Long-Term Outcomes after Adolescent Bariatric Surgery

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BACKGROUND: Metabolic and bariatric surgery (MBS) is a safe and effective treatment option for adolescents with severe obesity, but no long-term studies are available with more than10 years of follow-up data to document sustained improved outcomes.

METHODS: A total of 96 patients who completed MBS at 21 years of age or younger in a tertiary academic center 2002 to 2010 were contacted for a telehealth visit. Body weight, comorbidity status, social/physical function status, and long-term complications were evaluated 10 to 18 years after surgery.

RESULTS: Mean participant (83% female, 75% Hispanic) age at MBS was 18.8 (±1.6) years (median age 19 years, range 15–21 years), and median pre-MBS BMI was 44.7 kg/m^2 (SD 6.5). At follow-up (mean 14.2 [±2.2] years) post-MBS (90.6% Roux-en-Y gastric bypass [RYGB] or 8.3% laparoscopic adjustable gastric banding [LAGB]) mean total body weight decreased by 31.3% (interquartile range [IQR] 20.0% to 38.9%); 32.0% (IQR, 21.3% to 40.1%) among RYGB participants and 22.5% (IQR, 0.64% to 28.3%) among LAGB participants. Patients with pre-MBS hyperlipidemia (14.6%), asthma (10.4%), and diabetes/hyperglycemia (5.2%) reported 100% remission at follow-up ($p < 0.05$ for all). Pre–post decrease in hypertension (13.5% vs 1%, $p = 0.001$), sleep apnea (16.7% vs 1.0%, $p < 0.001$), gastroesophageal reflux disease (13.5% vs 3.1%, $p = 0.016$), anxiety (7.3% vs 2.1%, $p = 0.169$), and depression (27.1% vs 4.2%, $p < 0.001$) were also found.

CONCLUSIONS: Significant sustained reductions in weight and comorbidities, and low rates of long-term complications, a decade or more after completing MBS as an adolescent were found. These findings have important implications for adolescents who may be considering MBS for weight reduction and overall health improvements that extend into adulthood. (J Am Coll Surg 2022;235:592–601. © 2022 by the American College of Surgeons. Published by Wolters Kluwer Health, Inc. All rights reserved.)

In the US, almost 12% of non-Hispanic Black (NHB), 9% of Hispanic, and 7% of non-Hispanic White (NHW) adolescents ages 12 to 19 years old have severe obesity (defined as having a BMI greater than or equal to 35 kg/m^2 or greater than or equal to 120% of the 95th percentile for age and sex).[1] Evidence suggests that children with severe

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Abbreviations and Acronyms

AAP	=	American Academy of Pediatrics
LAGB	=	laparoscopic adjustable gastric band
MBS	=	metabolic and bariatric surgery
NHB	=	non-Hispanic Black
NHW	=	non-Hispanic White
IQR	=	interquartile range
RYGB	=	Roux-en-Y gastric bypass
TBWL%	=	total body weight loss percentage

obesity are at increased risk for developing chronic diseases including cardiometabolic disorders[2] and cancers,[3] which may result in long-term disability and premature death.[4]

Metabolic and bariatric surgery (MBS) has emerged as a safe and effective treatment modality for adolescents with severe obesity with similar perioperative complication rates as for adults who have undergone MBS.[5-8] The American Academy of Pediatrics (AAP) recently released a policy statement that recommended early referral to multi-disciplinary pediatric-focused MBS programs for adolescents with severe obesity.[9] MBS in adolescents has been an underused treatment modality, owing to barriers including referral, access,[10,11] and a lack of long-term evidence of MBS outcomes for adolescents. Recent reviews stress the urgent need for longitudinal studies demonstrating durable and sustainable weight loss.[12-14]

MBS patients are routinely lost-to-follow-up, thus limiting the availability of weight, comorbidities, and other outcomes. In adults, the Swedish Obesity Study documented 20-year post-MBS follow-up compared with usual care and showed a long-term reduction in incident diabetes, myocardial infarction, stroke, and mortality.[15] Although there have been short- and medium-term studies in adolescent MBS patients with similar outcomes,[16] studies with more than 10 years of follow-up do not exist. Major trials involving adolescents undergoing MBS, including the Teen-LABS cohort (NCT00474318, 161 patients),[17] the AMOS trial (NCT02378259, 81 patients),[18] and the Follow-Up of Adolescent Bariatric Surgery (NCT00776776, 58 patients)[19] have demonstrated similar decreases in post-MBS weight loss and reductions in comorbid conditions at 3 to 8 or more years after MBS. A recently published study in 632 in patients who received MBS at 5 to 18 years of age showed excellent maintenance of weight loss and comorbidity resolution 7 to 10 years after surgery.[20]

Although clinical trials with low-attrition offer insights into postoperative outcomes, this may limit overall generalizability because post-MBS loss to follow-up has been as high as 60%.[21,22] Long-term follow-up of adolescents who have completed MBS outside of a formal research protocol and were subsequently lost to follow-up has never been described in the literature. This is a novel area of research because these community-based practice patients may better represent the majority of MBS patients. We report post-MBS weight and comorbidity outcomes of adolescent patients who completed surgery between 10 and 18 years previously, most of whom had been lost to follow-up for multiple years. We hypothesized that despite long-term loss to follow-up, these patients would have sustained weight loss, comorbidity resolution, and an overall improved quality of life as an adult.

METHODS

Study design

A retrospective medical chart review was conducted at an academic tertiary referral center to identify patients who completed MBS at 21 years of age or younger and at least 10 years ago, (from January 2002 through September 2010). The surgeries were performed by the lead surgeon when he was in a community-based practice from 2002 through 2009. A new dataset was created from identified patients with the following variables: demographic data (age, sex, race/ethnicity), presurgery weight, BMI, and preoperative comorbidities. The number of post-MBS follow-up visits, duration of follow-up, number of months lost to follow-up, perioperative complications, and surgical interventions were also included. This information was subsequently used as the interview guideline to verify and capture new follow-up information among study participants. This study was approved by the IRB.

Participants

A total of 130 patients who met inclusion criteria were identified. Ninety-seven patients were successfully contacted and 96 agreed to participate in the study.

Study Procedures

Patients were assigned a bariatric practice team clinical healthcare provider (MD, RD, ARNP, or LPN) who attempted telephone contact. Once contacted, the provider followed an IRB-approved verbal script to attempt to obtain consent for the study. All patients who were successfully contacted, except 1, consented to participate. The providers then read from a 2-page questionnaire to obtain the follow-up data.

Up to 10 attempts were made to contact a patient. All phone numbers in the database and in a separate university health system database were used. For patients who could not be reached, a fee-based online national search was conducted to obtain the latest phone numbers and addresses on record. If there was still no successful contact with the patient by telephone, patients were mailed a packet that included the consent form, the study questionnaire, and paid return envelopes. Finally, a nationwide mortality search was completed for all patients not successfully contacted.

Measures

Demographics

Participants were asked about their current age, sex, race/ethnicity, highest level of education completed, current employment status, marital and relationship status (committed, long-term, etc), pregnancy, and pregnancy outcomes.

Anthropometrics

Participants were asked to report their current weight, current height, and lowest weight.

Comorbidities and complications

Participants previously documented complications and comorbidities were reviewed during the visit and the current status recorded. Participants were also asked about any new health conditions since having surgery.

Behavioral outcomes

Participants were asked about personal relationship status and current and past alcohol consumption, physical activity, and dietary intake patterns.

Statistical analysis

Categorical variables were presented as frequencies and percentages, and continuous variables were assessed for normality via the Shapiro-Wilk test. Normally distributed continuous variables were summarized as means (SD) or were summarized as a median (interquartile range [IQR]). We assessed the weight change from baseline to current weight and lowest weight post-MBS based on both actual weight and BMI. Wilcoxon signed-rank test was performed to examine the statistical significance of weight and BMI change. Furthermore, nonparametric statistics were used at baseline to test whether there were any significant differences between those who were contacted for a telehealth visit as compared with those who were not.

Total body weight loss percentage (TBWL%) was calculated by the formula below:

$$\%\text{TBWL} = \frac{(\text{Baseline weight}) - (\text{Follow}-\text{up weight}) \times 100}{\text{Baseline weight}}$$

Fisher's exact tests were used to compare patient comorbidities including anemia, asthma, anxiety, back pain, depression, type 2 diabetes, gastroesophageal reflux disease, hyperlipidemia, hypertension, and sleep apnea from baseline to long-term follow-up. The association between baseline and current BMI was explored with a Pearson correlation. Because a positive and significant correlation was found, we analyzed the normalized BMI difference by dividing with the standard deviation of the current BMI in a multivariable linear regression model. This model was adjusted for demographic factors and comorbidities to identify predictors for BMI. The equation for calculating the normalized BMI difference (ie the dependent variable of the linear model) is as follows:

$$\text{Normalized BMI difference} = \frac{(\text{Current BMI}) - (\text{Baseline BMI})}{\text{Standard deviation of current BMI}}$$

The final model included 12 levels, resulting in 80% power (assuming 8 responses per participant).[23] All analyses were conducted with SAS (version 9.4). Two-sided p values < 0.05 was considered as statistically significant.

Sensitivity analysis

A post hoc sensitivity analysis using Pearson chi-square test was performed to compare risk of further abdominal operations in patients who had band vs Roux-en-Y gastric bypass (RYGB) surgery. We found no difference between number of related abdominal surgeries and surgery types; 20.69% (n = 18) and 37.50% (n = 3) RYGB and Lap band patients had other abdominal surgeries, respectively (p = 0.273).

RESULTS

Thirty-two potential participants could not be reached; additionally, 1 did not consent, and 1 was deceased 9 months after surgery (from unrelated medical condition). Thus, the final analytical sample included a total of 96 consented patients (73.9% follow-up). Table 1 shows the

Table 1. Baseline Characteristics Among Those Who Had Metabolic and Bariatric Surgery at 21 Years of Age or Younger (n = 130) by Contact Status

Characteristic	Patients consented (n = 96)	Patients not consented (n = 34)	p Value*
Age at surgery, y, mean (SD)†	18.8 (1.6)	19.1 (1.4)	0.269
Sex, n (%)			
Male	16 (16.7)	8 (23.5)	0.376
Female	80 (83.3)	26 (76.5)	
Race/ethnicity, n (%)			
NHW	16 (16.7)	2 (5.9)	
NHB	9 (9.4)	0 (0)	0.023
Hispanic	71 (73.9)	31 (91.2)	
Native American	0 (0)	1 (2.9)	
Procedure type, n (%)			
RYGB	87 (90.6)	30 (88.2)	0.642
Lap band	8 (8.3)	4 (11.8)	
Sleeve gastrectomy	1 (1.0)	0 (0)	
Insurance type, n (%)			
Commercial	65 (67.7)	20 (58.8)	0.724
Government	9 (9.4)	4 (11.8)	
Self-pay	20 (20.8)	9 (26.5)	
Not available	2 (2.1)	1 (2.9)	
BMI at surgery, median [kg/m^2, (IQR)]	45.0 (41.0-49.0)	45.5 (42-49.0)	0.758

*Mann-Whitney U test for continuous variables; Pearson Chi-square or Fisher's exact test for categorical variables.
†Patients consented: median age 19 years (range 15–21 years); Patients not consented: median age 19 years (range 16–21 years).
IQR, interquartile range; NHB, non-Hispanic Black; NHW, non-Hispanic White; RYGB, Roux-en-Y gastric bypass.

mean (±SD) pre-MBS age was 18.8 (±1.6) years (median age 19 years, range 15–21 years). The majority (83.3%, n = 80) were female, and 73.9% (n = 71) were Hispanic followed by NHW (16.7%, n = 16) and NHB (9.4%, n = 9). Most patients (90.6%, n = 87) completed RYGB. Of the 8 band patients, 2 underwent band removal for reflux and slippage, 1 underwent repositioning for slippage, and 1 had a spontaneous band deflation that has been left in place. The other 4 patients still have their bands intact but they have not been adjusted in more than 10 years. There was no difference between participants and nonparticipants in age at time of surgery, sex, insurance type, or baseline BMI.

The 3 most common patient responses to the question "why did you get lost to follow-up" were changes in insurance and coverage, immaturity and not realizing the importance of follow-up, and moving away from the area. Although lost to the bariatric clinic, many patients were followed by their pediatricians and primary care physicians.

Table 2 summarizes the changes of weight status from baseline to long-term follow-up. The baseline median (IQR) weight was 278.5 (241.5–324) lbs. At present, current median weight was 195 (IQR, 160–240) pounds converting to a TBWL% of 31.3% (IQR, 20.0% to 38.9%) in the total cohort, 32.0% (IQR, 21.3% to 40.1%) among participants who completed RYGB, and 22.5% (IQR, 0.64% to 28.3%) among those who completed laparoscopic adjustable gastric banding (LAGB) surgery ($p < 0.001$ for all comparisons). The 1 patient who underwent a sleeve gastrectomy has a current TBWL% of 33%. (data not shown). When calculating with lowest weight after surgery, the results were even more striking with a TBWL% of 44.4% (IQR, 40.1% to 48.6%). Patients' BMI values were also significantly decreased from 44.9 (IQR, 41.5–50.1) before surgery to the lowest BMI of 25.2 (IQR, 23.4–27.5), equating to a 44.4% (IQR 40.1% to 48.6%) decrease after surgery, and 31.7 (IQR, 27.3–37.3) at present equating to a 31.4% (IQR 21.3% to 39.8%) decrease ($p < 0.001$ for all comparisons). The long-term weight loss responder rate (defined as having a TBWL greater than 20% after 5 years) was 74.7% in RYGB patients and 62.5% in LAGB patients.[23]

Table 3 lists comorbid conditions and resolution rates. Remission was defined as off medicine and not undergoing any medical management or treatment. Patients with hyperlipidemia (14.6%), asthma (10.4%), and type 2 diabetes/hyperglycemia (5.2%) reported 100% remission at follow-up ($p < 0.05$ for all). Remission of hypertension (13.5% vs 1%, $p = 0.001$), sleep apnea (16.7% vs 1.0%, $p < 0.001$), gastroesophageal reflux disease (13.5% vs 3.1%, $p = 0.016$), anxiety (7.3% vs 2.1%, $p = 0.169$), and depression (27.1% vs 4.2%, $p < 0.001$) were also found.

Table 2. Weight Change from Baseline to Long-Term Follow-Up Among Those Who Had Metabolic and Bariatric Surgery at 21 Years of Age or Younger (n = 96)

Variable	Baseline/at MBS	Long-term follow-up	
		Current weight	Lowest weight
Weight change			
Weight, lbs, median (IQR)	278.5 (241.5-324)	195 (160-240)	155 (135-179)
Weight loss, lbs, median (IQR)	—	83 (54-117)	125 (98-147)
Total body weight loss, %, median (IQR)	—	31.3 (20.0-38.9)	43.4 (38.9-48.3)
p Value*	—	<0.001	<0.001
BMI change			
BMI, median (IQR), kg/m^2	44.9 (41.5-50.1)	31.7 (27.3-37.3)	25.2 (23.4-27.5)
BMI absolute change, kg/m^2,median (IQR)	—	14.5 (9.3-18.5)	19.9 (17.4-24.5)
BMI change, %, median (IQR)	—	31.4 (21.3-39.8)	44.4 (40.1-48.6)
p Value*	—	<0.001	<0.001

*Wilcoxon Signed-Rank test for weight and BMI change from baseline to long-term follow-up.
IQR, interquartile range; MBS, metabolic and bariatric surgery.

Since surgery, 19.8% of participants were readmitted for various complications, with anemia (4.2%) and intussusception (3.1%) being the most common. Thirty-eight (39.6%) underwent post-MBS abdominal surgical interventions, with cosmetic surgery (18.8%) and cholecystectomy (8.3%) being the most common (**Supplemental Table 1**, http://links.lww.com/JACS/A131). Whereas 3.1% had anemia preoperatively, the rate was 67.7% in the postoperative period; 24% of the patients required transfusion (Table 3).

Other post-MBS outcomes are reported in **Supplemental Table 2**, http://links.lww.com/JACS/A131. In summary, the mean number of years since MBS was 14.3 (2.2). More than half (59%) had graduated college or pursued a graduate degree and 84.2% reported current employment. More than half (52.2%) reported currently being married, and 67.1% of females had a successful pregnancy and birth. About half (52.1%) reported regular alcohol consumption, whereas 8.3% reported having a drinking problem at some point postoperatively. More than half (60.4%) reported engaging in regular physical activity, and 86.5% reported improved dietary habits since surgery. Almost all (88.5%) participants were satisfied with their MBS results, and 91.7% said they would undergo MBS again.

Figure 1 shows a significant but modest association between current BMI and baseline BMI ($r = 0.376$, $p < 0.001$). The multivariable linear regression adjusting for age at surgery, sex, race/ethnicity, education, surgery type, insurance, and comorbidities showed that NHB had significantly more weight loss compared with NHW ($\beta = -0.95$, SE = 0.47, $p = 0.047$; Table 4). All other predictors were insignificant.

Table 3. Patient Comorbidities from Baseline (pre-MBS) to Long-Term Follow-Up (post-MBS) Among Those Who Had Metabolic and Bariatric Surgery at 21 Years of Age or Younger (n = 96).

Comorbidity	Pre-MBS, n (%)	Post-MBS, n (%)	p value*
Anemia	3 (3.1)	65 (67.7)	<0.001
Asthma	10 (10.4)	0	0.002
Anxiety	7 (7.3)	2 (2.1)	0.169
Back pain	32 (33.3)	4 (4.2)	<0.001
Depression	26 (27.1)	4 (4.2)	<0.001
Diabetes or hyperglycemia	5 (5.2)	0	0.059
GERD	13 (13.5)	3 (3.1)	0.016
Hyperlipidemia	14 (14.6)	0	<0.001
Hypertension	13 (13.5)	1 (1.0)	0.001
Sleep apnea	16 (16.7)	1 (1.0)	<0.001
Transfusion	0	23 (24.0)	<0.001

*Fisher's exact test.
GERD, gastroesophageal reflux disease; MBS, metabolic and bariatric surgery.

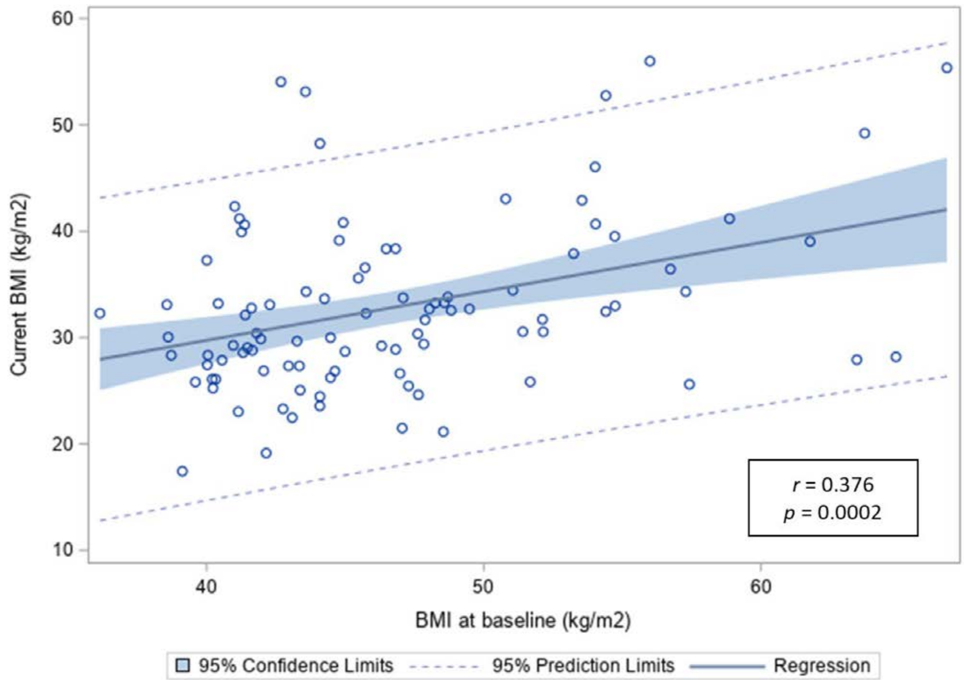

Figure 1. Pearson correlation of BMI at baseline with current BMI among those who had metabolic and bariatric surgery at 21 years of age or younger (n = 96).

DISCUSSION

We report here the longest follow-up data currently available in the literature on adolescent MBS patients. A portion of this cohort has been previously reported with 4-year outcomes showing a median BMI of approximately 31 kg/m^2.[24] Long-term weight loss was sustained and significant, up to almost 2 decades and without consistent clinical follow-up with their surgeon. Comorbidity resolution was equally significant, with several conditions completely resolving via self-report. This is an important area of inquiry because these patients may represent the majority of MBS patients who are not enrolled in a formal research protocol, are frequently lost to follow-up, and may be indicative of real-world outcomes and the sustainability of adolescent MBS. Our cohort had a lower prevalence of presurgery comorbid conditions vs other published studies,[17-19] because the majority of adolescents were not referred by a physician but rather by a parent. Moreover, our program did not actively engage referring physicians. Most of the patients had parents who were successful MBS completers, and had experienced the benefits as a result, and thus did not want their child to experience the same life challenges.

The AAP supports greater access to MBS for the nearly 4 million US youth experiencing severe obesity.[9] Although MBS is an invasive treatment option, and perhaps not an agreeable weight loss solution for many youths and their families, it is an evidence-based, safe, and effective tool that healthcare providers can introduce as an option to their patients. Patients with psychiatric or emotional conditions, such as eating disorders, severe depression, or anxiety, may need to address these issues before completing MBS. The potential disadvantages, beyond the complications of any surgery, can include vitamin deficiencies and/or weight regain. Moreover, Woolford and colleagues[25] found in 2007 that 48% of physicians would not ever refer an adolescent for MBS and 46% would not make a referral until the patient was 18 years old. Results here show that completing MBS as an adolescent has durable weight loss and comorbidity resolution that last at least up to almost 2 decades. These positive health effects may also influence patients' decision to pursue education, employment, and social relationships. The majority of the female patients had successful pregnancies, confirming findings that MBS decreases pregnancy complications compared with patients with obesity—in particular, hypertensive disorders and gestational diabetes and its complications.[26]

Inadequately treated or poorly managed obesity can have significant psychological consequences in adolescents and young adults.[27] Many teens with extreme obesity struggle with depression and conflicts within their peer groups. Our findings suggest that the psychological, social, and overall quality of life outcomes reported by patients favor surgery over no intervention. The percentage of patients undergoing treatment for depression

Table 4. Multivariable Linear Regression to Explore Possible Predictors for BMI Among Those Who Had Metabolic and Bariatric Surgery at 21 Years of Age or Younger (n = 96).

Variable	Beta-coefficient	SE	p Value*
Age at surgery	0.09	0.07	0.220
Sex			
Male	0 (ref)	N/A (ref)	
Female	0.414	0.311	0.188
Race/ethnicity			
NHW	0 (ref)	N/A (ref)	
NHB	-0.95	0.47	0.047
Hispanic	-0.18	0.32	0.581
Education			
Some high school	0 (ref)	N/A (ref)	
High school graduate	-1.73	1.10	0.118
Some college	-1.77	1.05	0.095
College graduate	-1.45	1.05	0.174
Postgraduate	-1.63	1.08	0.133
Surgery type			
RYGB	0 (ref)	N/A (ref)	
Lap band	0.76	0.39	0.057
Sleeve gastrectomy	0.86	1.22	0.445
Insurance type			
Commercial	0 (ref)	N/A (ref)	
Government	-0.57	0.39	0.147
Self-pay	-0.15	0.28	0.581
Comorbidity at baseline			
No	0 (ref)	N/A (ref)	
Yes	0.27	1.06	0.801

The dependent variable of the linear regression model is normalized BMI difference between current and baseline BMI divided by the standard deviation of current BMI.
*Multivariable linear regression adjusted for BMI at baseline, age, sex, race/ethnicity, education, surgery type, insurance type, and comorbidity at baseline.
†Statistically significant.
NHB, non-Hispanic Black; NHW, non-Hispanic White; RYGB, Roux-en-Y gastric bypass

significantly decreased from 27.1% to 4.2% (as defined by either pharmacotherapy and/or counseling). Overall, participants were satisfied with the decision to undergo MBS, and 91% reported that they would undergo surgery again. These findings show holistic health improvements as a result of MBS that are critically important for both pediatricians and families to understand when considering this procedure for their patient or child.

The AAP policy statement[9] highlights "watchful waiting," defined as long-term lifestyle management, as a barrier of access to care with MBS because adolescents with severe obesity are unlikely to benefit from this treatment approach. A simulation study that used nationally representative data assessing the risk for adult obesity based on childhood obesity status showed that if a child experienced severe obesity at age 19 years, their chances of being normal weight at age 35 years was 3.5% among boys and 8.2% among girls.[28] Studies show very low MBS use rates among adolescents.[29,30] Recent population-level analyses by our group showed that adolescents are referred later than adults with a higher proportion entering MBS with a BMI greater than 50 kg/m^2.[10] There is additional disparity in that ethnic minority patients are even less likely to undergo MBS.[25] Recent data show that there may be a protective effect of MBS on youth, as adolescents undergoing these operations have greater improvements on their comorbid conditions compared with adults.[31] MBS can prevent years of experiencing the cumulative impact of multiple comorbid diseases. Our findings show that there is long-term weight loss, reduced rates of comorbidities, and improved quality of life as a result of MBS. Additionally, long-term post-MBS complication, readmission, and reoperation rates were comparable with those reported in adult patients.[32,33] In summary, there is a greater benefit to having MBS at a younger age than waiting until the patient is older.

Reporting outcomes on patients lost to follow-up has not been previously documented in the adolescent literature.

A sustained TBWL% of 31.3% and a mean decrease in BMI from 45.4 mg/m^2 to 31.7 mg/m^2 at 10 to 18 years after MBS is remarkable, especially given that this was not a controlled research study. Pre-MBS preparation included completing extensive psychological, nutritional, and medical evaluations as part of a rigorous screening process because of their age. We stressed that successful outcomes require a lifelong commitment to significant changes in diet and vitamin supplementation. Most patients are currently taking at least 1 of the recommended supplements, with many patients taking all of them. Most admitted to being poorly compliant in their early 20s, consistent with the history of anemia that many experienced. Even with a lack of formal postsurgical follow-up, the absence of significant long-term complications is reassuring.

It should be noted that about half (52.1%) of the sample reported regular alcohol consumption, and almost 10% (8.3%) reported having a drinking problem at some point postoperatively. This is consistent with previous studies that suggest that some patients develop progressive alcohol use disorder several years after RYGB.[34] Our team has previously reported that 4.2% of an ethnically diverse sample of young MBS patients developed a post-MBS alcohol use disorder, with 14.5% of respondents reporting binge drinking and 42% reported drinking until intoxication.[35] Qualitative findings showed 4 major themes prompting an increase in post-MBS alcohol use: (1) increased sensitivity to alcohol intoxication, (2) using alcohol as a replacement self-soothing mechanism for food, (3) increase in socialization, and (4) using alcohol as a coping mechanism.[36] Risk factors for problematic postoperative alcohol use include regular or problematic alcohol use before MBS, male sex, younger age, tobacco use, and symptoms of attention deficient and hyperactivity disorder.[37]

Another important finding was that 4.2% of participants were readmitted with anemia (4.2%), and although 3.1% had anemia preoperatively, the rate was 67.7% in the postoperative period; 24% of the patients required transfusion. Anemia has been a well-documented, highly prevalent post-MBS complication.[38,39] Indeed, a recent meta-analysis showed that patients undergoing RYGB had a higher risk of postoperative vitamin B12 deficiency than those undergoing SG (relative risk, 1.86; 95% confidence interval 1.15–3.02; p = 0.012; high level of evidence).[40] The authors suggest that that patients undergoing RYGB require more stringent vitamin B12 supplementation and surveillance than those undergoing SG. These results have important preoperative implications for pre-MBS discussions concerning appropriate procedure type. Although our sample included only 1 sleeve and 8 lap bands given that some participants had their surgeries almost 20 years ago, our practice now conducts primarily sleeve gastrectomy procedures and no lap bands.

Regression analysis showed no significant differences in age at surgery, sex, race/ethnicity, education level, insurance type, and baseline comorbidities in predicating long-term BMI status. The model also showed that LAGB had a less favorable sustained BMI outcome vs RYGB, which is consistent with the literature.[41,42] These findings are encouraging in that MBS is a safe and effective long-term weight loss option for all patients who qualify, regardless of these many factors.

Limitations and strengths

Some study limitations should be noted. The study includes a retrospective medical chart review combined with a questionnaire. The absence of a matched non-MBS control group with similar severe obesity limits the rigor of study conclusions. Although the results of this population-based observational study should be validated in a large randomized, controlled trial of adolescent MBS vs optimal medical therapy to conclusively establish the impact of MBS on reducing clinically significant outcomes, this will not occur for the foreseeable future owing to a lack of international collaboration to study the long-term effects of these rare procedures. Second, patient height, weight, and other data were self-reported. However, many studies have reported that self-reported weight in bariatric surgery candidates is equally valid as in-person measurement.[43,44] Although use of a survey cannot medically include or exclude comorbidities, these findings are valuable because they are patient-perceived health assessments in a real-world setting. In some ways, that is more valuable than the subclinical laboratory assessments of an objective measure. In addition, we were unable to reach a quarter of the cohort, thus there may be an inclusion bias. However, a sensitivity analysis showed no substantial baseline differences between long-term follow-up participants vs those not reached, indicating no systematic bias. In addition, all subjects, except 1, who were successfully contacted consented for the study. A strength was the inclusion of a high percentage of Hispanic and NHB participants given that these populations are disproportionately impacted by many of the severe obesity-related comorbidities[38] and less likely to undergo MBS than their NHW peers.[45]

CONCLUSIONS

Our results show sustained and remarkable weight loss up to almost 2 decades after adolescent MBS without weight regain. Comorbidity resolution was equally notable, with several conditions completely resolving. Participants also reported positive quality-of-life outcomes. This is an important area of inquiry because MBS patients who do not return for follow-up visits represent the majority of those who complete surgery each year in the US. These results can encourage health care providers to consider MBS as a viable treatment option to prevent and reduce the risk of clinically significant events developing in adolescents with severe obesity.

Author Contributions

Study conception and design: de la Cruz-Muñoz
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Invited Commentary

Outcomes 10 to 18 Years after Bariatric Surgery as an Adolescent

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Long-term outcomes of metabolic and bariatric surgery (MBS) in adolescents is not a widely reported subject in the bariatric literature. Cruz-Munoz and colleagues,[1] through their study "Long-Term Outcomes after Adolescent Bariatric Surgery," reviewed the effects of MBS on 96 adolescent patients who underwent laparoscopic Roux-en-Y gastric bypass and laparoscopic adjustable gastric band with a mean follow-up of 14.2 years. The authors concluded that patients at the last contacted follow-up lost 31.3% of their total body weight. This weight loss was coupled to a complete remission of diabetes, hyperlipidemia, and asthma added to a statistically significant resolution of hypertension, gastroesophageal reflux disease, sleep apnea, anxiety, and depression. This is the longest reported follow-up thus far for this patient population after MBS, hence filling a substantial gap in the currently available literature.

MBS in adolescents has been proven to be a safe modality for weight loss. Lopez and colleagues reported the 30-day outcomes of MBS in the adolescent population through assessing the MBSAQIP for the year 2015.[2] The authors deduced that, similar to the adult group, MBS is safe and share a similar perioperative risk–safety profile. These findings were corroborated by El Chaar and colleagues, who additionally concluded that sleeve gastrectomy had fewer adverse events, readmissions, and reinterventions when compared with Roux-en-Y gastric bypass,[3] a fact that mirrors what is witnessed in the adult age group. Although these aforementioned analyses assessed the early safety of MBS in adolescents, they lacked the medium- and long-term outcomes required to establish MBS as a safe, durable, and effective treatment for weight loss in adolescents.

The medium-term data were, however, reported in the PCORnet bariatric study showing a decrease of 21% and 24% of BMI in sleeve gastrectomy and Roux-en-Y gastric bypass, respectively, at a 5-year follow-up period (n = 544).[4] Cruz-Munoz and colleagues, in this publication, undoubtedly managed to portray MBS as a definitive treatment for adolescent patients suffering from obesity. That said, level 1 evidence regarding procedure selection is still missing awaiting the results of randomized control trial (TEEN-BEST) to be published in the near future.[5]

The challenges of MBS in adolescents go beyond the safety and weight loss effectiveness because it can affect essential physiologic and nutritional measures including derangements to the gonadal axis as well as bone health.[6] Moreover, the quality of life after MBS is yet to be properly studied in this population. Adolescents after MBS often relocate for college or work and might lose the supportive environment they had when undergoing the surgery. Change in food quality, peer pressure, and exposure to illicit drugs might also affect compliance and impose further risks. Therefore, a thorough psychological support is mandatory both for the patient and the family before and after the operation.

With the increased prevalence of obesity in adolescents in the US and the absence of actual prevention measures for this disease at both the governmental and societal levels, more patients will be seeking this effective modality for weight loss. The questions that will continue to resurface are the following: Who is a candidate? When should the candidate be referred? At what age do we offer surgery? How informed is the patient? Who gives the consent? Who performs the surgery? Most importantly, are the patients ready for an anatomy-altering lifetime procedure in the earlier stages of their lives? With the advancements of endoscopic bariatric surgery, organ-preserving anatomy-altering endoscopic options might present an early bridge before definitive surgical options. Only data and time will tell.

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