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ORIGINAL ARTICLE

Sleeve Gastrectomy for Morbid Obesity: Robotic *vs* Standard Laparoscopic Sleeve Gastrectomy Methods

[1]RF Ijah, [2]Parveen Bhatia, [3]Sudhir Kaltan, [4]Mukund Khetan, [5]Suviraj John, [6]Vivek Bindal, [7]Asfar Ali

ABSTRACT

Aim: The aim of this study is to compare robotic laparoscopic sleeve gastrectomy with standard laparoscopic sleeve gastrectomy done for morbid obesity with regards to operative time and short-term patient outcome in a developing world.

Background: Excision of the fundus and greater curvature of the stomach in sleeve gastrectomy not only restrict intake but also reduces the level of ghrelin in the circulating blood. Obesity surgery has benefited from the advent of surgical robot with its celebrated advantages (enhanced dexterity, precision and control of endowrist instruments, with 7° of freedom, 90° of articulation, intuitive motion and finger-tip control, motion scaling and tremor reduction). How this new technology under development affect patient outcome has only been reported in a few centers especially in the developed world.

Materials and methods: Data for 21-month retrospective comparative study was collected from the records of 20 adult patients who had robotic sleeve gastrectomy (RSG) and 20 standard laparoscopic sleeve gastrectomy (SLSG) (obtained by randomized sampling of the total number of SLSG during the study period).

Results and discussion: Duration of surgery, cost of operation, duration of hospital stay, percentage excess weight loss (%EWL)/BMI, quality of life, comorbidity resolution and complications were the measures of outcome studied in comparing RSG to SLSG. The mean duration of surgery of 143.05 minutes for SLSG and 152.7 minutes RSG (ratio 1:1.07) were in agreement with previous studies in which the duration of RSG was longer than SLSG. The RSG mean docking time of 12.6 minutes in this study obviously contributed to increasing the total operative time.

The cost of surgery was found to be higher RSG 9000 USD compared to 7500 USD for SLSG (ratio1.2:1). This value is relatively higher than that documented in a study in which 400 euros was quoted. Understandably, this varied from center to center. Three patients (15%) were observed to have some significant complications among the SLSG group as against one patient (5%) in the RSG group.

Conclusion: Sleeve gastrectomy by robotic method in a developing country experience, has comparative advantage over standard laparoscopic methods in reducing complications, though the duration and cost of surgery were higher in the robotic methods. The choice of the method would therefore depend on availability, surgeon's skills, the patient's informed choice and ability to afford.

Keywords: Robotic/standard laparoscopic sleeve gastrectomy, Gastric/vertical sleeve gastrectomy, Robotic *vs* standard laparoscopic sleeve gastrectomy.

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[1]Senior Registrar, [2]Chairman and Chief Consultant Surgeon
[3-7]Consultant Surgeon

[1]Department of Surgery, University of Port Harcourt Teaching Hospital, Port Harcourt, Rivers State, Nigeria

[2-7]Institute of Minimal Access, Metabolic and Bariatric Surgery Sir Ganga Ram Hospital, New Delhi, India

Corresponding Author: RF Ijah, Senior Registrar, Department of Surgery, University of Port Harcourt Teaching Hospital, Port Harcourt, Rivers State, Nigeria, e-mail: rexijah@gmail.com

INTRODUCTION

Central to the development and progression of obesity is ghrelin, a peptide hormone secreted by X/A-like cells of the oxyntic glands of the fundus[1] (18-20 times than any other site)[2] of the stomach, which is involve in both stimulation of hunger and growth hormone secretion. It has been found to be an endogenous ligand[3-5] for the growth hormone secretagogues receptor (a specific G protein-coupled receptor) in the pituitary gland and hypothalamus thus, making this stimulating effect more potent (about seven times over) than that of growth hormone releasing hormone. Also, the increase in mRNA expression of hypothalamic neuropeptide Y (a potent stimulator of food intake) after intracerebroventricular administration of ghrelin in rodents, appear to demonstrate the orexigenic effect of this peptide. Thus, excision of the fundus and greater curvature of the stomach in sleeve gastrectomy not only restrict intake but also reduces the level of ghrelin in the circulating blood.

Obesity surgery has benefited from the advent of surgical robot with its celebrated advantages.[6] How this new technology under development affect patient outcome has only been reported in a few centers, especially in the developed world.

TECHNIQUE AND OPERATIVE TIME

The technique of surgery is similar for both robotic[7] and standard laparoscopic[8] sleeve gastrectomy with the exception of docking and undocking of robotic arms for robotic sleeve surgery. This involves longitudinal resection of the greater curvature of the stomach from the antrum to the angle of His. After achieving pneumoperitoneum, inserting trocars/

cannulas under the guidance of the standard laparoscopic camera (and docking of robotic arms) and retracting the liver, the essential steps commences from the greater curvature with the division of the gastroepiploic and short gastric vessels at the gastrocolic and gastrosplenic omentum up to the left crus of the diaphragm, thus completely freeing the stomach. Gastrolysis is performed from 5 cm[9] (authors vary: 2 cm,[8] 4 cm,[10] 10 cm[11]) proximal to the pylorus up to the angle of His. Approximately, 100 to 150 ml (60-200 ml[12]) of sleeve is created over size 38 Fr[13] (size 32 F14-60 F) bougie using Echelon Flex linear stapler with 60 mm. Smaller size bougie and shorter distance from the pylorus are preferred, especially when sleeve gastrectomy is intended as a sole procedure for morbid obesity. The staple line is imbricated with PDS (polydioxanone) 2-0 continuous sutures[15] to reduce the risk of leakage and bleeding. Peroperative endoscopy is done to rule out intraluminal bleed/leak and Biovac drain is placed in perisleeve region.

A comparative measure of the speed of surgery for both procedures is the duration of surgery (operative time). From published data, the average operative time varies from 65[11] to 120 minutes[15] in the standard laparoscopic sleeve method. This wide gap could probably be accounted for by the method employed in re-enforcing the staple line (oversewing takes longer time than use of prosthetic material), experience and learning curve of the different surgeons. Reported operative time for robotic sleeve gastrectomy varies from 70.1[16] to 165 minutes[17] with overall average of 101.1 minutes. Similar factors also apply. If the docking time (and undocking time) of 16 ± 4.2 is subtracted, only then will robotic sleeve gastrectomy (RSG) be considered to be shorter.

MEASURES OF OUTCOME

There are few publications on the outcome of RSG for morbid obesity with highlight on percentage excess weight loss, duration of hospital stay (and cost of operation), quality of life (QOL) and complications encountered. The relatively new status of the procedure may have strongly contributed to this. Also, available studies are of short follow-up duration and hence could not draw reasonable conclusions on long-term outcome of this procedure.

The duration of hospital stay for RSG varied from 2.5 to 4 days, comparable to that of standard laparoscopic sleeve gastrectomy (SLSG) (4-4.4 days). However, Frezza EE[11] reported the shortest of 1 day in a review of 10 patients. Burgos AM, in a study describing gastric leak after laparoscopic sleeve gastrectomy[8], reported a mean hospital stay of 28.8 days among 214 patients. It appears reasonable to conclude therefore that occurrence of complications negatively impact on sleeve patients and prolong their hospital stay.

The prime target of sleeve surgery is to effectively reduce excess weight and therefore reduce the negative impact this has on the morbidity (obstructive sleep apnea, diabetes mellitus, hypertension, osteoarthritis, etc.) of the patients. Available data on robotic sleeve gastrectomy revealed percentage excess weight loss of 65.5 ± 25.6% at 1 year. This also is comparable to that of standard sleeve gastrectomy of about 33 to 90% in a review study of 940 patients,18 and 60.8 ± 4.3% in a study of 25 patients.[19] The mean preoperative body mass index (BMI) varied from 40 to 67.7 kg/m^2 for robotic sleeve surgery and 35 to 74 kg/m^2 for standard laparoscopic sleeve studies.

The follow-up duration of available studies varied from 3 to 12 months for robotic sleeve and 4 months to 5 years for SLSG with an average of 1 year. There appeared to be a fall (35%-71.6% at 6 months, 45-83% at 1 year, 47-83% at 2 years and 66% at 3 years) in the peak of percentage of excess weight loss achieved after a while as reported by Trelles N and Gagner M.[12]

The percentage of main complications was reported less in robotic sleeve than in SLSG. Miller N et al[20] in a study of 317 patients demonstrated this in a ratio of 5:12% in favor of RSG. The precision and high maneuverability of the robotic arms coupled with the comfort of the sitting surgeon at the console, would have significantly contributed to this more than double complication rate.

It is worth noting from available studies that the following issues still call for attention for possible consensus: its use as single-stage procedure; use of intragastric balloon in high-risk and super-obese patients; resection distance from the pylorus; the size of the gastric bougie used (hence size of remaining gastric pouch), variation of bougie size with degree of obesity; reinforcement of the staple line and type of material used.

The aim of this study, therefore, is to compare RSG with SLSG done for morbid obesity with regards to operative time and short-term patient outcome in a developing country.

MATERIALS AND METHODS

Retrospective comparative study was done in a minimal access bariatric surgery unit of a busy hospital over 21 months (data collection of surgeries from October 2011 to October 2012, and follow-up to June 2013). Data was collected for 20 RSG and 20 SLSG (obtained by systematic sampling of the total number of SLSG during the study period.

Inclusion Criteria

Patients with BMI^3 40 kg/m^2, patients aged between 30 and 60 years.

Exclusion Criteria

Patients with BMI ≥40 kg/m². Operative technique used was similar: gastrolysis is performed from 5 cm proximal to the pylorus up to the angle of His. Approximately, 100 to 150 ml of sleeve is created over size 38 Fr[21] bougie using Echelon Flex linear stapler with 60 mm. The staple line is imbricated with PDS (polydioxanone) 2-0 continuous sutures and peroperative endoscopy is done.

The measures of outcome studied were: duration of surgery, cost of operation, duration of hospital stay, percentage of excess weight loss (%EWL)/BMI, quality of life, comorbidity resolution and complications.

RESULTS

The duration of surgery for SLSG was found to vary from 121 to 150 minutes with a mean of 142.7 minutes, while the overall operative time for RSG was between 132 and 188 minutes with an average of 150.4 minutes (Table 1). The mean docking time was 17.9 minutes.

The cost of surgery for SLSG was found to be 7500 USD while that of RSG was 9000 USD (Table 1 and Graph 1). The duration of hospital stay for SLSG varied from 3 to 11 days with a mean value of 4.6 days, while for RSG it span from 3 to 6 days with a mean value of 3.9 days.

The mean percentage excess weight loss for SLSG at 1 year was 83.8 and 82.0% for RSG (Table 2). The mean preoperative BMI for SLSG and RSG were 53.1 and 51.0 respectively (Tables 2 and 3). In this series, the progression of mean percentage excess weight loss by month for SLSG was 23.4% → 45.1% → 58.9% → 83.9%, and 23.7% → 40.8% → 60.8% → 82.8% for RSG at 1, 3, 6 months and 1 year. In this study, the mean preoperative body weight reduced from 139.2 to 79.6 kg at 1 year for SLSG and from 141.4 to 85.8 kg for RSG patients. Likewise, the mean preoperative BMI reduced from 83.8 to 30.3 among SLSG patients and 51 to 30.5 at 1 year for RSG patients.

The mean quality of life for SLSG rose from a preoperative value of 2.3 to 8.3 after surgery, and from a value of 2.3 to a postoperative value of 8.45 for RSG.

In this series, 14 out of 20 SLSG patients (70%) and 11 out of 20 RSG (55%) patients had obstructive sleep apnea. The resolution of obstructive sleep apnea was dramatic with a value of 78.6% observed within the first 1 month and 100% in 3 months for patients operated by SLSG. 81.8% in 1 month 100% in 3 months were observed for RSG patients. Eleven out of the 20 (SLSG 55%) and seven out of 20 (RSG 35%) had diabetes mellitus. There was a noticeable improvement in diabetic status as seen in the reduction in the percentage of patients on insulin from 81.9% in the first month to 18.1% at 1 year for SLSG patients, i.e. 81.9% being off their insulin at 1 year. A similar drop was noticed for RSG patients from 71.4 to 28.6% respectively, with 71.4% of diabetics going off their insulin at 1 year.

Sixty percent (12 out of 20) of SLSG patients and 70% (14 out of 20) of patients operated by RSG were hypertensive. From this value, there was a reduction in the number of patient taking antihypertensive agents to control their blood pressure from 100% in the first month to 41.7% (58.3% being off their drugs) at 1 year for SLSG patients and from 100 to 35.7% (64.3% off drugs) respectively for RSG patients. Three patients (15%) were observed to have some significant complications among the SLSG group as against one patient (5%) in the RSG group.

DISCUSSION

Duration of surgery, cost of operation, duration of hospital stay, %EWL/BMI, QoL, comorbidity resolution and

Table 1: Summary of parameters for SLSG and RSG

Parameters	*SLSG*				*RSG*			
	Mean value	χ^2	*p-value*	*Conclusion*	*Mean value*	χ^2	*p-value*	*Conclusion*
Mean operative time	142.7	17.4	30.144	$p > \chi^2$	150.4	17.003	30.144	$p > \chi^2$
Mean hospital stay	4.6	14.81	30.144	$p > \chi^2$	3.9	3.59	30.144	$p > \chi^2$
Mean postop QOL	8.3	0.899	30.144	$p >> \chi^2$	8.45	0.576	30.144	$p >> \chi^2$
Mean %EWL at 1 year	83.8	45.11	30.144	$p < \chi^2$	82	82	30.144	$p < \chi^2$
Mean preop body weight	139.2	138.36	30.144	$p < \chi^2$	141.4	146.60	30.144	$p < \chi^2$
Mean percentage of change in BMI at 1 year	41.5	15.309	30.144	$p > \chi^2$	40.1	4.323	30.144	$p > \chi^2$
Resolution of hypertension at 1 year (%)	58.3				64.3			
Resolution of diabetes mellitus at 1 year (%)	81.9				71.4			
Percentage of complications	15				5			
Mean cost of surgery	$7500				$9000			
Resolution of obstructive sleep apnea at 1 year (%)	100				100			

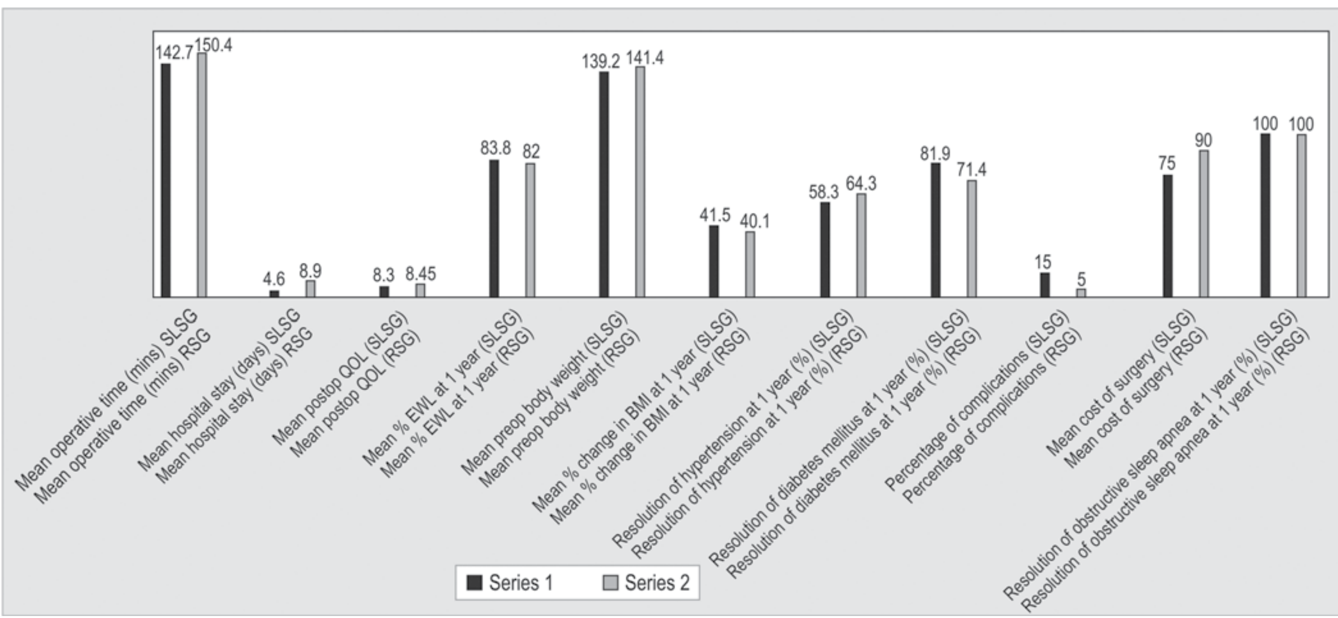
Note: Data is highly reproducible, if p-value >> χ^2; Data is reproducible, if p-value > χ^2; Data is nonreproducible, if p-value < χ^2

complications were the measures of outcome studied in comparing RSG to SLSG. The table below is a summarized highlight of the comparison between SLSG and RSG in terms of the measures of outcome.

The mean duration of surgery of 142.7 minutes for SLSG and 150.4 minutes RSG (ratio 1:1.05) were in agreement with previous studies[11,15-17] in which the duration of RSG was longer than SLSG. There was a wide variation in time from 121 to 150 minutes for SLSG and 132 to 188 minutes for RSG. The RSG mean docking time of 17.9 minutes in this study obviously contributed to increasing the total operative time and was comparable to a previous study by Diamantis T et al[19] in which 16 ± 4.2 was documented.

The cost of surgery was found to be higher RSG 9000 USD compared to 7500 USD for SLSG (ratio1.2:1). This value is relatively higher than that documented in a study[19] in which 400 euros was quoted. Understandably this varied from center/region to center/region as some online patient information manuals quoted 9500 to 22,000 USD with an average of 17,000 USD in the Indian subcontinent. The mean duration of hospital stay was 4.6 and 3.9 days (ratio 1.18:1) for SLSG and RSG respectively. The observation for SLSG was similar to the finding of Givon-Madhala O et al[15] in his study of 25 patients and Shi X et al in his study of 940 patients. Also, a value of 3.9 days observed for RSG is within the range of previous studies.[17,19,20] The study differs from Frezza EE et al report of duration of 1 day[11] and 28 days reported by Burgos AM et al[8] among 214 patients who had gastric leak. This observed difference was obviously due to absence of major complications in this study.

The mean percentage excess weight loss for SLSG at 1 year was 83.8 and 82.0% for RSG (ratio 1.02:1). This difference is less than significant. However, this value is similar to previous studies which reported 47 to 83%[12] and 33 to 90%[18] in 1 year, but differs from that of Damantis T et al[19] which recorded 60.8 ± 4.3. Varied patients adherence to postoperative exercise and dietary advice could probably have contributed to this observed difference. In this study, the mean preoperative body weight reduced from 139.2 to 79.6 kg at 1 year for SLSG and from 141.4 to 85.8 kg for RSG patients. Likewise, the mean preoperative BMI reduced from 83.8 to 30.3 among SLSG patients and 51 to 30.5 at 1 year for RSG patients. These values are also in agreement with a previous study.[21] However, the observed higher value of preoperative body weight/BMI for SLSG patients was contrary to findings in previous studies which advocated use of RSG method for patients with higher preoperative body weight/BMI. The explanation for this discrepancy could be that some patients with high body weight/BMI may not have been able to afford the high cost for robotic surgery in this developing or the initial learning curve of the surgeons in the team following acquisition of



Graph 1: Summarized chart—SLSG *vs* RSG

Table 2: SLSG *vs* RSG: mean percentage excess weight loss/BMI by months

	SLSG (mean BMI)	*RSG (mean BMI)*	*SLSG (mean %EWL)*	*RSG (mean %EWL)*
Preop BMI	53.1	51	—	—
1 month	46.5	44.9	23.4	23.7
3 months	40.8	40.8	45.1	40.8
6 months	36.7	38.3	58.9	60.0
1 year	30.3	30.5	83.8	82.0

Table 3: Mean percentage change in BMI at 1 year

Si/no.	*SLSG*			*RSG*		
	Preop BMI	*Postop BMI*	*Change in BMI (%)*	*Preop BMI*	*Postop BMI*	*Change in BMI (%)*
1	44.5	26.3	40.9	48.1	33.1	31.2
2	47.0	26.1	44.5	60.0	36.3	39.5
3	49.0	33.0	32.7	48.3	29.0	40.0
4	58.2	34.4	40.9	54.4	33.2	39.0
5	72.1	39.7	44.9	45.9	29.3	36.2
6	44.2	23.0	48.0	46.5	26.5	43.0
7	54.0	31.8	41.1	43.0	27.1	37.0
8	42.0	22.2	47.1	40.9	23.3	43.0
9	46.0	29.3	36.3	47.0	29.1	38.1
10	45.0	30.2	32.9	42.6	25.6	39.9
11	59.1	36.1	38.9	82.6	50.3	39.1
12	42.4	26.4	37.7	42.0	24.0	42.9
13	49.0	28.1	42.7	44.0	27.0	38.6
14	43.0	26.1	39.3	46.0	27.1	41.1
15	62.0	27.4	55.8	51.5	29.4	42.9
16	77.3	38.7	49.9	55.0	31.2	43.3
17	47.5	30.8	35.2	48.0	26.7	44.4
18	61.6	37.2	39.6	42.0	25.7	38.8
19	53.6	33.3	37.9	51.0	29.1	42.9
20	45.2	25.8	42.9	81.0	47.2	41.7
Mean	53.1	30.3	41.5	51.0	30.5	40.1

p = 30.144; χ^2 = 15.309 (SLSG); χ^2 = 4.323 (RSG); p > χ^2; Data is reproducible; BMI: Body mass index

this new technology may have influenced their choice of patient selection.

The mean quality of life index for SLSG rose from a preoperative value of 2.3 to 8.3 after surgery, and from a value of 2.3 to a postoperative value of 8.45 for RSG. These values are in agreement with a previous study by Bindal V et al[21] which reported a rise in value from 2.7 to 8.2. This study was carried out in the same center and the surgeries were done by the same team of bariatric surgeons.

The resolution of obstructive sleep apnea was dramatic with a values of 81.8 and 78.6% (ratio 1.04:1) observed for RSG and SLSG patients respectively, within the first 1 month, and 100% for both in 3 months. Among diabetic patients, 81.9% in SLSG group and 71.4% of RSG patients (ratio 1.15:1) were off their insulin at 1 year. Fifty-eight (58.3%) of hypertensive patients were off their drugs at 1 year for SLSG patients and 64.3% (ratio 1:1.1) was the finding for RSG patients. Similar resolutions were observed by Bindal V[21] with values of 93% for OBSA; 78.94% for diabetes and 62% for hypertensive patients. It is also in agreement with the work of Noun R et al[22] with a value of 70.5% for comorbidities.

Three patients (15%) were observed to have some significant complications among the SLSG group as against one patient (5%) in the RSG group. These values corroborated the study conducted by Nathan Miller et al which reported a 12% for SLSG and 5% RSG as complication rates.

The findings above implied that the use of robotic Da Vinci in carrying out sleeve gastrectomy for morbid obesity had comparable outcome in terms of percentage excess weight loss, quality of life index, and duration of hospital stay. Though RSG attracted a higher operative cost and a longer duration of surgery, the complication rate was more than twice lower than SLSG. This is significant, as any major complication when it occurs could increase cost of care of such patient. Improved surgeon's comfort and uniqueness of the robot indirectly reduced complication rate.

That this study was done in a bariatric surgery center in which the same team of surgeons operated and followed up the patients and the findings came out to be in agreement with that of other researchers on this subject, is an area of strength. However, being a short-term retrospective study is a limitation. A prospective long-term study would have been preferred to enable one to draw conclusion on long-term benefit of the two methods.

CONCLUSION AND RECOMMENDATION

Sleeve gastrectomy by robotic method in a developing country experience, has comparative advantage over standard laparoscopic methods in reducing complications in the ratio of more than 2:1, as earlier reported in the developed world. The main advantage of the robotic method is to the surgeon, by improving comfort and reducing fatigue, and indirectly to the patient reducing complications. The short-term outcome of percentage excess weight loss, quality of life index, duration of hospital stay and comorbidity resolution were similar to that of standard method, though the duration and cost of surgery were higher in the robotic methods. The choice of the method would therefore depend on availability, surgeon's skills, the patient's informed choice and ability to afford.

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