obesity Surgery Mortality Risk Score, which predicts operative mortality. [14] Maciejeski and co-authors and stratified mortality risk for gastric bypass. [8] Ramanan et al [15] developed a validated bariatric surgery mortality risk calculator, and Gupta and co-authors [16] generated a morbidity risk calculator, both of which are available online: http://www.surgicalriskcalculator.com/bariatric-surgery-risk-calculator. These clinical aides complement the prognostic models described in the present study.

A practical hypothetical demonstration of the outcomes models described here as applied to individual patients may be illustrative. In this clinical example, consider a 50 year-old Caucasian female who is 5ft.4in.tall, weighs 320 lbs., is employed full-time, drinks socially, takes ibuprofen for back and musculoskeletal pain, has stress urinary incontinence occasionally, has OSA, and takes antidepressants, proton pump inhibitors for GERD, one medication for hypertension, and oral agents for Type II diabetes. She does not have angina, asthma, CHF, cholelithiasis, liver disease, obesity hypoventilation syndrome, psychologic impairment, pulmonary hypertension, abdominal hernia, or other mental health diagnoses. This baseline information was entered into the prognostic models, and the program provided outcomes predictions of weight and relative risk of abdominal hernia, CHF, cholelithiasis, GERD, diabetes, hypertension, liver disease, and surgeon follow-up/support group attendance. Predicted outcomes for this patient are listed in Table 3.

To be clear, the prognostic models in this report use pre-operative clinical data, without laboratory or radiology results, to predict outcomes for individual morbidly obese patients, within the validation predicted versus observed statistical analyses presented, that would result if individuals were to choose RYGB or LRYGB or AGB or SG or BPD/DS. Prediction of the relative probability of a patient choosing one bariatric surgery approach over another was not attempted, as no database, including BOLD, can support statistical modeling for the ultimately subjective choices individuals make for their healthcare. Similarly, comparing statistically the outcomes following one operation versus another was not part of this study. Results variation among these procedures have been well-described in the literature[5-9]. The concept underlying the present investigation was that pre-operative clinical characteristics of morbidly obese patients could be linked statistically to known bariatric surgery outcomes in the Modeling cohort, and that the accuracy of those models could be validated in a separate, similar population. The goal thus achieved was to give morbidly obese individuals and their healthcare providers additional advance knowledge of what outcomes could be for them if they were to choose one of the operations analyzed.

There are several limitations to this study. Firstly, the definitions of obesity co-morbidities in BOLD were entirely clinical. For example, that liver biopsies were not performed universally may have made the BOLD data incomplete academically. Secondly, BOLD contains no pre-operative laboratory or radiology information, all of which might have facilitated even more accurate predictive models. However, as a serendipitous benefit, the data on which the models here were based comprises common clinical information that enables every patient to benefit from the bariatric surgery prognostications presented. Thirdly, the decrease in follow-up patient visits over time may have contributed to sub-optimal modeling/validation for some conditions. Finally, the possible inconsistencies of a retrospective analysis on a prospectively collected database apply, which was the rationale for randomizing the entire BOLD population into Modeling and Validation databases at the beginning of this study.

Conclusions: Statistical models in this investigation provide individual morbidly obese patients clinically usable predictions of what weight and relative risk of the presence/absence of diabetes, hypertension, OSA, liver disease, cholelithiasis, GERD, and abdominal hernia would be up to 24 months in advance, comparing results from RYGB, LRYGB, LAGB, SG, and BPD/DS. Such advance knowledge may help facilitate optimized bariatric surgery outcomes. The clinical predictions described here are intended to supplement the knowledge and judgment of bariatric surgeons in recommending the best operation for each patient. Certainly medical and anatomical conditions can render the predicted best procedure for individual patients from these models suboptimal for her/him. In addition, it may be that, in spite of this objective advance knowledge and the surgeon's counseling, some patients still will choose bariatric procedures that are not optimal for them. For example, although Schauer and co-investigators reported superiority of LRYGB over SG in controlling Type 2 diabetes(35), in the current wave of public popularity for SG, the latter may be chosen in spite of the published data. Also, some patients who could benefit from bariatric surgery still might not choose operative treatment of their obesity even with the individualized pre-operative outcomes predictions afforded by this research, as, ultimately, it remains a personal, individual decision. Nevertheless, in the net effect, one hopes that the new predictive methodology presented here will become accessible to patients and physicians so that it might facilitate optimized patient care and, possibly, thereby may encourage more morbidly obese patients to embrace the benefits of weight loss surgery. The next step in this research, then, is to identify and engage formats that will enable utilization of the predictive models described in this report, so as to put into practice the clinical benefits for which they were developed.

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Table 1. Pre-Operative Parameters Screened and Parameters Identified as Weighted Independent Variables for Prognostic Models

Pre-Operative Parameters Screened as Potential Independent Variables:

Height (cm)	IVC Filter
Weight (kg)	Bariatric Procedure Planned
BMI	Age
Gender	Abdominal Hernia
African-American	Alcohol Use
Asian	Angina
Caucasian	Asthma
Native American	Back Pain
Hispanic	Cholelithiasis
Pacific islander/Hawaiian	Mental Health Diagnosis
Other Race	Congestive Heart Failure
Cholecystectomy	Depression
Cholecystectomy with Common Bile Duct Exploration	GERD
	Hypertension
Endoscopic Examination	Liver Disease
Gastrectomy Partial	Musculoskeletal Pain
Gastrectomy Total	Obesity Hypoventilation Syndrome
Hiatal Hernia Repair	Psychological Impairment
Liver Biopsy	Pulmonary Hypertension
Lysis of Adhesions	Stress Urinary Incontinence
Small Bowel Resection	Tobacco Use
Umbilical Hernia Repair	Full Time Employment
Ventral Hernia Repair	Sex

Final Independent Variables Used in the SMART Bariatric Models:

Age	Height (cm)
Abdominal Hernia	Hypertension
African-American	Operation
Alcohol Use	Liver Disease
Angina	Mental Health Diagnosis
Asthma	Musculoskeletal Pain
Back Pain	Obesity Hypoventilation Syndrome

Congestive Heart Failure	Psychological Impairment
Caucasian	Employment
	Pulmonary Hypertension
Cholelithiasis	Stress Urinary Incontinence
Depression	Weight (kg)
GERD	Gender

Table 2. Modeling and Validation Results for Continuous and Categorical Dependent Variables

Model Fit for Continuous and Categorical Dependent Variables

Observation:	**2 Months**	**6 Months**	**12 Months**	**18 Months**	**24 Months**
Number of Patients	120,909	75,130	42,410	15,387	11,014
Continuous Dependent Variables:					
(r-squared)					
Weight/Weight Loss	0.910	0.813	0.725	0.638	0.61
Dichotomous Dependent Variables:					
(ROC/AUC)					
Cholelithiasis	0.985	0.975	0.967	0.957	0.949
Diabetes Mellitus	0.956	0.940	0.933	0.930	0.926
GERD	0.898	0.860	0.829	0.818	0.804
Hypertension	0.913	0.891	0.874	0.869	0.858
Liver Disease	0.963	0.956	0.950	0.940	0.941
Obstructive Sleep Anea	0.887	0.858	0.837	0.841	0.827
Congestive Heart Failure	0.881	0.878	0.883	0.883	0.872
Abdominal Hernia	0.971	0.960	0.947	0.935	0.921
Surgeon Follow-up/ Support Group Attendance	0.597	0.600	0.599	0.603	0.620

Any Adverse Event		0.683	0.683		

Predicted Versus Observed Outcomes from Validation Group Pre-Operative Data Entered into Prognostic Models Built on the Modeling Group

Observation:	**2 Months**	**6 Months**	**12 Months**	**18 Months**	**24 Months**
Number of Patients	41,528	25,768	14,527	5,255	3,703
Continuous Dependent Variables:					
Pearson Correlation Coefficient					
Weight/Weight Loss	0.959	0.932	0.875	0.837	0.811
Dichotomous Dependent Variables:					
Cholelithiasis					
Sensitivity	97.13	94.7	91.78	90.94	86.93
Specificity	98.83	98.34	97.62	97.42	97.21
Diabetes Mellitus					
Sensitivity	98.39	74.87	72.14	69.14	60.28
Specificity	88.59	91.85	91.59	91.36	93.97
GERD					
Sensitivity	95.12	74.81	49.82	47.32	44.77
Specificity	81.05	80.27	87.07	87.25	86.65
Hypertension					
Sensitivity	92.44	92.61	77.91	79.15	79.56
Specificity	85.21	74.58	80.92	80.02	79.3
Liver Disease					
Sensitivity	88.55	85.22	84.79	79.39	77.58
Specificity	99.2	98.86	98.41	98.47	98.05
Obstructive Sleep Apnea					
Sensitivity	73.99	87.57	64.06	59.05	50.76

Specificity	93.68	87.64	88.01	89.94	90.95
Abdominal Hernia					
Sensitivity	93.31	90.03	85.99	79.2	75.27
Specificity	99.56	99.45	99.16	99.27	99.1
Congestive Heart Failure					
Sensitivity	40.35	40.62	37.61	42.47	25
Specificity	99.84	99.79	99.71	99.68	99.4
Post-Operative Surgeon Follow-up and/or Support Group Attendance					
Sensitivity	0.38	0.05	0.19	0	0.23
Specificity	99.87	99.98	99.94	99.89	99.9
Any Adverse Event					
Sensitivity		0.52	0.51		
Specificity		99.92	99.92		

Table 3. Example Output of Prognostic Models Predicting Outcomes for 50 Year-Old Female, 5ft 4in Tall, 320 lbs, with Depression, Diabetes, GERD, Hypertension, and Stress Urinary Incontinence.

Date:	**2 months**	**6 months**	**12 months**	**18 months**	**24 months**
Weight					
AGB	292	277	263	254	251
BPD/DS	275	230	194	183	182
LRYGB	277	234	208	200	200
RYGB	277	235	208	199	198
SG	280	245	222	217	211
Relative Risk of Having Morbid Obesity Co-Morbidities (%)					
Abdominal Hernia					
AGB	0	1	1	1	1
BPD/DS	0	2	9	16	13
LRYGB	0	1	1	1	1
RYGB	0	1	2	3	4
SG					
Congestive Heart Failure					
AGB	0	1	1	1	0
BPD/DS	1	1	1	1	1
LRYGB	1	1	1	1	1
RYGB	0	1	0	1	0

SG	1	1	1	1	0
Cholelithiasis					
AGB	1	1	2	2	2
BPD/DS	14	20	26	31	29
LRYGB	1	1	2	2	3
RYGB	1	1	1	2	2
SG	1	2	3	4	5
GERD					
AGB	38	30	25	25	24
BPD/DS	47	41	26	31	32
LRYGB	36	23	17	18	16
RYGB	36	28	22	24	25
SG	41	32	34	25	25
Diabetes					
AGB	23	20	17	15	14
BPD/DS	21	14	7	7	4
LRYGB	24	15	10	8	7
RYGB	24	17	13	11	10
SG	23	16	11	10	8

Hypertension					
AGB	58	52	43	37	38
BPD/DS	39	25	14	14	13
LRYGB	42	27	19	16	16
RYGB	48	32	28	29	25
SG	46	33	24	23	21
Liver Disease					
AGB	1	1	1	1	1
BPD/DS	4	5	3	2	3
LRYGB	1	1	1	1	0
RYGB	3	2	2	1	2
SG	1	1	1	1	1
Obstructive Sleep Apnea					
AGB	47	45	40	38	35
BPD/DS	55	45	34	33	31
LRYGB	48	38	28	26	23
RYGB	51	42	32	28	25
SG	49	42	32	30	26

Surgeon Follow-up/Support Group Attendance

AGB	12	13	11	11	9
BPD/DS	20	22	19	21	18
LRYGB	16	18	16	16	14
RYGB	16	17	15	14	15
SG	15	17	14	15	12