Journal of Gastrointestinal Surgery (2019) 23:445–450
https://doi.org/10.1007/s11605-018-3920-9

ORIGINAL ARTICLE

Sleeve Gastrectomy and Roux-En-Y Gastric Bypass Lead to Comparable Changes in Body Composition in a Multiethnic Asian Population

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Received: 30 March 2018 / Accepted: 6 August 2018 / Published online: 5 September 2018

Abstract

Background Changes in body composition after bariatric surgery such as a sustained loss of body fat are often associated with an inevitable loss of fat free mass. This can contribute to an undesirable disturbance in resting metabolic rate and weight maintenance. Our aim was to study changes in body composition in a multiethnic Asian cohort following bariatric surgery and to identify differences between laparoscopic sleeve gastrectomy and laparoscopic Roux-en-Y gastric bypass.

Methods A retrospective review of prospectively collected data on 295 patients who underwent either laparoscopic sleeve gastrectomy (256 patients) or laparoscopic Roux-en-Y gastric bypass (39 patients) was performed. Body composition variables were measured with the analyzer, GAIA 359 PLUS, which included the parameters; total body weight, body mass index, excess weight, basal metabolic rate, fat-free mass, fat mass, and total body water.

Results There were no statistical differences in gender, ethnicity, age, weight, height, and body mass index between laparoscopic sleeve gastrectomy and Roux-en-Y gastric bypass. At each time point (6, 12, 24, and 36 months) post-operation, there was no significant differences in % total body weight loss, basal metabolic rate, fat mass, fat percentage, and total body water between sleeve gastrectomy and bypass patients. There was significant difference ($p < 0.05$) in fat free mass only at 3 years post-operation, with sleeve gastrectomy patients having 9.79 kg less fat-free mass than bypass patients. However, after multivariate analysis, we found no statistically significant differences.

Conclusion Sleeve gastrectomy and gastric bypass seemed to give similar changes to body composition.

Keywords Body composition · Sleeve gastrectomy · Gastric bypass

Introduction

Surgery for obesity and weight-related diseases has proven to be highly efficacious in treating obesity and its comorbidities.[1] The number of surgeries for obesity and weight-related diseases worldwide has increased from 340,768 in 2011 to 468,609 in 2013.[2,3] The trend in Asia is even more dramatic, showing a 98% increase from 23,296 operations in 2011 to 59,744 in 2014.[2,3] The popularity of laparoscopic sleeve gastrectomy (LSG) in Asia has increased exponentially with LSG comprising 1% of all bariatric procedures performed in 2005 but 25% in 2009.[4] This increase has persisted with LSG comprising 60% of all surgeries compared to 13.8% for laparoscopic Roux-en-Y gastric bypass (LRYGB) in 2014.[3]

The evaluation of patients who undergo surgery for obesity and weight-related diseases often entails body composition measurements in many practices. However, there is limited data in the literature with regard to the changes in body composition brought about by LSG and LRYGB.[5–8] Much of the available data are limited to Western populations, with no data available more than 1 year after surgery. Only one study compared body composition changes between LSG and LRYGB, showing no significant differences at 1 year after surgery.[6]

The problem of weight regain is seen in the medium to long term for either procedures. With a drive to study the factors that predisposes patients to weight recidivism as well as strategies to combat it such as medical therapy or revision surgery, an understanding of body composition changes in the medium to long term could potentially help improve our understanding

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of our patients. As such, this study aims to identify the changes in body composition after LSG and LRYGB.

Methods

We report an analysis of prospectively collected data on a cohort of patients who underwent LRYGB and LSG in a tertiary university hospital with a dedicated bariatric unit in Singapore from August 2008 to December 2015.

All patients were offered LRYGB and LSG during the counseling for metabolic surgery, with no strict selection criteria being used to decide the type of surgery. All operations were done by the same surgical team laparoscopically using a standard technique with no conversion to open surgery. LRYGB was performed with a 100-cm antecolic Roux–limb with a linear stapled gastrojejunostomy and a 100-cm long biliopancreatic limb. For LSG, a 38-Fr bougie was inserted along the lesser curvature for calibration of the gastric sleeve, starting the linear stapling 5 cm proximal to the pylorus.

Baseline body measurements and patient demographics were recorded prior to surgery. Post-operative follow-up was done in the outpatient clinic where body weight, waist circumference, and body composition were assessed. Body composition variables were measured with the analyzer, GAIA 359 PLUS (Jawon Medical, Korea) which included parameters such as total body weight (TBW), body mass index (BMI), basal metabolic rate (BMR), percentage of fat mass (%fat), fat-free mass (FFM), fat mass, and total body water.

We used mean (standard deviation) and count (percent) to summarize continuous and categorical variables collected for this study. To compare patient characteristics between patients who underwent LSG versus LRYGB, we used Fisher's exact tests and two-sample *t* tests for categorical and continuous variables, respectively. To compare body composition variables between patients who underwent LSG versus LRYGB at each follow-up time point (i.e., 6, 12, 18, 24, and 36 months), we performed a simple linear regression with type of bariatric surgery as the predictor and a multiple linear regression to adjust for age, gender, ethnicity, and baseline BMI. We used R statistical software program (cran.r-project.org) to perform the analysis, and *p* values less than 0.05 were considered as statistically significant.

Results

Two-hundred and ninety-five patients who underwent either LSG (256 patients) or LRYGB (39 patients) with available body composition data were included in this study. The post-operative follow-up rates of patients at 6, 12, 18, 24, and 36 months were 69.2, 54.3, 38.2, 40, and 26.7%, respectively, for LRYGB patients and 64.5, 53.3, 37.9, 31.3, and 27.8%, respectively, for LSG patients. Patient study population characteristics at baseline (see Table 1) showed no significant differences between LRYGB and LSG groups.

There were no significant differences in percentage (%) total body weight loss (TBWL) between LRYGB (23.7% ± 13.1) and LSG (23.9% ± 15.5) at 6, 12, 18, 24, and 36 months after surgery (see Fig. 1). Similar findings were noted for TBW, BMI change, TBWL, and waist circumference. There were also no significant differences in BMR, fat mass, % fat, FFM, and total body water between both groups of patients (see Table 2) except for FFM, where patients who underwent LRYGB were found to have 9.79 kg (95% confidence interval 0.14; 19.44) more FFM than LSG at 36 months post-operation. Body composition parameters were found to be comparable after adjusting for differences in the baseline characteristics between LRYGB and LSG (see Fig. 2). When performing analysis using the generalized estimating equation approach, no significant differences were noted between both groups of patients at all time points up to 36 months after surgery.

Discussion

LSG and LRYGB have been shown to have comparable weight loss effects up to 5 years after surgery.[9–13] The encouraging results from either surgery has driven a search for the underlying mechanisms of weight loss. The classical mechanisms of restriction of food intake (LSG and LRYGB) and nutrient malabsorption (LRYGB) insufficiently explain the weight loss and metabolic changes seen in patients. Complex mechanisms such as decreasing hunger, increasing satiation during a meal, changing food preferences, and energy expenditure have been shown to play a role. The underlying mediators for these mechanisms, though inadequately understood currently, have been

Table 1 Study population characteristics at baseline

		LRYGB, $n = 39$	LSG, $n = 256$	p value
Age, years		39.9 (12.3)	39.5 (11.2)	0.863
Gender	Female, $n = 173$	24 (61.5)	149 (58.2)	0.730
	Male, $n = 122$	15 (38.5)	107 (41.8)	
Ethnicity	Malay, $n = 114$	12 (30.8)	102 (39.8)	0.463
	Chinese, $n = 81$	14 (35.9)	67 (26.2)	
	Indian, $n = 74$	11 (28.2)	63 (24.6)	
	Others, $n = 26$	2 (5.1)	24 (9.4)	
Height, metres		1.6 (0.1)	1.7 (0.1)	0.782

Results are expressed as mean (standard deviation, SD) for continuous variables and number (percentage) for categorical variables

LRYGB laparoscopic Roux-en-Y gastric bypass

LSG laparoscopic sleeve gastrectomy

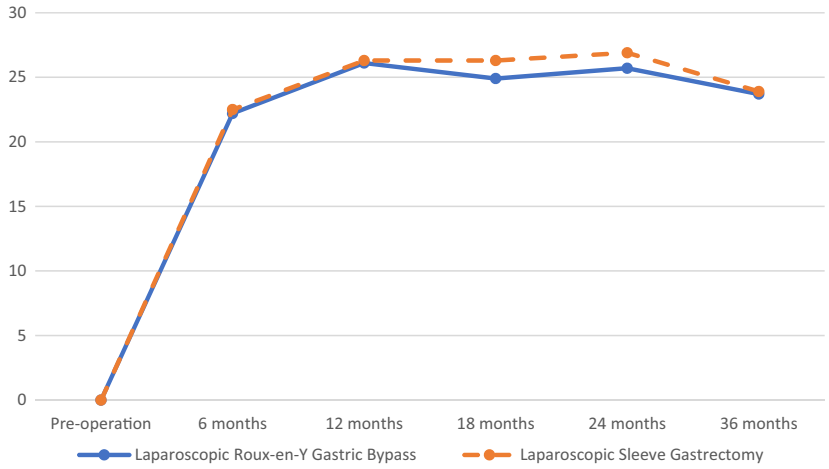

Fig. 1 Percentage total body weight loss with respective follow-up rates

Follow-up **rates**	6 months	12 months	18 months	24 months	36 months
Roux-en-Y gastric bypass	69.2%	54.3%	38.2%	40%	26.7%
Sleeve gastrectomy	64.5%	53.3%	37.9%	31.3%	27.8%

attributed to a complex interplay of hormones (e.g., glucagon-like peptide 1 (GLP-1), peptide YY (PYY), ghrelin, cholecystokinin, and leptin), bile acid metabolism, and altered gut microbiota.[14,15] While the complex

Table 2 Weight and body composition parameters following LRYGB and LSG

		Pre-operation	6 months	12 months	18 months	24 months	36 months
Weight, kg	LRYGB	110.7 (24.9)	83.3 (19.3)	79.7 (18)	82.9 (19.6)	82.4 (20.3)	86.8 (16.2)
	LSG	117.6 (24.2)	89.7 (18.1)	82.4 (17.7)	82.9 (16.2)	83.2 (22.6)	85.7 (19.8)
BMI, kg/m^2	LRYGB	40.6 (7.2)	31.1 (6.8)	29 (4.7)	29.6 (5.3)	29.3 (5.8)	30.4 (5.8)
	LSG	43 (7.6)	33.1 (6)	30.2 (5.6)	30.4 (6.1)	30.9 (8.7)	32 (6.9)
%EWL	LRYGB	–	66.1 (27.6)	77.5 (30.4)	74.9 (32.2)	77.3 (37.2)	67.7 (32.5)
	LSG	–	59.5 (23.1)	71.8 (30.5)	71.1 (32.1)	66.8 (46.6)	64.3 (37.8)
TBWL, kg	LRYGB	–	23.3 (7.3)	27.9 (9.1)	27.3 (9.7)	28.4 (12.2)	27.4 (13.1)
	LSG	–	26.4 (10.2)	30.1 (13.6)	30.7 (15.5)	31.3 (19.1)	28 (15.5)
%TBWL	LRYGB	–	22.2 (6.9)	26.1 (7.7)	24.9 (7.8)	25.7 (9.5)	23.7 (10.1)
	LSG	–	22.5 (6.7)	26.3 (9.8)	26.3 (10.8)	26.9 (17.3)	23.9 (11.1)
Waist circumference, cm	LRYGB	123.2 (15.9)	99.8 (14.2)	96 (13.9)	96.7 (15.9)	96.7 (16.4)	100.1 (15)
	LSG	125.2 (17)	103.5 (13.7)	97.1 (12)	98.7 (14.8)	99.8 (16.3)	100.1 (14.3)
BMR, Kcal/day	LRYGB	1546.5 (347.8)	1486.3 (227.9)	1452.7 (220.6)	1477.8 (230.1)	1453.2 (217.9)	1574.4 (219.6)
	LSG	1609.4 (323.6)	1573.9 (278.7)	1502.2 (239.4)	1528.8 (254.1)	1519.6 (251.6)	1542.6 (266)
% fat	LRYGB	41 (8)	35 (11.6)	30 (11.5)	31.5 (11.4)	35.2 (12.5)	26 (10)
	LSG	42.2 (8.4)	37.1 (10.4)	33.9 (11.6)	32.4 (11)	32.7 (12.1)	34.1 (11.6)
Fat mass, kg	LRYGB	44.6 (12.7)	29.5 (14.7)	23.2 (11.5)	25.2 (10.7)	28.2 (11.9)	24.1 (13)
	LSG	49.3 (13.2)	33.6 (12.5)	27.7 (12.6)	26.3 (9.9)	27.4 (15)	29.5 (14.9)
Fat-free mass, kg	LRYGB	66 (18.3)	52.5 (12.6)	52.6 (12)	54.1 (12.8)	51.2 (11.7)	64.5 (9.1)*
	LSG	67.8 (18)	55.9 (13.6)	52.7 (12.6)	55 (13.2)	54.6 (13.2)	54.7 (12.9)*
Total body water, L	LRYGB	47.6 (13.4)	38.4 (9.3)	38.5 (8.8)	39.6 (9.4)	36.9 (9.6)	47.1 (6.9)
	LSG	49 (13)	41 (10)	38.6 (9.2)	40.2 (9.6)	40 (9.7)	40.1 (9.5)

Values in parenthesis denote the 95% confidence interval

BMI body mass index, *EWL* excess weight loss, *TBWL* total body weight loss, *BMR* basal metabolic rate, *LRYGB* laparoscopic Roux-en-Y gastric bypass, *LSG* laparoscopic sleeve gastrectomy

*Significant difference between LRYGB and LSG, $p = 0.047$

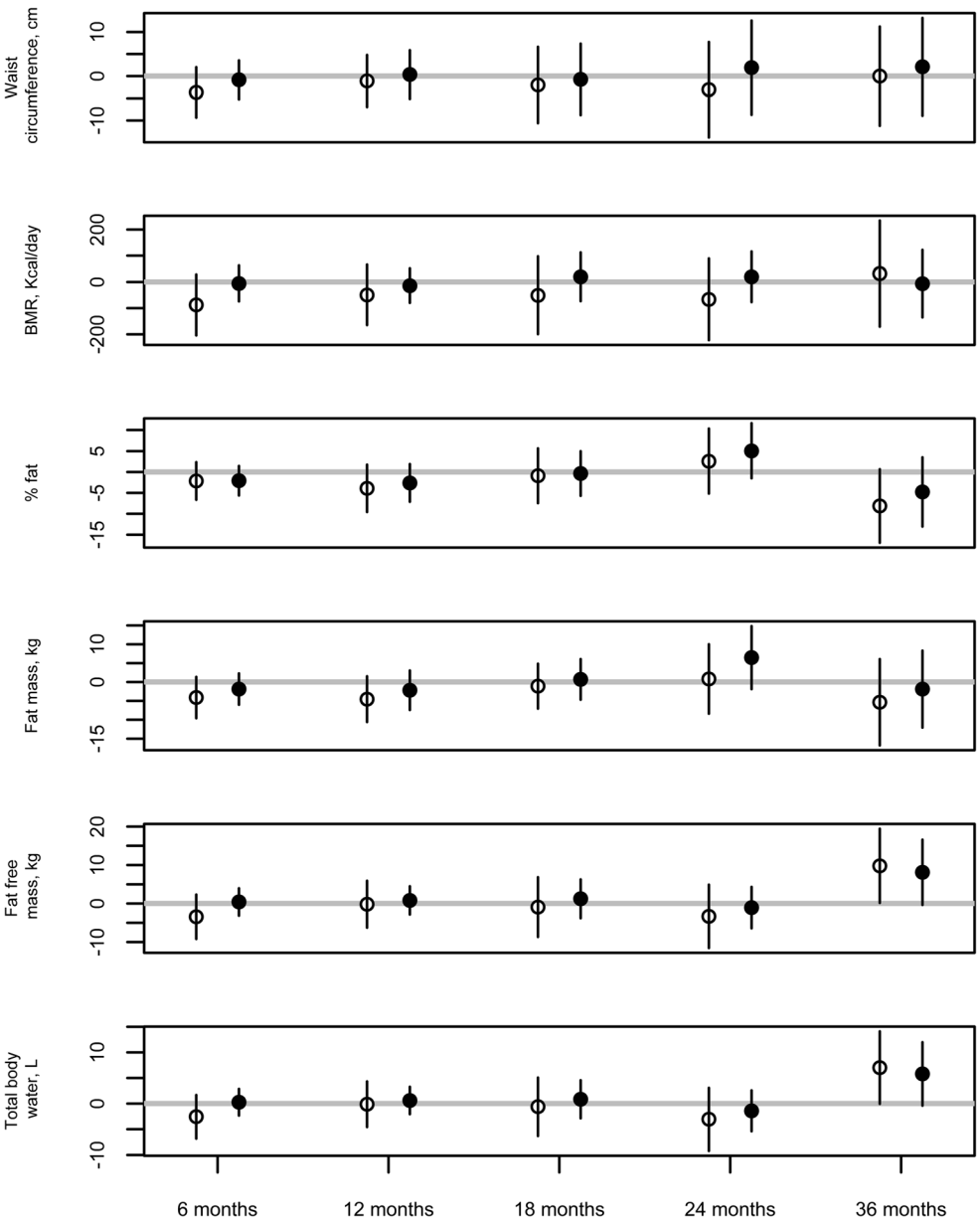

Fig. 2 The difference in mean body composition (from top to bottom: waist circumference in cm, basal metabolic rate [BMR] in Kcal/day, percent [%] fat, fat mass in kg, fat-free mass in kg, and total body water in liter [L]) of laparoscopic Roux-en-Y gastric bypass compared against laparoscopic sleeve gastrectomy (reference) at each follow-up visit (6, 12, 18, 24, and 36 months). The white and black circles correspond to unadjusted and adjusted (adjusted for age, gender, ethnicity, and baseline body mass index) difference in means at each follow-up visit with the vertical lines corresponding to the 95% confidence interval

mechanisms of weight loss between LSG and LRYGB differ, some of the clinical and physiological effects are similar.[14]

Bioelectrical impedance analysis (BIA) is a common and easy-to-perform tool for post-bariatric evaluation of body composition. It has been shown to provide accurate values comparable to those obtained by dual-energy X-ray absorptiometry (DXA).[16,17] BIA is based on measuring the resistance and reactance of an alternating electrical current in the human body. This method uses a mathematic modeling technique on a range of resistance values measured at different frequencies to extrapolate the resistance of the extracellular and intracellular fluid. These applied empirical prediction equations, developed by regression analyses, also include height, body weight, age, and gender as variables. However, there are also significant limitations to the use of BIA in obese populations, given the large variability in readings when used in relatively non-healthy populations. Furthermore, BIA is influenced by the hydration status, position of the body and movements during measurement, degree of degreasing of the skin for securing the electrodes, and exercise and food intake prior to measurements.[18] Despite these limitations, BIA is still the most practical tool available to assess body composition repeated over time in patients who will or have underwent bariatric surgery.

The literature comparing body composition differences between Asian and Western populations is limited. Specific to bariatric patients, most of the literature have been based on Western populations,[5–8] with the only two publications to our knowledge on an Asian post-bariatric surgery population—one published by our institute on its initial 68 patients at 1 year post-surgery, which

evaluated the relationship of kidney function to body composition changes,[19] and another based on a Taiwanese cohort of 198 patients that compared body composition changes between sleeve gastrectomy versus adjusted gastric banding.[20] Furthermore, these study populations are predominantly female (who consist of 70–76% of the total number of participants),[5–7] which may skew the body composition data due to sexual dimorphism in human body composition.[21] While our study does also have a larger proportion of females, the distribution is less skewed, with only 58.6% of our patients being female. There were also no differences in gender distribution between patients who underwent LRYGB versus LSG in our study. While population-based studies have shown that females have a higher % fat as compared to males,[22] our study did not show any difference in body composition change between LSG and LRYGB, a finding that is also seen in the Taiwanese bariatric surgery cohort, which also showed no difference in body composition change between LSG versus adjusted gastric banding despite baseline body composition differences between gender.[20] However, this finding may be limited by the relatively small numbers in both studies.

Our study's results concur with conclusions from a recent study from Germany[6] which also showed no significant differences in body composition between LSG and LRYGB at 1 year after adjusting for differences in initial BMI pre-operatively. In addition, our current study also showed that the body composition did not statistically differ at 2 and 3 years after surgery, which suggest that the differing mechanisms of weight loss between LSG and LRYGB may not translate to great differences in body composition changes between the two surgeries. When revisiting the mechanisms of weight loss after bariatric surgery, one possible explanation for these similar changes could partly be explained by similar changes in gut hormones, with both LRYGB and LSG shown to result in decreased ghrelin and increased GLP-1 and PYY.[23] However, the literature on this can be conflicting, with a systemic review of the literature on ghrelin after bariatric surgery failing to come to a conclusion on the direction or magnitude of post-bariatric surgery ghrelin levels.[24] When scrutinizing our results, there seemed to be a trend for patients who had underwent LRYGB having better preservation of FFM at 36 months post-surgery as compared to patients who had underwent LSG (64.5 kg versus 54.7 kg). There was also a greater decrease in % fat in the LRYGB group. These differences may be due to possible differences in postprandial ghrelin suppression, as ghrelin has been shown to have both orexigenic effects as well as anabolic effects which increase skeletal muscle growth and decrease protein breakdown.[25] This is supported by a randomized prospective trial by Peterli et al. showing that patients who underwent LRYGB regained physiologic postprandial suppression of ghrelin at 1 year post-surgery as compared to LSG, where ghrelin levels at 1 year post-surgery was still markedly suppressed,[23] though this also highlights the need for longer-term data on FFM as well as ghrelin beyond 1 year. Perhaps of greater clinical importance is the fact that both groups of patients had a substantial decrease in FFM that persisted at 1, 2, and 3 years after bariatric surgery. This occurred despite a rigorous multidisciplinary approach with physiotherapists and dieticians working together with the surgical team to maintain adequate protein intake and exercise regimes. Clearly, there is a need for novel intervention to prevent or reduce FFM loss to reap maximum benefits from metabolic surgery.

The main limitation of this study can be attributed to the suboptimal body composition data at 2 and 3 years after surgery, with relatively small numbers of patients who underwent LRYGB at these time points. There is significant difficulty in improving follow-up compliance, and this seems to be a difficult problem especially in Asian bariatric patients.[20] As there is additional cost and time required to perform BIA, some patients who do return for follow-up declined BIA, further reducing the data available for analysis, and introducing potential bias to the body composition analysis.

Conclusion

%TBWL in our study was similar between LRYGB and LSG up to 3-years post-operation, with most of the weight loss occurring within the first year after surgery, after which the weight loss plateaus and some weight recidivism is seen. There were no significant differences in body composition up to 3 years after LRYGB or LSG. Further studies on the underlying mechanisms of weight loss are required as there is a need to optimize weight loss by increasing loss of fat mass while maintaining fat-free mass.

Author Contribution GK contributed to the conception and design of the work, the analysis and interpretation of the data, and drafted the manuscript. CST contributed to the analysis and interpretation of the data for the work and in revising the manuscript. KWT contributed to the acquisition of data and revising the manuscript. SL and JS were significantly involved in the interpretation of the data and in revising the manuscript. AS contributed with the conception and design of the work, interpretation of data and in revising the manuscript. All the authors approve of the final version of the manuscript and agree to be accountable for this work.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflicts of interest.

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