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Bariatric surgery outcomes: is age just a number?

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Abstract

Introduction Obesity and its associated comorbidities represent a pervasive problem in the United States across all age groups. There are conflicting data regarding the effectiveness and postoperative recovery of bariatric surgery in elderly patients. The aim of this study was to compare outcomes of bariatric surgery across age groups.

Materials and Methods After obtaining institutional review board approval, patients with morbid obesity who underwent non-revisional laparoscopic Roux-en-Y gastric bypass (LRYGB) and sleeve gastrectomy (LSG) at our institution between 2011 and 2015 were included in this retrospective study. Patients were subdivided into five age groups: < 30, 30–39, 40–49, 50–59, and ≥ 60 years. Patient baseline demographics and comorbidities were collected. Postoperative outcomes including reinterventions/reoperations, 30-day-readmissions, 90-day-mortality, comorbidities' resolution, and change in BMI (ΔBMI) up to 4 years were recorded and compared. The groups were compared with ANOVA and chi-square tests and multivariable analyses.

Results LRYGB was performed in 74.7% of the 1026 study patients. Patients ≥ 60 years old demonstrated lower preoperative BMI than patients < 50 years ($p < 0.001$). Patients 50–59 years old had increased length of stay compared to 30–39 ($p = 0.003$) and a higher prevalence of all comorbidities was found in older patients ($p < 0.001$). There was no significant difference in 30-day-readmissions; 90-day-mortality; reoperations; and reinterventions among the study groups. The ΔBMI was higher in younger patients and comorbidity resolution was more likely in younger patients with the exception of obstructive sleep apnea.

Conclusion Bariatric surgery can be accomplished safely across all age groups with satisfiable postoperative weight loss. However, older age had higher hospital stay and convalescence and lower comorbidity resolution compared to younger patients. Thus, bariatric surgery should be offered earlier in life to allow the patients to reap its benefits.

Keywords Bariatric surgery · Age · Elderly · Outcomes · Comorbidity resolution · Weight loss

Obesity is a well-known epidemic in the United States [1, 2]. The obesity rates have increased in all ages and sexes irrespective of location, and socioeconomic status [3]. It is estimated that, by 2030, the prevalence of both obesity and severe obesity will reach 50% and 25% of the adult population in the US, respectively [4]. The literature suggests that all adult age groups are affected by obesity similarly and require appropriate management [5]. Additionally, obesity is considered a disease as it is linked to higher mortality [6], and is the causative factor of many comorbidities including diabetes mellitus-II (DMII), hypertension (HTN), hyperlipidemia (HLD), and obstructive sleep apnea (OSA).

Weight loss achieved through surgery improves quality of life [7]and leads to medical comorbidity resolution and mortality improvement [8, 9]. Additionally, weight reduction

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achieved through bariatric surgery is currently the most effective and durable method [10].

Bariatric surgery in elderly patients, even those over 60 years of age, has been shown to be beneficial with satisfactory weight loss [11], while others failed to reveal a weight loss difference between elder and younger patients [12]. On the contrary, there are studies showing superior comorbidity resolution in adolescents compared to more elderly patients even with similar weight loss [13]. However, there is a dearth of published literature assessing the effect of bariatric procedures across all age groups.

Thus, we aimed to assess the short- and mid-term outcomes of the most commonly performed bariatric operations, laparoscopic Roux-en-Y gastric bypass (LRYGB), and laparoscopic sleeve gastrectomy (LSG), across the adult age continuum.

Methods

Following institutional review board approval, a retrospective chart review was conducted from the prospectively maintained database of our hospital. All patients who underwent primary LRYGB and LSG procedures during 2011–2015 were selected. This date range was chosen because it allowed for a follow-up of at least 4 years for all patients. Additional manual review of other physician notes was performed for patients whose data were missing from our database. To study the bariatric outcomes in the various age groups, all patients were divided into 5 age groups: < 30, 30–39, 40–49, 50–59, and ≥ 60 years as proposed by Andrade-Silva et al. [14]. The recorded outcomes included patient baseline demographics such as age, sex, and body-mass-index (BMI) along with preoperative comorbidities (HTN, HLD, DMII, and OSA), type of surgery (LRYGB, LSG), and type of insurance (private including University insurances and public). Additionally, we collected postoperative outcomes including length of stay (LOS) in the hospital, 30-day readmissions, 90-day mortality, comorbidity resolution, all reoperations and reinterventions (endoscopic interventions related to the bariatric procedure) for up to 4 years, along with weight loss at the 1st year, 2nd year, 3rd year, and 4th postoperative year.

In compliance with standard outcome reporting [15] weight loss was defined as change in BMI (ΔBMI) which was calculated as below:

$$\Delta\text{BMI} : (\text{preoperative BMI}) - (\text{follow} - \text{up BMI})$$

The presence of a comorbidity was recorded when a relevant medication for DMII, HTN, and HLD was taken by the patients or when they had a positive sleep test or were under CPAP therapy for OSA. Remission of a comorbidity was considered when at follow-up their respective medications/device had been discontinued or they had normal sleep test study.

Statistical analysis

The groups were compared with ANOVA and chi-square tests. Multivariable binary and linear logistic regressions were performed to investigate whether the difference in the groups was affected by group allocation. We adjusted for potential confounders including type of operation, sex, and type of insurance. Specifically, for comorbidity resolution, a multivariable binary logistic regression analysis was performed for each comorbidity (presence of DMII, HLD, HTN, and OSA at follow-up) controlling for the aforementioned confounders with the addition of the preoperative presence of each comorbidity and the preoperative BMI.

A p value < 0.05 was considered significant. All the analyses were performed using the SPSS 26 (Chicago, IL).

Results

One thousand and twenty-six patients, comprising of 77% females, were included out of whom 74.7% (n = 766) underwent LRYGB and 25.3% (n = 260) LSG. The study patients were on average 44.9 ± 11.9 years old and the majority had a private insurance (58.6%). There were 102 patients in the < 30 group, 254 in the 30–39 years group, 295 in the 40–49 years group, 250 in the 50–59 years, and 125 in the ≥ 60 years group. The patients aged ≥ 60 years were more likely to have public insurance and 40–59 years subgroup were more likely to be male when compared with the < 30 years ones. The baseline characteristics of the five age groups can be found in Table 1.

The weight loss in the different age groups (Fig. 1) based on patients' follow-up at the end of each year can be found in Table 2. After adjusting for confounders such as sex, type of surgery, and insurance, the 30–39 year old patients lost more weight in the first, second, and third follow-up years compared with patients over 50 years of age. (Table 3).

LRYGB was strongly associated with higher ΔBMI when compared with LSG (1st year coefficient—3.593, $p < 0.001$; 2nd year—5.106, $p < 0.001$; 3nd year—5.553 $p < 0.001$; and 4th year—5.196, $p < 0.001$). However, sex and type of insurance were not associated with weight loss after controlling for age and the type of surgery.

We observed 1 death in the first 90 days in our study population, a 45 year-old patient, who expired due to pulmonary embolism. Sub-group analysis for LOS showed significant difference between the 50–59 years and 30–39 years groups; while 30 day readmission,

Table 1 Patient baseline characteristics among age groups

	< 30	30–39	40–49	50–59	≥ 60	*p* value
N	102	254	295	250	125	
Age (mean ± SD)	24.9 ± 4.4	35.1 ± 2.9	44.1 ± 2.9	54.5 ± 3.0	64.1 ± 3.5	
Female (%)	84	84	71	72	78	0.001
LRYGB (%)	77	73	77	72	74	0.641
Private insurance (%)	56.9	63.8	63.1	60.8	34.4	< 0.001

Age expressed in years

BMI body-mass-index; *LRYGB* laparoscopic Roux-en-Y gastric bypass

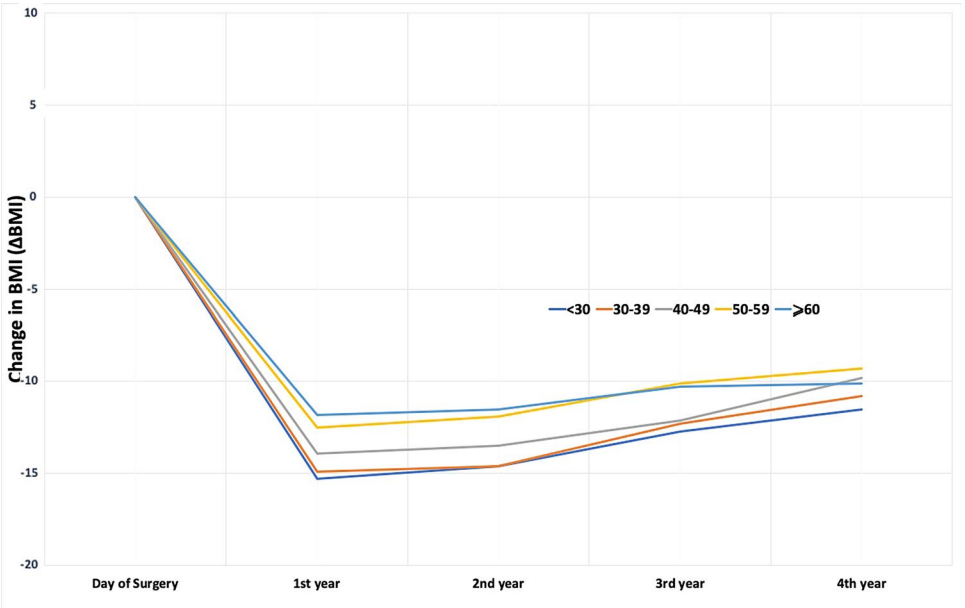

Fig. 1 Weight loss across age groups over a 4-year period

reintervention and reoperation rates of the age groups were similar and shown in Table 4. Multivariable analysis showed similar results.

Older patients presented with increased preoperative comorbidities. Baseline comorbidities and their subsequent presence or resolution during the follow-up period were detailed in Supplemental Table 1.

Older patients demonstrated smaller odds-ratios of comorbidity resolution even when adjusted for sex, type of surgery, preoperative BMI and type of insurance.

DMII resolution during 1st year was lower in patients ≥ 60 year old when compared to 30–39 year old patients (odds-ratio = 0.693, $p = 0.038$). The odds-ratio in the 2nd year was 0.870 ($p = 0.019$), while that in the 3rd year was 0.894 ($p = 0.007$). (Fig. 2).

The odds of HLD resolution in ≥ 60 year-old patients when compared with 30–39 year old subgroup was 0.605 at 1 year follow-up ($p = 0.031$), 0.851 at 2 years ($p = 0.002$), 0.781 at 3 years ($p = 0.044$), and 0.777 at 4 years ($p = 0.033$). HLD resolution in 50–59 year old when compared with 30–39 year old group was similar to that of ≥ 60 year old patients with the 2nd year odds-ratio being 0.768 ($p = 0.008$), 3rd year 0.878 (p = 0.002), and 4th year 0.805 ($p = 0.015$). (Fig. 3).

The odds of OSA resolution in 50–59 year old patients was 0.705 when compared with OSA resolution in 30–39 year old patients during the 1st year of follow-up ($p = 0.035$). (Fig. 4).

Finally, similar results were observed in the HTN resolution between older and younger patients. Patients ≥ 60 years old when compared to 30–39 patients had a resolution odds-ratio of 0.600 during 1st year ($p = 0.024$), 0.652 during 3rd year ($p = 0.038$), and 0.768 during 4th year ($p = 0.012$). Similarly, 50–59 year old patients had an odds-ratio of 0.540 during 1st year ($p = 0.03$), and 0.658 during 3rd year ($p = 0.016$) compared with 30–39 year-old patients. (Fig. 5).

Discussion

Obesity and its associated comorbidities are a public health crisis, which continues to worsen. With bariatric surgery being the most effective and sustained method of weight reduction and comorbidity resolution, it was the purpose of

Table 2 Weight Loss among age groups

	< 30	30–39	40–49	50–59	≥ 60	*p* value
Baseline						
N	102	254	295	250	125	
BMI	48.0 ± 8.5	47.8 ± 8.4	46.4 ± 7.3	44.7 ± 7.3	43.3 ± 7.2	< 0.001
1st year						
N	63	177	210	189	94	
BMI	33.2 ± 8.3	32.8 ± 6.6	32.4 ± 7.1	31.9 ± 6.7	32.1 ± 6.5	0.659
ΔBMI	15.3 ± 4.6	14.9 ± 5.3	13.9 ± 4.7	12.5 ± 5.2	11.8 ± 4.8	< 0.001
2nd year						
N	49	140	170	152	74	
BMI	33.3 ± 9.8	33.4 ± 7.3	32.5 ± 7.0	32.5 ± 7.4	32.8 ± 7.7	0.814
ΔBMI	14.6 ± 5.8	14.6 ± 7.1	13.5 ± 6.0	11.9 ± 6.0	11.5 ± 6.2	< 0.001
3rd year						
N	43	120	138	139	71	
BMI	33.2 ± 7.7	35.3 ± 7.2	33.9 ± 7.3	34.2 ± 8.0	34.6 ± 7.8	0.472
ΔBMI	12.7 ± 4.9	12.3 ± 7.4	12.1 ± 6.2	10.1 ± 6.6	10.3 ± 6.8	0.012
4th year						
N	38	122	106	120	63	
BMI	36.4 ± 10.1	36.4 ± 7.9	35.2 ± 7.1	35.0 ± 8.1	34.7 ± 7.6	0.490
ΔBMI	11.5 ± 6.5	10.8 ± 7.1	9.8 ± 5.7	9.3 ± 6.3	10.1 ± 6.6	0.268

All values are expressed as mean ± standard deviation; BMI expressed in kg/m^2

BMI body-mass-index; *ΔBMI* change in BMI

Table 3 Logistic linear regression regarding 1st, 2nd and 3rd year ΔBMI

	Coefficient	*p* value
Dependent variable 1st year ΔBMI		
< 30	0.482	0.487
40–49	− 1.026	0.034
50–59	− 2.168	< 0.001
≥ 60	− 3.593	< 0.001
Dependent variable 2rd year ΔBMI		
< 30	0.362	0.710
40–49	− 1.204	0.074
50–59	− 2.511	< 0.001
≥ 60	− 3.392	< 0.001
Dependent variable 3rd year ΔBMI		
< 30	0.327	0.764
40–49	− 0.446	0.562
50–59	− 1.932	0.012
≥ 60	− 2.241	0.018

Values in reference to 30–39 age group

Adjusting for sex, insurance type and procedure type

our study to determine whether age would have an impact on these variables, and thus, potentially affect long-term morbidity and mortality.

Our study demonstrates that although bariatric surgery can be performed safely regardless of age, younger patients show a greater degree of comorbidity resolution with regards to HTN, DMII, and HLD. These differences in comorbidity resolution can be explained by greater improvement in BMI of the younger patients compared to the older age groups [20]. Losing a greater amount of weight at a younger age translates to a greater number of years of benefit. A decrease in BMI at an earlier age also decreases the incidence and severity of other comorbidities such as osteoarthritis, coronary artery disease etc., which may lead to more serious sequela [17, 18, 21]. It is possible that the difference, observed in the change in BMI between the younger and older groups, can be attributed to the former being more motivated as well as physically capable of increased activity [22]. On the other hand, it is true that the baseline BMI of patients over 50 years was lower than that of the younger patients. One possible explanation is that older patients with higher BMIs had higher morbidity and mortality and did not survive or were not healthy enough to be considered for bariatric surgery. One might argue that, since the baseline BMI of patients in the > 50 years subgroups was lower than the younger subgroups, these patients had less weight to lose to achieve ideal body weight. Thus, it might explain the difference in the magnitude of ΔBMI between the studied age groups. However, the outcomes did not change after accounting for preoperative BMI in the multivariable analysis, thus confirming that age was the only causative factor. OSA was the only comorbidity which did not have a difference between the age subgroups, although there was a

Table 4 Postoperative morbidity between age groups

	< 30	30–39	40–49	50–59	≥ 60	*p* value
LOS (mean ± SD)	2.1 ± 1.1	2.2 ± 1.3	2.3 ± 1.9	2.6 ± 1.9	2.7 ± 1.7	0.003
30 day readmission (%)	10	9	6	6	7	0.463
Reintervention (%)	13.7	18.1	15.9	14.4	13.6	0.705
Reoperation (%)	7	11	10.8	10	12.8	0.679

LOS length of stay; *SD* standard deviation

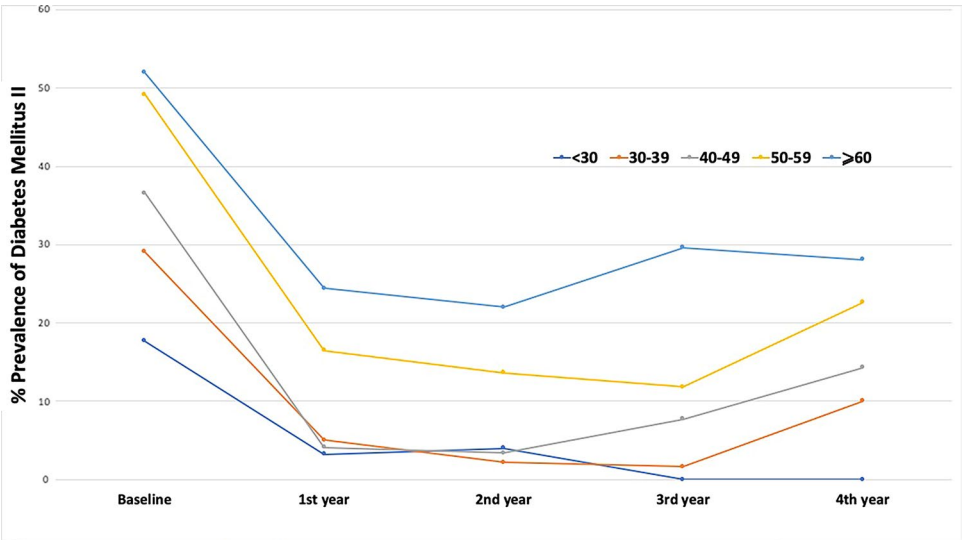

Fig. 2 Prevalence of diabetes mellitus type-II across age groups

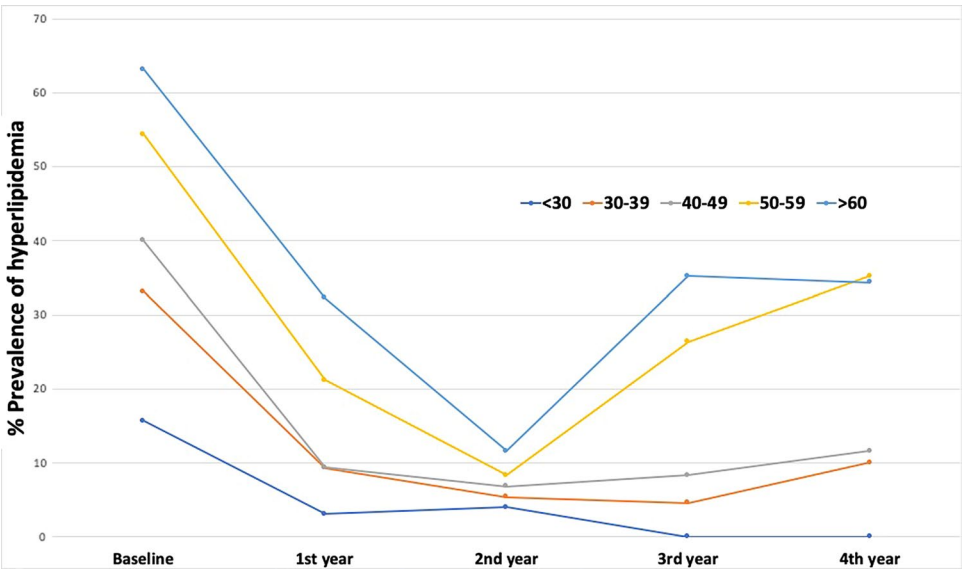

Fig. 3 Prevalence of hyperlipidemia across age groups

declining trend within all the groups from their respective baselines. Additionally, although the rate of 30-day readmission, 90-day mortality, reoperation, and reinterventions were not different between the age groups, there was an increase in the LOS in the 50–59 year-old patients compared to 30–39 year-old ones. This further emphasizes the benefit of bariatric surgery at a younger age.

There is a plethora of journal articles that examined the relationship between age and outcomes of bariatric surgery [24–29]. Some studies assessing perioperative morbidity have found that bariatric surgery is safe (no increase in early and late postoperative complications) in older patients (≥ 60 years) but also associated with lower efficacy [24, 25]. Others have found that older patients (≥ 60 years) have

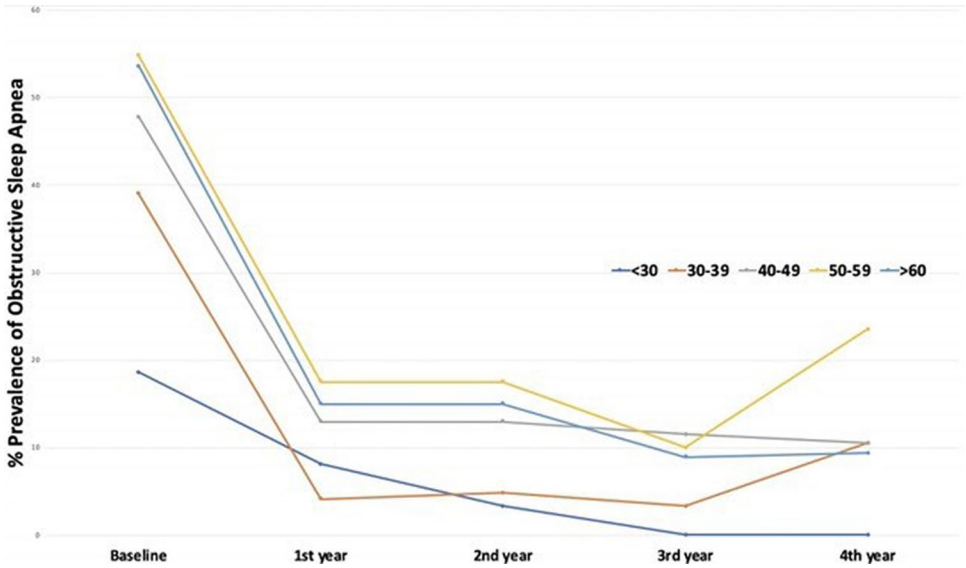

Fig. 4 Prevalence of obstructive sleep apnea across age groups

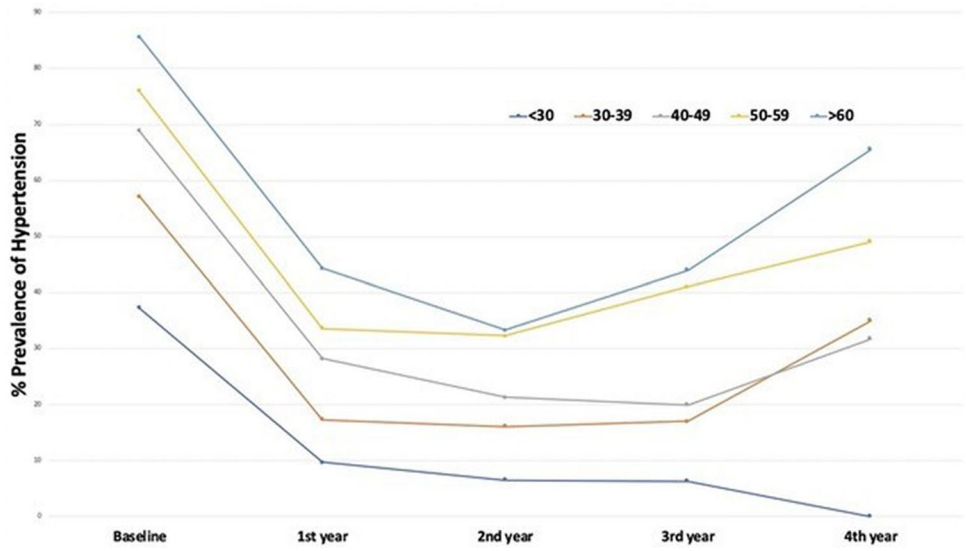

Fig. 5 Prevalence of hypertension across age groups

significant increase in perioperative morbidity compared to younger patients [26]. Several articles agree that performing bariatric surgery on younger patients leads to greater weight loss (measured by change in BMI, % EWL, or TBWL) and a significant difference in degree of comorbidity resolution (HTN, DMII, and HLD) compared to older patients [24, 27, 28]. A systematic review and meta-analysis evaluated the effectiveness and safety of laparoscopy and open Roux-en-Y Gastric Bypass in elderly patients (greater than age 60) [28]. They evaluated nine studies which met their inclusion criteria, of which only three included data pertaining to %EWL (proxy for weight loss). The meta-analysis showed that the %EWL was significantly lower in the elderly population (≥ 60 years). It also showed a significant decrease in comorbidity resolution for HTN and DM in the older (≥ 60 years) compared to the younger groups, but an increase for OSA. LOS was also evaluated and, in contrast to our results, showed no difference between the different age groups. Some of the limitations of this meta-analysis were that the follow-up duration was variable between the studies included, only a few studies reported % EWL, and that they only included Roux-en-Y gastric bypass operations. Regardless, the meta-analysis results suggest that performing Roux-en-Y gastric bypass at an earlier age has a greater effect on weight loss and comorbidity resolution. Our study contributes significantly to the existing literature as it provides a longer follow-up time, data regarding sleeve gastrectomy operations, and more information regarding the relation of different age groups with weight loss and comorbidity resolution; valuable data for further meta-analysis.

Our study has several implications for bariatric surgery practices. We identified that younger age groups such as

30–39 years old patients have better mid-term weight loss and comorbidity resolution than patients of older age groups; such as 40–49 years, 50–59 years and ≥ 60 years. Even though older aged patients seem to have similar complication rates along with satisfactory weight loss and comorbidity resolution, younger patients respond even more favorably and have more years to reap the benefits of the bariatric surgery.

Our study had several limitations. Our data were collected from a single MBSAQIP accredited Center of Excellence, thus raising questions on the generalizability of our results. Although there are several practicing surgeons at our institution, they, on average, used similar techniques for both LRYGB and LSG. This may not be true for other institution across the country. Furthermore, we recorded outcomes until the fourth postoperative year and thus, the changes in BMI and comorbidity resolution for the different age groups might not hold true in the long-term (5–10 years). Further evaluation of data from the national MSBAQIP database would provide population data with higher external validity. Finally, a proportion of our patients were lost to follow-up during the four years of our study which might introduce a bias.

Conclusions

Bariatric surgery is the most potent treatment of obesity. Thus, it is imperative to identify optimal timing of surgery, which would be most beneficial to the patient. In our study, we identified that bariatric surgery can be accomplished safely across all age groups with good weight loss up to four years after surgery. Nevertheless, younger patients lost more weight and experienced higher resolution of comorbidities, except for OSA. In addition, older age with increasing comorbidities may prolong LOS and convalescence. It may be inferred that young patients with higher BMI will likely develop advanced comorbidities later, which may result in reduced life expectancy as older patients typically present for bariatric surgery with lower BMI. Thus, performing bariatric surgery earlier will not only provide a greater impact on weight loss and comorbidities, but will also provide more years to reap its benefits.

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Compliance with ethical standards

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