

Is Laparoscopic Sleeve Gastrectomy for Asian Super Obese a Safe and Effective Procedure?

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Abstract

Introduction: Outcomes of bariatric surgery for super obese Asians are not well reported. We aimed to compare short-term outcomes of laparoscopic sleeve gastrectomy (LSG) in Asian patients with body mass index (BMI) <47.5 kg/m² to those with BMI ≥ 47.5 kg/m². **Materials and Methods:** A total of 272 patients from a Singapore university hospital who underwent LSG from 2008 to 2015 with a follow-up of at least 6 months were included in the study. Primary endpoint was weight loss at 1-year and 3-years. Morbid obesity (Group 1, G1) was defined as BMI <47.5 kg/m² and super obesity (Group 2, G2) was defined as BMI ≥ 47.5 kg/m². **Results:** There were 215 patients in G1 and 57 patients in G2 (mean preoperative weight: 107.3 kg and 146.8 kg; mean follow-up: 27.9 and 26.8 months, respectively). Mean total weight loss at 3-years of 41.9 kg for G2 was significantly higher ($P = 0.003$) than 27.2 kg for G1. Mean percentage excess weight loss (EWL) did not differ at 3-years. There was no difference in operating time, blood loss, length of stay, 30-day morbidity and readmission. There were no conversions and mortality in both groups. Remission of hypertension ($P = 0.001$) and dyslipidaemia ($P = 0.038$) were significantly associated with achieving EWL percentage (%EWL) >50 in G1. **Conclusion:** LSG is an equally safe and effective operation in Asians with BMI ≥ 47.5 kg/m² when compared to patients with BMI <47.5 kg/m² in achieving significant weight loss and improvement in comorbidities. Super obese lose more weight but have lower %EWL.

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Introduction

The obesity epidemic is a major public health concern worldwide. In Singapore, 8.6% of the population has a body mass index (BMI) ≥ 30 kg/m² and 34.3% of the population is overweight, i.e. BMI ≥ 25 kg/m².¹ Obesity is an independent risk factor for chronic diseases such as hypertension, dyslipidaemia and type 2 diabetes mellitus (T2DM), as well as premature death.^{2,3} As a result, extensive resources and efforts are currently being allocated to search for an ideal solution to this epidemic.

Should lifestyle interventions and medical therapy fail, one possible solution for morbidly obese Asian patients (BMI ≥ 37.5 kg/m²), or patients with BMI ≥ 32.5 kg/m²

with obesity-associated comorbidities, would be bariatric surgery.⁴ Of the many available procedures, laparoscopic sleeve gastrectomy (LSG) has been an increasingly popular procedure globally because of the perceived ease to perform, lower morbidity and good postoperative weight loss with amelioration of comorbidities in comparison to other techniques employed.⁵⁻⁹

In Asia, reports on the difference in outcomes of LSG between super obese patients (BMI ≥ 47.5 kg/m²) and non-super obese patients (BMI <47.5 kg/m²) are scarce. Hence, this study aimed to examine and compare the short-term outcomes of LSG in patients with BMI <47.5 kg/m² and BMI ≥ 47.5 kg/m² in Singapore. The aim of our study was to

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compare outcomes following LSG at 1- and 3-years between obese and super obese patients of Asian descent to determine if it's safe and effective for the super obese Asians.

Materials and Methods

We classified obesity as recommended by the World Health Organization (WHO), that is, a decrease by 2.5 points for each obesity category for Asians as compared to international classifications.¹⁰ This is because Asians have a differing body composition in comparison to Caucasians, and at any given body fat percentage, Asians tend to have a lower BMI than that of Caucasians. Also, at lower BMI values, the risks for cardiovascular disease and T2DM are higher for Asians.¹⁰ This standard has also been used in published reports of outcomes from other Asian centres.^{11–13} At the 2nd Diabetes Surgery Summit, an international consensus was reached to similarly lower the BMI threshold by 2.5 kg/m² for Asian patients with T2DM requiring bariatric surgery.^{14,15} We followed this trend in our paper.

Patients with BMI ≥ 32.5 kg/m² and with comorbidities, or BMI ≥ 37.5 kg/m² and without comorbidities—who had failed to achieve desired goals with lifestyle modifications and medical interventions—were offered bariatric surgery.

A prospective database of patients who received LSG at a university hospital in Singapore is being maintained since 2008. There were 299 patients who received LSG performed by a multidisciplinary team between August 2008 and July 2015. There are 3 bariatric surgeons in our institution, who perform approximately 100 bariatric cases combined, per year. Our technique of LSG is standardised with a 5 cm antral pouch and a gastric tube created over a 38F Bougie. Postoperatively, patients were reviewed at 2 weeks, 1 month, followed by 3-month intervals in the first year, and biannually thereafter. We strongly encourage our patients to attend support group meetings both pre and postoperatively but due to a very hectic lifestyle and time away from work, attendance at these group meetings is relatively poor.

Approval for this review of hospital records was obtained from the Institutional Review Board, DSRB NUH/2015-00002. Data for analysis on demographic, perioperative outcomes, comorbidities and weight was updated and analysed in September 2016. Twenty-seven patients were excluded from the data analysis as they did not follow-up for a minimum of ≥ 6 months. In total, 272 patients were grouped into BMI < 47.5 kg/m² (Group 1, G1) or BMI ≥ 47.5 kg/m² (Group 2, G2).

The primary endpoint of our study was weight loss following LSG up to 3 years. The secondary endpoints include perioperative outcomes and the outcomes of hypertension, dyslipidaemia and T2DM at 1-year following LSG.

We followed the American Society for Metabolic and Bariatric Surgery outcome reporting standards.¹⁶ However, we defined ideal weight by the weight corresponding to BMI 23 kg/m² as recommended by the WHO.¹⁰ We also classified the complications which occurred within 30 days postoperatively according to the Clavien-Dindo classification of surgical complications.^{17,18} Excess weight loss percentage (%EWL) > 50 at 1-year was taken as a cutoff for successful weight loss.^{19,20}

Data analysis was performed on IBM SPSS 23.0 statistical software (SPSS Inc., Chicago, IL, USA). Categorical data was presented as frequency and percentages, whereas continuous data was presented as mean and standard deviation (SD) for parametric distribution and median (interquartile range) for non-parametric distribution. For categorical data, comparisons were made by χ^2 and Fisher's Exact test and for continuous data, independent-samples *t* test were used. For multivariate analysis, multiple linear regression was performed. A *P* value < 0.05 was considered to be significant.

Results

There were 215 patients (79.0%) with a mean preoperative BMI of 39.3 ± 4.17 kg/m² in G1, and 57 patients (21.0%) with a mean preoperative BMI of 54.8 ± 6.78 kg/m² in G2. The characteristics of the patients are summarised in Table 1. Both groups were comparable in their mean ages, with an overall higher proportion of females. Malays formed the predominant racial group and are more likely to be super obese ($P = 0.02$). The mean duration of follow-up was 27.9 ± 16.6 months and 26.8 ± 16.4 months in G1 and G2, respectively.

In both groups, there were no conversions to open surgery. The mean operating time (skin-to-skin) was 112 ± 54.5 minutes (range, 30–389) and 115 ± 56.4 minutes (range, 40–352) in G1 and G2, respectively ($P = 0.73$). The mean intraoperative blood loss did not differ between groups and was 17.3 ± 25.0 ml and 22.3 ± 41.5 ml in G1 and G2, respectively ($P = 0.41$). The median length of hospital stay was 3 days in both groups. The overall total complication rates for G1 and G2 were 6.51% and 5.26%, respectively ($P = 1.00$). Ten patients (4.65%) in G1 had Grade I complications ($P = 0.13$), while 2 patients (0.93%) in G1 and 1 patient (1.75%) in G2 had Grade II complications ($P = 0.51$). There were 2 patients (0.93%) in G1 and 1 patient (1.75%) in G2 who had Grade III complications ($P = 0.51$), and 1 patient (1.75%) in G2 with Grade IV complications ($P = 0.21$).

The 30-day readmission rate was 6 (2.8%) in G1 and 1 (1.8%) in G2 ($P = 1.00$). In G1, 3 patients reported abdominal pain with vomiting, 1 patient was dehydrated, 1 patient developed Miller Fisher syndrome, and 1 patient

Table 1. Demographics

Parameter	BMI <47.5 (n = 215)	BMI ≥47.5 (n=57)	P Value, 95% CI
Mean age, years ± SD	39.3 ± 11.3	39.8 ± 11.7	0.77, (-2.8, 3.8)
Range	18 – 67	17 – 61	
Gender (%)			
Male	84 (39.1)	28 (49.1)	0.18
Female	131 (60.9)	29 (50.9)	
Race (%)			
Chinese	67 (31.2)	17 (29.8)	0.02
Malay	77 (35.8)	31 (54.4)	
Indian	57 (26.5)	9 (15.8)	
Other	14 (6.5)	0 (0)	
Mean preoperative weight, kg ± SD	107.3 ± 17.3	146.8 ± 26.8	
Range	75.3 – 152	106 – 230	
Mean preoperative BMI kg/m ² , ± SD	39.3 ± 4.17	54.8 ± 6.78	
Range	32.5 – 47.4	47.6 – 79.5	
Mean number of comorbidities* ± SD	1.14 ± 1.09	1.33 ± 1.15	0.24, (-0.13, 0.52)
Hypertension (%)	99 (46.0)	32 (56.1)	0.10
Dyslipidaemia (%)	87 (40.5)	22 (38.6)	1.00
T2DM (%)	59 (27.4)	22 (38.6)	0.07

BMI: Body mass index; CI: Confidence interval; SD: Standard deviation;
T2DM: Type II diabetes mellitus

*Comorbidities accounted for include hypertension, dyslipidaemia and T2DM.

suffered from early gastric stricture requiring stenting. In G2, the only readmission was due to gastroenteritis. These patients have been included in our analysis of complications.

We had no mortalities at 30-day follow-up. However, we lost 3 patients owing to medical conditions beyond 6 months follow-up. One patient died from acquired haemophilia A, another succumbed to sepsis secondary to *Klebsiella pneumoniae* urinary tract infection, and the last life lost was due to pneumonia.

The total weight loss (TWL) trends with the number of patients followed-up at all time points are shown in Figure 1. At any given point in time during follow-up, the mean TWL was significantly different between groups ($P < 0.05$), with patients in G2 having higher TWL when compared to G1. At 1-year, median weight loss in G1 and G2 was 26.5 kg and 41.3 kg respectively ($P < 0.0001$). Postoperatively, the weight loss stabilised at approximately 27 kg in G1, and approximately 42 kg in G2 between 9–36 months.

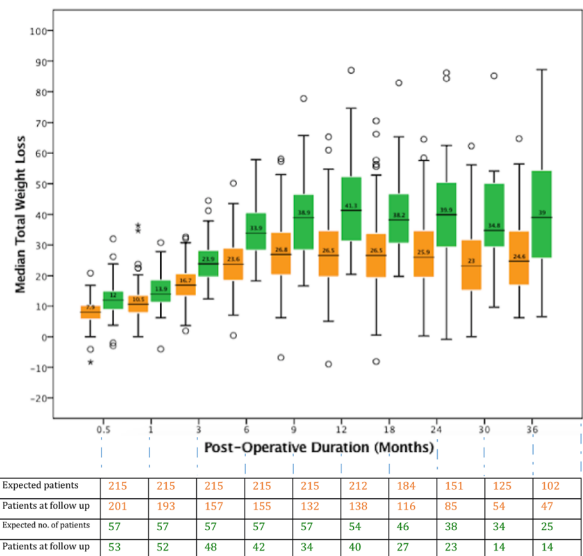


Fig. 1. Median total weight loss (TWL) trend after laparoscopic sleeve gastrectomy (LSG) in G1 (orange) and G2 (green).

Similar to TWL, the differences in mean %EWL were statistically significant in both groups at any follow-up time point up to 24 months ($P > 0.05$), with patients in G1 having higher %EWL when compared to G2 but at 3-years, no significant difference was noted. This trend is reported in Figure 2.

At 1-year, patients in G1 were more likely to achieve successful weight loss. There were 98 patients (71.0%) in G1 as compared to 19 patients (47.5%) in G2 ($P = 0.008$).

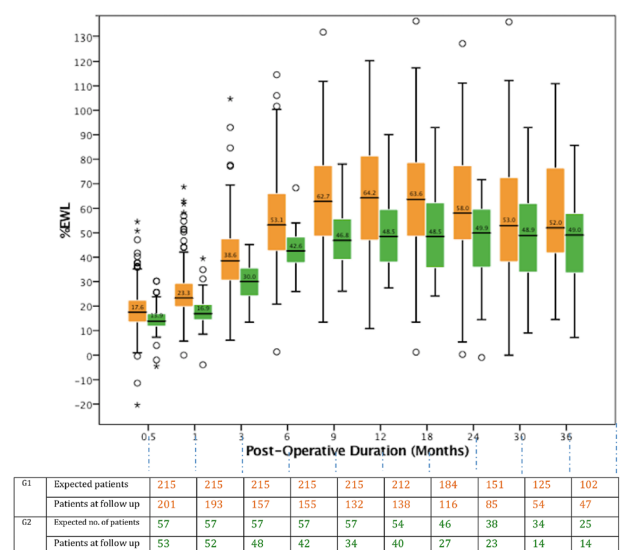


Fig. 2. %EWL trend in G1 (orange) and G2 (green).

However, in total, there were 164 patients (76.3%) in G1 and 28 patients (49.1%) in G2 who have achieved EWL >50%, irrespective of time frame ($P = 0.0001$). The trend in change in BMI (Δ BMI) and mean %TWL can be seen in Table 2.

Due to inherent differences between G1 and G2, multivariate analysis was performed, adjusting for age,

= 0.038) in G1. In patients with remission of hypertension, 15 (34.1%) achieved successful weight loss as compared to 1 patient (3.2%) who failed to achieve successful weight loss. In patients with remission of dyslipidaemia, 17 patients (34.0%) achieved successful weight loss as compared to 2 patients (9.5%) who failed to achieve successful weight loss.

For patients in G2, no significant difference ($P = 0.60$)

Table 2. Δ BMI and Mean %TWL in G1 and G2 with Multivariate Analysis

Duration (Months)	Δ BMI				Mean %TWL			
	BMI <47.5	BMI $\geq$ 47.5	Adjusted Difference*	P Value	BMI <47.5	BMI $\geq$ 47.5	Adjusted Difference*	P Value
0.5	2.9 $\pm$ 1.3	4.7 $\pm$ 2.6	1.73 (1.21 – 2.25)	<0.001	8.1 $\pm$ 3.7	9.3 $\pm$ 4.3	0.95 (-0.24 – 2.14)	0.118
1	4.0 $\pm$ 1.6	5.6 $\pm$ 2.6	1.58 (1.03 – 2.12)	<0.001	11.4 $\pm$ 4.7	11.4 $\pm$ 4.7	-0.21 (-1.62 – 1.20)	0.770
3	6.4 $\pm$ 1.9	9.3 $\pm$ 2.7	2.92 (2.23 – 3.62)	<0.001	19.6 $\pm$ 6.7	20.5 $\pm$ 5.6	1.01 (-1.15 – 3.17)	0.358
6	8.7 $\pm$ 2.5	12.9 $\pm$ 2.7	4.22 (3.37 – 5.08)	<0.001	29.0 $\pm$ 10.0	31.9 $\pm$ 7.3	3.12 (-0.11 – 6.34)	0.059
9	10.0 $\pm$ 3.3	15.0 $\pm$ 4.7	4.85 (3.53 – 6.18)	<0.001	35.0 $\pm$ 13.9	37.7 $\pm$ 12.8	2.70 (-2.25 – 7.65)	0.283
12	10.2 $\pm$ 4.0	15.7 $\pm$ 5.2	5.67 (4.21 – 7.12)	<0.001	36.5 $\pm$ 17.7	41.7 $\pm$ 17.0	5.73 (-0.12 – 11.58)	0.055
18	10.2 $\pm$ 4.2	16.0 $\pm$ 7.4	5.96 (3.90 – 8.01)	<0.001	37.2 $\pm$ 19.0	43.8 $\pm$ 26.3	7.74 (-0.72 – 16.20)	0.073
24	10.1 $\pm$ 4.0	15.3 $\pm$ 7.3	5.70 (3.43 – 7.96)	<0.001	35.9 $\pm$ 17.8	39.2 $\pm$ 18.7	5.55 (-2.80 – 13.90)	0.191
30	9.2 $\pm$ 4.3	15.7 $\pm$ 8.4	6.50 (3.06 – 9.95)	<0.001	31.8 $\pm$ 19.5	43.9 $\pm$ 33.7	8.99 (-5.62 – 23.60)	0.223
36	9.6 $\pm$ 4.3	15.3 $\pm$ 7.2	5.83 (2.89 – 8.77)	<0.001	34.6 $\pm$ 20.1	40.9 $\pm$ 24.0	7.90 (-3.68 – 19.48)	0.177

BMI: Body mass index; G1: Group 1; G2: Group 2; %TWL: Percentage of total weight loss

*Multivariate analysis adjusting for age, gender, race, hypertension, T2DM, dyslipidaemia.

gender, race and comorbidities (T2DM, hypertension and dyslipidaemia). There were significant differences between the groups in Δ BMI at all time points, with patients in G2 losing 5.83 kg/m² (95% CI: 2.89–8.77, $P < 0.001$) more than G1 at 36 months postoperation. However, when multivariate analysis was performed with regard to %TWL, no significant differences were seen at all time points. These results have also been expressed in Table 2.

At 1-year postoperation, both groups experienced a significant reduction in mean number of comorbidities, from 1.14 $\pm$ 1.09 to 0.65 $\pm$ 0.92 in G1 ($P < 0.0001$), and 1.33 $\pm$ 1.15 to 0.70 $\pm$ 0.93 in G2 ($P < 0.0001$).

Remission rates of hypertension, dyslipidaemia and T2DM were similar among groups at 1-year, though this did not achieve statistical significance. Remission of hypertension was achieved in 18 patients (18.2%) and 5 patients (15.6%) in G1 and G2, respectively ($P = 1.00$). There were a higher proportion of patients with a remission of dyslipidaemia in patients in G1, with 26 patients (29.9%) as compared to 4 patients (18.2%) in patients in G2 ($P = 0.56$). Remission of T2DM was recorded in 20 patients (33.9%) in G1 and 12 patients (54.5%) in G2 ($P = 0.27$).

Successful weight loss (%EWL >50) was associated with remission of hypertension ($P = 0.001$) and dyslipidaemia (P

was found in the remission rates of hypertension in patients who achieved successful weight loss (1 patient, 9.1%) and those who did not (3 patients, 21.4%). Also, no significant difference ($P = 0.52$) was found in the remission rate of dyslipidaemia in patients who achieved successful weight loss (2 patients, 28.6%) and those who did not (1 patient, 11.1%).

Remission of T2DM in both groups was not related to successful weight loss at 1-year. This can be seen in Table 3. The absolute value of TWL was not associated with remission of comorbidities. This can be seen in Table 4.

Discussion

LSG has been gaining traction as the operation of choice for bariatric patients as it is accepted as a safe and effective procedure.^{21–23} It was originally introduced as a bridging procedure for the super obese than as a primary outcome.²⁴

However, there is a paucity of Asian literature comparing the outcomes of LSG between patients with different BMI categories. The increasing trend towards the widespread use of this procedure thus requires a careful evaluation of its safety and efficacy, especially in super obese patients.

Singapore has a population of 5.54 million indigenous people, out of which 3.90 million are Singapore citizens.

Table 3. Remission of Comorbid Conditions as a Comparison to %EWL

Parameter	BMI <47.5			BMI ≥47.5		
	%EWL <50	%EWL >50	P Value	%EWL <50	%EWL >50	P Value
Hypertension (%)	n = 31	n = 44	0.001	n = 9	n = 7	0.52
Remission	1 (3.2)	15 (34.1)		1 (11.1)	2 (28.6)	
No remission	26 (83.9)	26 (59.1)		6 (66.7)	3 (42.9)	
Patients excluded*	4 (12.9)	3 (6.8)		2 (14.3)	2 (18.2)	
Dyslipidaemia (%)	n = 21	n = 50	0.038	n = 9	n = 7	0.52
Remission	2 (9.5)	17 (34.0)		1 (11.1)	2 (28.6)	
No remission	16 (76.2)	27 (54.0)		6 (66.7)	3 (42.9)	
Patients excluded*	3 (14.3)	6 (12.0)		2 (22.2)	2 (28.6)	
T2DM (%)	n = 18	n = 24	0.096	n = 10	n = 8	0.63
Remission	4 (22.2)	12 (50.0)		7 (70.0)	4 (50.0)	
No remission	11 (61.1)	9 (37.5)		2 (20.0)	2 (25.0)	
Patients excluded*	3 (16.7)	3 (12.5)		1 (10.0)	2 (25.0)	

BMI: Body mass index; %EWL: Percent of excess weight loss; T2DM: Type II diabetes mellitus

*Patients excluded are those patients whose 1-year (post-LSG) blood pressures, lipid panel and HbA1c were unable to be obtained.

Table 4. TWL at 1-year in Comparison to Remission of Comorbidities

Parameter	TWL 0 – 20 kg n = 37	TWL 20 – 40 kg n = 96	TWL 40 – 60 kg n = 39	TWL >60 kg n = 64	P Value
Hypertension (%)	n = 27	n = 49	n = 20	n = 35	0.14
Remission	4 (14.8)	9 (18.4)	6 (30.0)	3 (8.6)	
No remission	20 (74.1)	38 (77.6)	9 (45.0)	25 (71.4)	
Patients excluded*	3 (11.1)	2 (4.1)	5 (25.0)	7 (20.0)	
Dyslipidaemia (%)	n = 22	n = 53	n = 10	n = 22	0.79
Remission	4 (18.2)	14 (26.4)	3 (30.0)	4 (18.2)	
No remission	14 (63.6)	33 (62.3)	5 (50.0)	14 (63.6)	
Patients excluded*	4 (18.2)	6 (11.3)	2 (20.0)	4 (18.2)	
T2DM (%)	n = 19	n = 29	n = 11	n = 16	0.15
Remission	5 (26.3)	15 (51.7)	6 (54.5)	6 (37.5)	
No remission	12 (63.2)	9 (31.0)	3 (27.3)	6 (37.5)	
Patients excluded*	2 (10.5)	5 (17.2)	2 (18.2)	4 (25.0)	

TWL: Total weight loss; T2DM: Type II diabetes mellitus

*Patients excluded are those patients whose 1-year (post-LSG) blood pressures, lipid panel and HbA1c were unable to be obtained.

The ethnic distribution of Singapore citizens is 74.3% Chinese, 13.3% Malay, 9.1% Indian and 3.3% other minority racial groups, such as Eurasians.²⁵ In 2010, 10.8% of the population was obese in Singapore, as compared to 35.7% of the population in America, suggesting that the prevalence of obesity is not as high in Singapore.²⁶ However, this trend is only set to rise as a result of the global obesity epidemic. Correspondingly, the popularity of bariatric surgery has only recently experienced an uptrend. Overall in Singapore, approximately 350 bariatric procedures are performed annually and despite our small number of patients, our centre is one of the high volume centres. Despite being a

minority racial group in Singapore, Malays made up a high proportion of our patient population (39.7%) and Malays were more likely to have a BMI >47.5 kg/m² ($P = 0.02$). This is similar to Singapore's obesity prevalence in racial group distributions, where Malays were more likely to be obese, and a higher proportion of Malays were obese as compared to the other racial groups.²⁷ An explanation for this phenomenon could be due to cultural differences, as Malay cuisine is generally higher in saturated fat. Another possibility could be the lower socioeconomic status of Malays. However, no studies have been conducted to explore the causes for this disparity.

We also noted that super obese patients did not have more comorbidities as compared to obese patients. There were no differences in mean number of comorbidities between G1 and G2, with 1.14 ± 1.09 in G1 and 1.33 ± 1.15 in G2 ($P = 0.24$). We postulated that our relatively young patient population could have contributed to this trend.

In literature, it has been reported that LSG has a lower complication rate than other bariatric surgeries.^{28,29} It has also been reported that LSG is safe as a treatment for the super obese.³⁰ Similarly, we found that LSG is equally safe in patients with BMI = 47.5 kg/m^2 . There was no difference in the overall complication rate in both groups (4.65% in G1 and 5.26% in G2 [$P = 1.00$]) and within each grade of complication in the Clavien-Dindo classification.^{17,18} The majority of our complications fell into Grade I complications, followed by Grade II complications. The 2 patients in G1 with Grade III complications were due to an iatrogenic bowel perforation and the patient subsequently underwent a laparoscopic washout with suture repair (on postoperative day 2) and an early gastric tube stricture (which was treated with endoscopic stent insertion). The patient in G2 with Grade III complication was due to fluid collection necessitating drainage. The patient in G2 with Grade IV complication was due to type 2 respiratory failure who required intubation. All patients with Grade III and Grade IV complications subsequently recovered and there was no surgical mortality in our series up to 6 months. Additionally, we found no significant difference in intraoperative outcomes, length of hospital stay and readmission rate between both groups. Our operative times in both groups are reported in terms of skin-to-skin time and are deceptively long. We say this because we are involved in clinical and basic science research projects that necessitate specimen collection intraoperatively like omental fat and muscle biopsies, thus prolonging the operative time.

Overall, our study added evidence to support that LSG is an equally safe procedure in the super obese in comparison to the obese. Super obese patients should not be excluded from LSG because of a perceived risk based on BMI.

Consistent with literature, our results suggested that LSG was effective in achieving substantial weight reduction over short-term follow-up.³¹⁻³⁴ The mean %TWL of 36.5 ± 17.7 and 41.7 ± 17.0 at 1-year, 35.9 ± 17.8 and 39.2 ± 18.7 at 2-years, and 34.6 ± 20.1 and 40.9 ± 24.0 at 3-years in patients with BMI $<47.5 \text{ kg/m}^2$ and BMI $\geq 47.5 \text{ kg/m}^2$, respectively.

However, although LSG has been suggested as a reliable bariatric procedure, several studies have shown that there is a difference in the efficacy of LSG in patients with different BMIs.^{35,36} Junior et al found that patients with a higher BMI lost more %TWL in 48 months, with %EWL lower than that or equal to less heavy patients due to their much greater excess weight preoperatively.³⁷ In our series, our

3-year outcomes similarly revealed that patients with BMI $\geq 47.5 \text{ kg/m}^2$ have a higher quantum of TWL despite a lower mean %EWL as compared to patients with BMI $<47.5 \text{ kg/m}^2$. The mean TWL was $27.7 \pm 12.2 \text{ kg}$ and $42.2 \pm 15.2 \text{ kg}$ at 1-year, $27.2 \pm 12.5 \text{ kg}$ and $41.3 \pm 20.1 \text{ kg}$ at 2-years, and $26.8 \pm 13.6 \text{ kg}$ and $41.9 \pm 21.6 \text{ kg}$ at 3-years in patients with BMI $<47.5 \text{ kg/m}^2$ and BMI $\geq 47.5 \text{ kg/m}^2$, respectively.

We also found that despite a higher quantum of TWL in patients in G2 as compared to patients in G1 where the difference was significant at all time points ($P < 0.05$), %TWL at 1-, 2- and 3-year time points were similar between both groups ($P > 0.05$). We believe that because patients who are super obese do not perform inferiorly to patients who are obese in terms of %TWL, there could be a set point involved in the percentage of weight an individual could stand to lose from intervention.³⁸

Further, success of surgery (defined as %EWL >50) is an accepted benchmark and currently the only benchmark. This is because %TWL has only been recently introduced as an outcome to be measured and reported, and there is no widely accepted benchmark of %TWL to indicate success of surgery.^{19,20,39} Our 1-year %EWL >50 were 71% in G1 versus 47.5% in G2 ($P = 0.008$), demonstrating that patients in G1 were more likely to achieve surgical success. Postulating that super obese patients required a longer duration to achieve surgical success, we analysed %EWL >50 at 1-year in G1 versus %EWL >50 at 1.5-years and 2-years in G2. Patients in G1 were still more likely to achieve surgical success at 1-year versus 1.5-years in G2 ($P = 0.026$) and versus 2-years in G2 ($P = 0.033$). We further analysed success of surgery (irrespective of time frame). Overall, patients in G1 were still more likely to achieve surgical success ($P = 0.0001$). Conversely, this meant that patients in G2 were more likely to achieve surgical failure. Boza et al similarly reported a higher percentage of patients in lower BMI categories achieving surgical success.⁴⁰

As a result, we propose that the definition of surgical failure should differ between morbid and super obesity. %EWL is not a good measure to compare weight loss as the findings from TWL appear to be converse to those from %EWL, with the super obese requiring a higher quantum of TWL to achieve similar %EWL.³⁵ This can be attributed to the higher initial weight of patients with BMI $\geq 47.5 \text{ kg/m}^2$. To achieve similar %EWL for patients in both groups, patients with BMI $\geq 47.5 \text{ kg/m}^2$ would have to achieve a higher TWL in order to come close to their ideal body weight when compared to patients with BMI $<47.5 \text{ kg/m}^2$. Additionally, there may be greater impact of baseline weight on %EWL than on TWL. We note that recent studies have included %TWL in outcome reporting after a bariatric procedure.^{41,42} We similarly propose that on top of reporting %EWL, TWL should be included as a compulsory measure of reporting.

As there is no standard definition for success of surgery for patients in different BMI categories, more research is needed to define an acceptable and fair benchmark.

LSG is known to have a great impact on comorbidities, narrated in a systemic review by Shi et al.⁴³ Apart from weight control, our results also demonstrated the resolution of obesity-associated comorbidities at 1-year after LSG in both groups, with 18.2% and 15.6% for remission of hypertension, 29.9% and 18.2% for remission of dyslipidaemia, and 33.9% and 54.5% for remission of T2DM for patients in G1 and G2, respectively. From our analysis, the quantum of TWL was not associated with remission of comorbidities. No significant differences in rates of resolution of comorbidities were observed between the groups ($P > 0.05$), and this could suggest that LSG is equally effective in its impact in resolution of comorbidities in both the super obese and obese Asian patients. We also observed that patients who had a BMI $< 47.5 \text{ kg/m}^2$ and who achieved successful weight loss of $\%EWL > 50$ were significantly associated with remission of hypertension and dyslipidaemia. This suggests that adequate weight loss is important to achieve remission of hypertension and dyslipidaemia after LSG in patients with a lower BMI.

More importantly, our results demonstrate the reduction in the mean number of comorbidities at 1-year after LSG in both groups, with preoperative mean number of comorbidities at 1.14 ± 1.09 in G1 and 1.33 ± 1.15 in G2, and postoperative mean number of comorbidities at 0.65 ± 0.92 ($P < 0.0001$) in G1 and 0.70 ± 0.93 ($P < 0.0001$) in G2. In concordance with literature, this suggests that LSG in our series is effective in ameliorating comorbidities in both super obese and obese Asian patients.⁴⁴

There are several limitations to our study. The first is the small sample size of patients who are super obese (57 patients). This is due to the small number of super obese in Asia. Also, Singapore has a small population size, and bariatric surgery is a relatively new subspecialty in Singapore, thus there is low awareness of this treatment modality. The second limitation is the considerable loss of patients to follow-up at 3-years (at 52.6% for patients with BMI $< 47.5 \text{ kg/m}^2$, and 56.1% for patients with BMI $\geq 47.5 \text{ kg/m}^2$). This may cause bias in outcomes as patients with poor outcomes and equally those with excellent outcomes may have been lost to follow-up. This is because patients perceive themselves to be well, and they are not keen for follow-up. However, we are mitigating this by trying to reach out to these patients to grow our data pool. The third limitation of our study is that our study is retrospective in nature. However, all data were taken from a prospective database and we included all consecutive patients who had at least 6 months of follow-up to reduce reporting bias. Finally, we only examined short-term outcomes,

and a longer duration of follow-up is required to further support our results. We aim to revisit this when we have the optimum number of patients.

Conclusion

LSG is an equally safe and effective weight loss procedure for super obese Asian patients when compared to obese Asian patients. Asian patients with BMI $\geq 47.5 \text{ kg/m}^2$ should be considered as acceptable candidates for LSG.

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