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REVIEW ARTICLE

Laparoscopic Sleeve Gastrectomy: An Ideal Procedure for Control of Morbid Obesity

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ABSTRACT

Background: Sleeve gastrectomy is becoming increasingly popular within bariatric surgery. Initially introduced as a component of complex interventions and later as part of a two-stage operation in high-risk patients, the procedure is now more common as one-stage operation and subject of avid scientific discussion. However, the concept of longitudinal gastric resection is not new. The procedure was already established in ulcer surgery but soon faded into insignificance. This article aims to trace the historical development of resection of the greater curvature and review the current value of sleeve gastrectomy within the spectrum of bariatric surgical procedures.

Materials and methods: Extensive review of literature of articles published in english language was conducted using the following search engines: Google, Yahoo, Medline, PubMed, Medscape, HighWire press and the SpringerLink library available at the World Laparoscopy Hospital, Gurgaon, India. Articles that matched the criteria were selected for review.

Results: Six reviews and 90 articles were selected and reviewed and analyzed to reach the conclusions.

Conclusion: Laparoscopic sleeve gastrectomy is a safe and effective weight loss procedure. Resolution of comorbidity, health-related quality of life and food tolerance were comparable with that of Roux-en-Y gastric bypass with lower incidence of complications comparable to gastric banding. However, there is need for standardization of the procedure and long-term results are yet to be analyzed.

Keywords: Sleeve gastrectomy, Tube gastrectomy, Longitudinal gastric resection, Bariatric surgery.

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INTRODUCTION

Obesity is gradually turning into an epidemic condition throughout the world and has become a social, psychological and economic burden of growing proportions.[1,2] It is associated with a large number of concomitant diseases (including type-2 diabetes, cardiovascular and respiratory diseases, dyslipidemia and elevated risk of cancer) and also markedly shortens the obese person's life expectancy.[3,4]

Due to the limited options and especially the poor long-term results of conservative treatment, the surgical approach of bariatric surgery has been established in the last few decades.[3] A bariatric procedure is considered to be indicated in adult patients with morbid obesity body mass index (BMI) ≥ 40 kg/m^2 or a BMI ≥ 35 kg/m^2 with additional comorbidities.[5,6] Long-term results of the surgical approach have been convincing in terms of reduced morbidity and mortality as well as enhanced quality of life.[7,8] Due to growing experience and the introduction of the endoscopic technique, the procedures have become increasingly safe and can be performed more easily by the use of modern stapling devices. Therefore, bariatric surgery is even considered in adolescents with a high-risk profile or in patients with BMI < 35 kg/m^2.[9,10] Several surgical procedures have been developed over time and nearly all of them are currently performed by the laparoscopic approach. A distinction has been made between restrictive, malabsorptive, combined restrictive and malabsorptive and electrical procedures for gastric stimulation. This diversity and the ongoing modifications of the procedures highlight the fact that there is no ideal procedure for widespread application. The quality of the respective procedures is no longer established by the previously used primary parameter of 'excess weight loss', but by the procedure's potential to maintain sufficient weight reduction on a long-term basis while ensuring minimal mortality and morbidity.

Laparoscopic sleeve gastrectomy (LSG; Fig. 1) was introduced by Gagner et al as a first-step procedure to minimize surgical risk for super-super-obese or high-risk patients, followed by either laparoscopic biliopancreatic diversion with duodenal switch (BPD-DS; Figs 2 and 3) or laparoscopic Roux-en-Y gastric bypass (LRYGBP).[11,12] Recent studies suggest that a second-stage surgical procedure is not always warranted, if adequate weight loss and comorbidity resolution are achieved, and the procedure could be a safe and effective stand-alone procedure for the treatment of morbid obesity.[13-15] The benefits of LSG include a low rate of complications, maintenance of gastrointestinal continuity and absence of malabsorption. As with other bariatric procedures, the results of LSG have mostly been evaluated on the basis of weight loss, and studies have shown that LSG can achieve a satisfactory weight loss on a short- and mid-term follow-up basis, but data still are lacking regarding long-term outcomes.[14,16,17]

MATERIALS AND METHODS

A broad search of literature of articles published in english language was performed in September 2011 using physical

means and electronically using the following search engines: Google, Yahoo, Medline, PubMed, Medscape, HighWire press and the SpringerLink library available at the World Laparoscopy Hospital, Gurgaon, India. The keywords used for the search were 'sleeve gastrectomy', 'tube gastrectomy', 'longitudinal gastric resection' and 'bariatric surgery'. Articles that matched the criteria were selected for review.

The articles were grouped by level of evidence (Table 1) and reviews were made based on evidence-based arguments for and against.

HISTORY

Operations to alter the gastrointestinal tract and produce weight loss have been applied for half a century. Weight loss operations may cause malabsorption, restriction of food intake or a combination of the two. The original operation for morbid obesity, the jejunoileal bypass, was first performed in 1954. However, this purely malabsorptive operation led to unacceptable morbidity and mortality related to bacterial overgrowth and liver damage.[18] The focus shifted away from purely malabsorptive procedures until the 1970s, when BPD was first described,[19] with eventual description of DS in 1993.[20] This operation has been applied laparoscopically with effective weight loss.[21]

Gastric bypass was introduced by Mason in 1966 as a combined restrictive-malabsorptive procedure.[22] Several variations and modifications of the original procedure have evolved over time, such as complete gastric transection, reduction in gastric pouch size and application of a Roux-en-Y.[23] As of 2003, Roux-en-Y gastric bypass (RYGB) accounted for more than 80% of all bariatric procedures performed in the United States. Laparoscopic RYGB was popularized and validated in the early 1990s by Wittgrove and Clark,[24] and several corroborating series have followed.[25-28] Differences exist in the technique for laparoscopic gastrojejunostomy as part of the procedure, including transoral circular stapling,[24] transgastric circular stapling,[26] linear stapling[27] and hand sewing[28] approaches, but all are supported in the literature as producing similar safety and weight loss results.

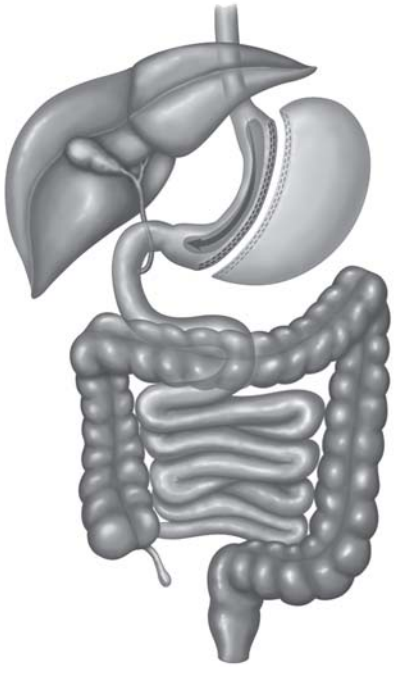


Fig. 1: Sleeve gastrectomy

Fig. 2: Biliopancreatic diversion and duodenal switch

Fig. 3: Roux-en-Y gastric bypass

Table 1: Levels of evidence

Level of evidence	*Criteria*
Ia	Evidence from meta-analysis of randomized controlled trials
Ib	Evidence from atleast one randomized controlled trial
IIa	Evidence from atleast one controlled study without randomization
IIb	Evidence from atleast one other type of experimental study
III	Evidence from descriptive studies, such as comparative studies, correlation studies and case-control studies
IV	Evidence from expert committee reports, opinions or clinical experience of respected authorities or both

In the early 1970s, Printen and Mason[29] developed a purely restrictive operation, the gastroplasty. This operation later developed into vertical-banded gastroplasty (VBG)[30] and ultimately laparoscopic VBG by the 1990s (Fig. 4).[31] Despite efforts to simplify the procedure,[32] gastroplasty operations decreased and accounted for only 7% of US bariatric procedures in 2002. Stomach banding for weight loss, originally introduced in the 1980s with nonadjustable devices, became popular in the early 1990s.[33] In 1993, Belachew and Legrand placed the first laparoscopic adjustable gastric band (AGB; Fig. 5) using the LAP-BAND® system (Allergan Inc, Irvine, CA, USA).[34] Although multiple versions of AGB are available for laparoscopic use, most published results are derived from the LAP-BAND® system.

Laparoscopic adjustable bands quickly became popular worldwide due to their relative ease of placement and safety. The LAP-BAND® system was not approved for use in the United States until 2001, and its use has increased steadily. A recent worldwide survey showed that the laparoscopic AGB accounted for 24% of obesity operations, whereas 26% of the operations were laparoscopic RGB and 23% were open gastric bypass.[35]

Another contemporary restrictive procedure that derives from the concept of vertical gastroplasty is the LSG. The LSG technique developed as a first-stage procedure before DS or gastric bypass for high-risk patients.[36,37] Studies have shown that LSG used in this manner reduces weight, comorbidities and operative risk [American Society of Anesthesiology (ASA) score; Fig. 6] at the time of a second bariatric procedure.[38-40] There is increasing application of LSG as a primary weight loss operation.[36,37,41,42] Evolving data demonstrate that LSG provides substantial weight loss and resolution of comorbidities over 3 to 5 years follow-up periods.[36,38,43-45] Early comparative data demonstrate that the percentage of excess body weight loss (EBWL) with LSG at 1 year is superior to that with AGB and approaches that with RGB and BPD.[46]

Other minimally invasive weight loss procedures are in developmental stages. Gastric pacing, under development in Europe for more than 10 years, has shown acceptable safety and early efficacy (<15 months), although its use is appropriately limited to clinical trials until more mature data become available.[47]

RESULTS

Most surgeons and medical insurance providers today adhere to the guidelines for surgical management of obesity established at the 1991 National Institutes of Health Consensus Conference on Gastrointestinal Surgery for Severe Obesity.[48] According to the guidelines, patients are eligible for surgery if they have failed attempts at nonsurgical weight loss and have a BMI > 35 (Fig. 7) with comorbidity or a BMI > 40 with or without comorbidity.

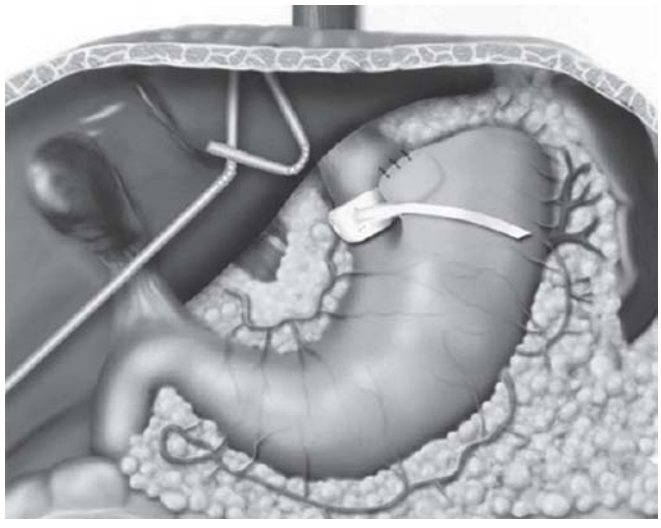


Fig. 4: Vertical-banded gastroplasty

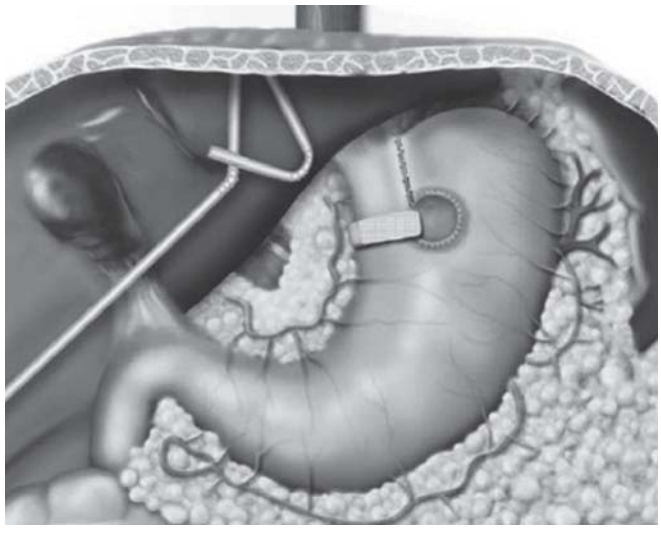


Fig. 5: Adjustable gastric banding

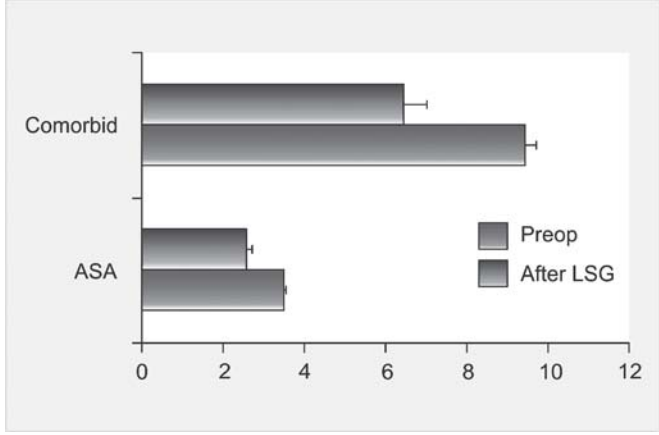


Fig. 6: Effect of LSG on ASA

The only operations endorsed by the panel were gastric bypass and VBG which at the time were the primary procedures with well documented long-term data.

In order to assess new laparoscopic bariatric operations, it is appropriate to establish benchmark outcome goals for comparison. The RYGB is most suitable for comparison because there is significant evidence to document both short-term and long-term outcomes, and it is considered by most surgeons in North America to have the most favorable risk/benefit profile. Table 2 demonstrates selected series of open RYGB published primarily over the past decade with key outcome parameters.[49-59]

The SAGES appropriateness conference statement on optimal management of the morbidly obese patient in 2004 after review of more than 1,500 articles reached consensus regarding indications for surgery, resolution of comorbid illnesses with significant weight loss and the importance of committed bariatric programs (Figs 8 and 9). The indications were similar to that agreed upon by National Institutes of Health Consensus Conference on Gastrointestinal Surgery for Severe Obesity held in 1991 and RYGB was accepted as the 'gold standard' of weight loss surgeries as it was the only procedure which was supported by level 1 evidence of 10 prospective randomized controlled studies in the subject.[60-69]

In 2007, the review 'surgery for obesity: A review of the current state of the art and future directions' by Stephen S McNatt, James J Longhi, Charles D Goldman and David W McFadden compared gastric bypass, biliopancreatic diversion, gastric banding and gastric pacing by reviewing 112 articles and put forward the following observations.

These results clearly indicate that bariatric surgery (Table 3) is an effective and safe method of weight loss with the scientific evidence. The indications for bariatric surgery have been standardized with RYGB as the 'gold standard' of weight loss procedures (Tables 4 and 5).

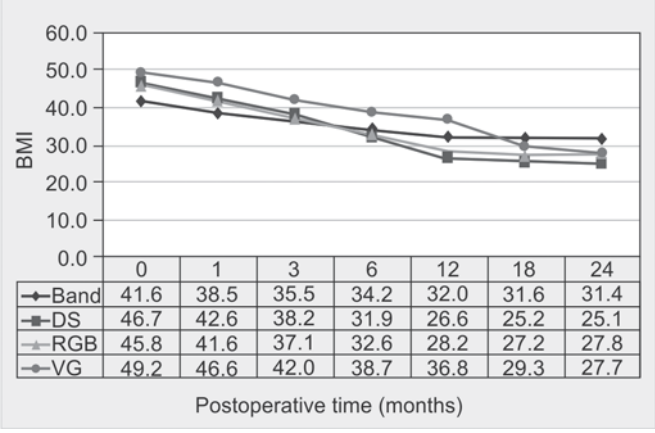


Fig. 7: Postoperative BMI in patients who underwent various laparoscopic bariatric surgeries

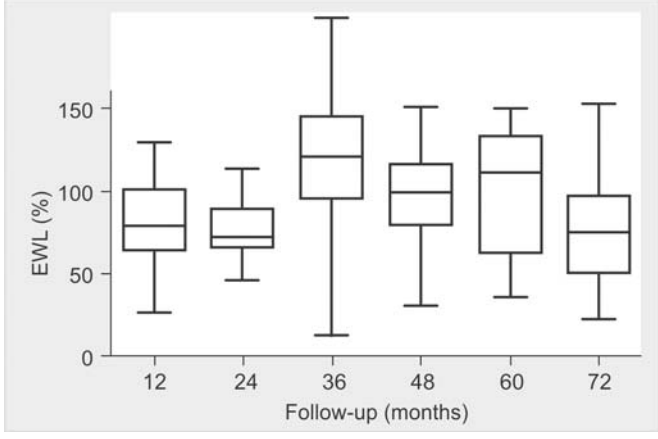


Fig. 8: Percentage of estimated weight loss at different points of time after LSG

Table 2: RCT in favor of RYGB[25]

	N	*Patient size (BMI, kg or % IBW)*	*time (min)*	*Hospital stay (day)*	*Early complication rate (%)*	*Mortality (%)*	*PE rate (%)*	*Leak rate (%)*	*Hernia (%)*	*Follow-up (months)*	*Weight loss*
Mason 1969	26	42	—	—	19	7.7	3.4	0	11.5	12	43 kg
Griffin 1981	402	134 kg	—	—	4.2	0.75	0.25	5.47	3.5	6	35 kg
Linner 1982	174	126 kg	—	—	10.4 (all)	0.57	0	0.57	0	24	64% EWL
Sugerman 1989	182	213%	—	6-7*	—	1	0	1.6	18*	12	67% EWL
Hall 1990	99	198%	120	8	20	0	3	0	2	36	67% lost >50% EBW
Brolin 1992	90	62	—	—	5	0	1.1	0	6.6	43	64% EWL
MacLean 1993	106	50	—	—	—	0	—	5.6	—	33	58% lost >50% EBW
Poires 1995	608	50	—	5-6*	25.5	1.5	—	—	23.9	168	49% EWL
Capella 1996	560	52	—	—	1	0	0	0	—	60	62% EWL
Fobi 1998	944	46	—	4*	2.7	0.4	0.6	3.1	4.7	24	80% EWL
MacLean 1999	243	49	—	—	—	0.41	—	—	16	66	BMI 44→ 29

BMI: Body mass index; EBW: Excess body weight; EWL: Excess weight loss; IBW: Ideal body weight; PE: Pulmonary embolism; — :not reported.

*As reported by the investigator, without mean and standard deviation of the mean; one subphrenic abscess; change in BMI for patients with initial BMI 40-50.

In 2005, in the article 'Laparoscopic sleeve gastrectomy as an initial weight-loss procedure for high-risk patients with morbid obesity' by D Cottam and FG Qureshi of Department of Surgery, University of Pittsburgh Medical Center, Pittsburgh, PA, and Department of Surgery, Veterans Hospital, Pittsburgh, PA, USA, SG Mattar, S Sharma, S Holover, G Bonanomi and R Ramanathan of Department of Surgery, University of Pittsburgh Medical Center, Pittsburgh, PA, USA and P Schauer of Cleveland Clinic, Cleveland, OH, USA published the results of their study on the effect of LSG as an initial procedure prior to laparoscopic RYGB in a staged intervention in superobese patients. In this study, 126 patients (53% female) with mean age 49.5 ± 0.9 years and mean BMI 65.3 ± 0.8, underwent LSG (Tables 6 and 7) as a first stage during the period January 2002 to February 2004 (Fig. 10). After achieving significant weight loss and reduction in comorbidities, these patients then proceeded with the second stage, LRYGBP (Tables 8 and 9).

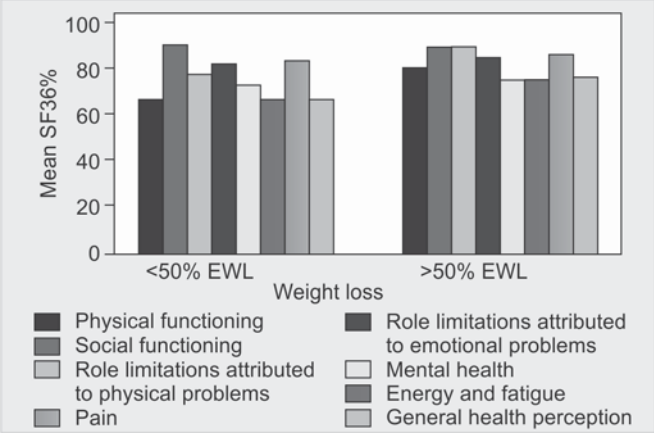


Fig. 9: Comparison of medical outcome score of patients with percentage of estimated weight loss more than 50% with those less than 50%

Table 3: Effects of bariatric surgery on gastrointestinal hormones

Surgery	*Hormone*	*Change*
Gastric bypass	Ghrelin	↓
(Roux-en-Y)	Ghrelin	↑
	Ghrelin	↓
	Ghrelin	No change
	Ghrelin	↓
	Ghrelin	↓
	Ghrelin	↑
	Enteroglucagon	↑
	Enteroglucagon	↑
	GLP-1	↑ (NS)
	CCK	No change
Gastric banding	Ghrelin	↓
	Ghrelin	↓
VBG	PYY	↑
BPD-DS	Enteroglucagon	↑
	Enteroglucagon	↑
	Enteroglucagon	↑
	Ghrelin	↑ (initial only)
Jejunoileal bypass	CCK	↑ (cell no.)
	CCK	↑
	PYY	↑
	Enteroglucagon	↑
	GLP-1	↑

In 2008, in the review 'Clinical application of laparoscopic bariatric surgery: An evidence-based review' by Timothy M Farrell, Stephen P Haggerty, D Wayne Overby, Geoffrey P Kohn, William S Richardson and Robert D Fanelli, 254 articles were analyzed with respect to the impact of laparoscopic bariatric surgery on mortality, weight loss and comorbidities and the following guidelines were

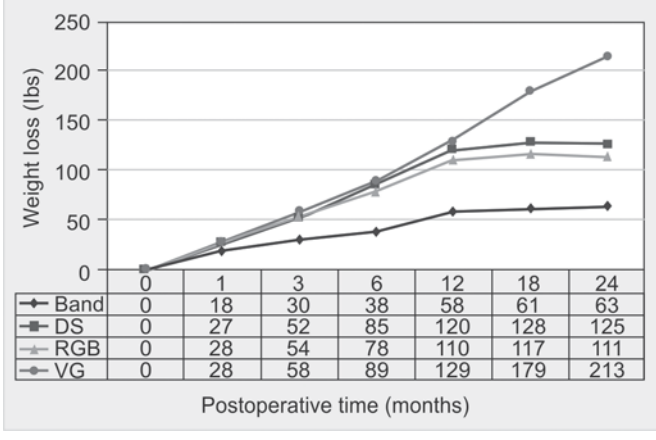


Fig. 10: Postoperative weight loss in patients who underwent various laparoscopic bariatric surgeries

Table 4: Summary of clinical trials showing mean excess weight loss from LAP-BAND and gastric bypass

Author	*n*	*Mean excess weight loss (%)*					*Country*
		*1 yrs**	*2 yrs*	*3 yrs*	*4 yrs*	*5 yrs*	
Watkins et al	138	48.2	—	—	—	—	USA
Spivak et al	500	39	45	47	—	—	USA
Ren et al	99	44	—	—	—	—	USA
Ren et al	115	41.6	—	—	—	—	USA
Rubenstein	63	39	46.5	53.6	54	54	USA
O'Brien and Dixon	709	47	52	53	52	—	Australia
Dargent	500	56	65	64	—	—	France
Holloway	502	50	61	65	—	—	USA

*Follow-up time

Table 5: Summary of clinical trials showing postoperative complications resulting from various bariatric surgeries

Authors	*n*	*Postoperative complications (%)*		
		Erosions	*Prolapse*	*Mortality*
Hollyway et al	502	1(2)*	5(28)	0.2(1)
O'Brien and Dixon	1120	3 (34)	25 (first 500)	0
			47 (second 600)	—
Fielding and Allen	335	0	3.6	—
Weiner et al	184	1.1	2.2	0
Vertruyen	543	4.6	1	—
Belachew et al	763	0.9	8	—
Favretti et al	830	0.5	10	—
Cadiere et al	652	0.3	3.8	—
Spivak et al	500	0.2	2.8 (14)	0
Ren et al	445	0.2(1)	3.1 (14)	—
Ren et al	500	<1(1)	2(2)	0

*Number in parentheses represents number of complications in each group

put forward which were reviewed and coendorsed by the American Society for Metabolic and Bariatric Surgery (Tables 10 to 13).

The results clearly indicate that laparoscopic bariatric surgery is a safe and effective weight loss procedure with efficacy and safety established through scientific research. The review also concluded that along with laparoscopic RGB, AGB, BPD +DS, primary LSG has also been proven to be effective.

In 2007, a study on 'Vertical gastrectomy for morbid obesity in 216 patients: Report of two-year results' by Crystine M Lee, Paul T Cirangle and Gregg H Jossart of the Department of Surgery, California Pacific Medical Center, San Francisco, CA, USA was published which concluded that vertical gastrectomy achieves significant weight loss as par with that of RYGB and DS operations while with fewer complications comparable with AGB. The study was conducted in a nonrandomized form on a total number of 846 patients who underwent laparoscopic bariatric surgery of which 216 (173 female) underwent VG (Tables 14 to 16).

By this time LSG has started to become a popular surgery amongst bariatric surgeons due to its efficacy in weight loss and control of comorbidities and reduced rate of

Table 6: Preoperative comorbid conditions in patients who underwent LSG

Condition	*Percentage of population*
Fatty liver disease	100
Sleep apnea	82
Peripheral edema	59
Hypertension	68
Degenerative joint disease	69
Type II diabetes	59
Low back pain	42
Gastroesophageal reflux disease	36
Elevated triglycerides	52
Depression	36
Asthma	25
Coronary artery disease	18

Table 7: Effect of LSG on comorbid conditions

Condition	*Resolved(%)*	*Improved(%)*
Sleep apnea	80	7
Peripheral edema	91	3
Hypertension	78	7
Degenerative joint disease	85	6
Type II diabetes	81	11
Low back pain	44	10
Gastroesophageal reflux disease	70	8
Elevated triglycerides	73	5
Depression	67	9

Table 8: Comorbid conditions in patients who underwent completion RYGB

Condition	*Percentage unresolved*
Sleep apnea	27
Peripheral edema	8
Hypertension	14
Degenerative joint disease	12
Type II diabetes	14
Low back pain	40
Gastroesophageal reflux disease	20
Elevated triglycerides	38
Depression	27

Table 9: Summary of weight, comorbidities and ASA after each stage

	Preoperative	*12 months after stage I*	*6 months after stage II*	*p-value*
Mean weight (kg)	177	131	109	<0.05
BMI	65 ± 9	49 ± 8	39 ± 8	<0.05
Comorbidities	9 ± 3	6 ± 3	2 ± 1	<0.05
ASA ≥ 3	94%	44%	NA	<0.05

Table 10: Percentage excess body weight lost after bariatric surgical procedures

Operation		*Mean follow-up period (years)*							
		1	*2*	*3*	*4*	*5*	*7*	*8*	*10*
BPD ± DS	(%) EBWL	71.8	75.1	76.3	75.5	73.3	69	75.8	77.0
	Aggregate n	896	1,623	410	1,278	174	89	405	122
	No of studies	4	3	4	3	3	1	2	1
RGB (proximal)	(%) EBWL	67.3	67.5	62.5	58.0	58.2	55.0		52.5
	Aggregate n	1627	385	285	509	176	2		194
	No. of studies	7	5	4	4	3	1		2
AGB	(%) EBWL	42	57.2	54.8	54.5	55.2	51.0	59.3[a]	
	Aggregate n	4456	3383	3104	1435	640	29	100	
	No. of studies	11	11	12	9	5	2	1	

BPD ± DS: Biliopancreatic diversion with or without duodenal switch; RGB: Roux-en-Y gastric bypass; AGB: Adjustable gastric banding; [a]42 patients with 8-year follow-up and band not removed

Table 11: Improvement of comorbidities after bariatric surgery

Operation	*Diabetes resolved (%)*	*Hypercholesterolemia improved (%)*	*Hypertension resolved (%)*	*Sleep apnea resolved (%)*
Banding	47.8	71.1	38.4	94.6
RGB	83.8	93.6	75.4	86.6
BPD ± DS	97.9	99.5	81.3	95.2

RGB: Roux-en-Y gastric bypass; BPD ± DS: Biliopancreatic diversion with or without duodenal switch

Table 12: Mortality and morbidity after laparoscopic bariatric surgery

Operation	*30-day mortality (%)*	*Overall complications (%)*	*Major complications (%)*
Lap AGB	0.05-0.4	9	0.2
Lap RGB	0.5-1.1	23	2
Lap BPD	2.5-7.6	25	5

Table 13: Relative risk and benefits of laparoscopic bariatric surgical procedures

	AGB	*RGB*	*BPD*
Objective			
• Least perioperative risk	+++	++	+
• Most effective durable weight loss	+	++	+++
• Best comorbidity resolution	+	++	+++
• Most reversible	+++	+	+
• Best procedure for avoiding reoperation due to			
– Technical complications—early	+++	++	+
– Technical complications—late	+	++	+++
– Metabolic complications—late	+++	++	+
• Least chance of inadequate weight loss	+	++	+++
Subjective			
• Fewest outpatient visits needed	+	+++	++
• Fewest unintended metabolic consequences of poor follow-up	+++	++	+
• Durable weight loss despite poor patient compliance	+	++	+++

Relative scale: +++ > ++ > +

Table 14: Preoperative variables for patients undergoing various laparoscopic bariatric surgeries

	VG (n = 216)	*Band (n = 271)*	*RGG (n = 303)*	*DS (n = 56)*	*p-value*
Age (y)	43 ± 11	42 ± 12	43 ± 19	42 ± 8	NS
Male (%)	43 (20%)[†]	34 (13%)	46 (14%)	7 (9%)	<0.05 *vs* band, DS[†]
Preop weight (lbs)	302 ± 77[†]	257 ± 42*	281 ± 47	288 ± 49	<0.01 *vs* band, RGB[†]; <0.01 *vs* RGB, DS*
Preop BMI (kg/m^2)	49 ± 11[†]	42 ± 5*	46 ± 6	47 ± 6	<0.01 *vs* band, RGB[†]; <0.01 *vs* RGB, DS*
OR time (min)	90 ± 30[†]	89 ± 25*	140 ± 37	226 ± 45	<0.01 *vs* RGB, DS[†]; <0.01 *vs* RGB, DS*
EBL (ml)	35 ± 19[†]	29 ± 18[†]	53 ± 44[†]	89 ± 47[†]	<0.01 *vs* all other groups[†]
Length of stay (d)	1.9 ± 1.2[†]	1.2 ± 0.7*	2.8 ± 1.4	3.2 ± 2.0	<0.01 *vs* all[†]; <0.01 *vs* RGB, DS*

Table 15: Postoperative parameters in patients who underwent various laparoscopic bariatric surgeries

	VG (n = 216)	*Band (n = 271)*	*RGG (n = 303)*	*DS (n = 56)*	*p-value*
Preop weight (lbs)	302 ± 77†	257 ± 42*	281 ± 47	288 ± 49	<0.01 *vs* band, RGB†; <0.01 *vs* RGB, DS*
1 year weight (lbs)	242 ± 64†	194 ± 33*	174 ± 36	165 ± 29	<0.0 *vs* all†; <0.01 *vs* RGB, DS*
Preop BMI (kg/m^2)	49 ± 11†	42 ± 5*	46 ± 6	47 ± 6	<0.01 *vs* Band, RGB†; <0.01 *vs* RGB, DS*
1 (year) BMI (kg/m^2)	37 ± 9†	32 ± 5*	28 ± 5	27 ± 4	<0.01 *vs* all†; <0.01 *vs* RGB, DS*
1 (year) EWL (%)	59 ± 17†	47 ± 20*	75 ± 16	79 ± 12	<0.05 *vs* all†; <0.01 *vs* RGB, DS*
1 (year) weight lost (lbs)	129 ± 51†	58 ± 27*	110 ± 37	120 ± 24	<0.01 *vs* band, RGB†; <0.01 *vs* RGB, DS*

Table 16: Postoperative complications in patients who underwent various laparoscopic bariatric surgeries

	VG (n = 216)	*Band (n = 271)*	*RGG (n = 303)*	*DS (n = 56)*	*p-value*
Nonoperative readmissions (%)	5 (2.3%)	4 (1.5%)†	12 (7.1%)	4 (7.1%)	<0.05 *vs* DS†
Reoperations (%)	6 (2.8%)†	13 (4.8%)‡	26 (8.6%)	18 (32.1%)	<0.03 *vs* RGB, DS†; <0.01 *vs* all*
Deaths (%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	NS
Major complications (%)	10 (4.6%)†	13 (4.8%)‡	32 (10.6%)	22 (39.3%)*	<0.03 *vs* RGB, DS†; <0.03 *vs* RGB, DS†; <0.01 *vs* all*
Total complication (%)	16 (7.4%)	18 (6.6%)†	69 (22.8%)	27 (48.2%)	<0.03 *vs* RGB, DS†; <0.03 *vs* RGB, DS†; <0.01 *vs* all*

complications. But there was lack of standardization of the procedure especially with regard to technique, volume of gastric tube and oversewing of gastric serosa over the staple line to prevent bleeding and leak.

In 2008, in an article 'Laparoscopic sleeve gastrectomy: Standardized technique of a potential standalone bariatric procedure in morbidly obese patients' by Markus A Kueper, Klaus M Kramer, Andreas Kirschniak, Alfred Königsrainer, Rudolph Pointner and Frank A Granderath of the Department of General, Visceral and Transplant Surgery, University Hospital Tuebingen, Tuebingen, Germany, an attempt was made in proposing a standardized form of LSG so that it could be compared with other procedures like malabsorptive procedures and AGB which already have standardized format.

The surgical technique proposed by the article is given below:

The patient is positioned in a modified antitrendelenburg position with the right arm away from the body. The abdomen is prepared and draped in the customary fashion. Five 12 mm trocars (Ethicon endosurgery, Norderstedt, Germany) are placed as shown in Figure 11. After exploration of the abdomen and the anterior wall of the stomach, the liver is retracted via trocar No. 5. We then start the dissection of the short gastric vessels to the point of the angle of His using the UltraCision harmonic scalpel (Ethicon endosurgery). The greater omentum is then separated from the greater curvature under protection of the gastroepiploic arcade. The endpoint of the preparation is about 7 to 8 cm prepyloric. A 34-Fr tube is then positioned along the minor gastric curvature as the leading structure for the stapling line to follow. The greater curvature is then stapled strictly along the stomach tube using a 60 mm Endo-GIA (Ethicon endosurgery). The starting point is 7 to 8 cm prepyloric to the point of the angle of His. Typically, four to five staple lines are needed. The dissected part of the stomach is withdrawn from the abdomen at trocar No 3 and the staple line will be overstitched by simple sutures. This is done not to prevent insufficiency in the staple line but rather to prevent staple line bleeding. It is possible to overstitch only areas of bleeding between the staples, not the whole staple line.

The analysis of operative data and early outcome showed that the results of LSG were comparable to that of LAGB (Figs 12A to C) which has the least complication rate (Table 17).

In 2011, Mathieu D'Hondt, Sofie Vanneste, Hans Pottel, Dirk Devriendt, Frank Van Rooy and Franky Vansteenkiste of the Department of Digestive Surgery, Groeninge

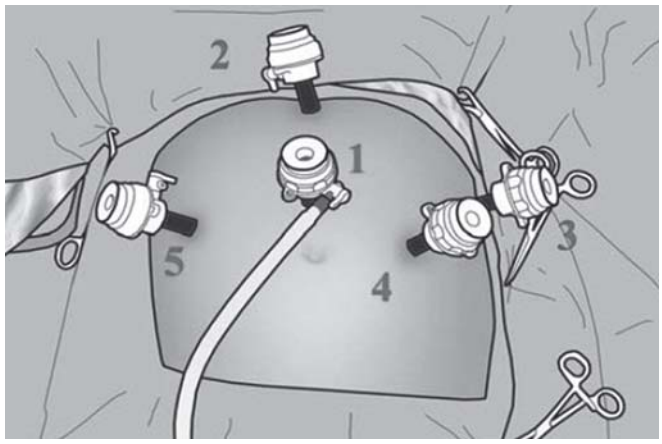
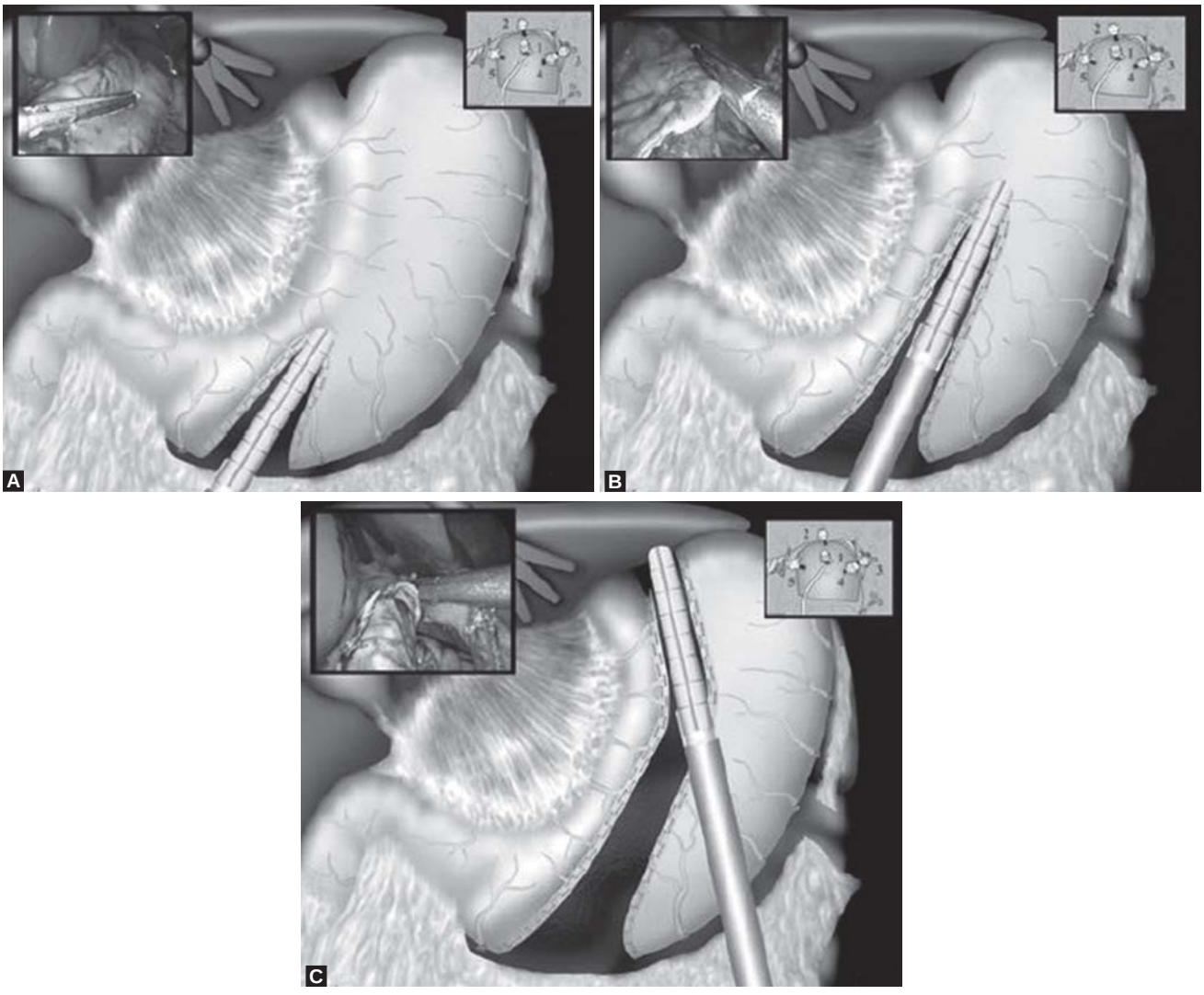


Fig. 11: Trocar position for LSG



Figs 12A to C: Technique of LSG

Hospital, President Kennedylaan 4, 8500 Kortrijk, Belgium published a study 'Laparoscopic sleeve gastrectomy as a single-stage procedure for the treatment of morbid obesity and the resulting quality of life, resolution of comorbidities, food tolerance, and 6-year weight loss' (Tables 18 to 20), which evaluated long-term weight loss, resolution of comorbidities, quality of life (QoL) and food tolerance after LSG (Fig. 13). A retrospective review of a prospectively collected database was performed on 102 patients who underwent LSG as a sole bariatric procedure during the period January 2003 to July 2008.

The study concluded that LSG is a safe and effective bariatric procedure, although a tendency for weight regain is noted after 5 years of follow-up evaluation. Resolution of comorbidity is comparable with that reported in the literature. The LSG procedure results in good to excellent health-related QoL. Food tolerance is lower for patients after LSG than for nonobese patients who had no surgery (Figs 14 and 15), but 95.2% described food tolerance as acceptable to excellent.

DISCUSSION

Bariatric surgery is the cornerstone of the treatment of morbid obesity. Various procedures have been developed which can be classified mainly into restrictive, malabsorptive, combined restrictive and malabsorptive and electrical procedures for gastric stimulation. The restrictive procedures have fewer complications with lesser excess weight loss whereas malabsorptive procedures have greater excess weight loss at the risk of increased complications. Thus, we can see that the complexity of the surgical techniques and the potential surgical and metabolic complications of the various procedures are inversely related to the anticipated course of weight loss. Due to these reasons, a procedure like sleeve gastrectomy which apparently can be performed easily and has a favorable risk-benefit ratio would appear to have arrived at the right moment. The renaissance and the enormously rapid and widespread application of this method as a single-step procedure, is quite understandable.[70]

Table 17: Comparison of operative data and early outcome between LSG and LAGB

	LAGB	*LSG*	*p-value*
Sex (M/F)	7/9	7/9	
Age (years), mean and range	43.9 (27-62)	42.8 (24-68)	0.79
BMI (kg/m^2), median and range	44.9 (41-65)	49.1 (43-68)	0.22
Operating time (min), mean and range	106 (60-210)	115 (55-180)	0.43
EWL (kg), mean and range	24.4 (8-47)	24.1 (9-34)	0.93
EWL (%), mean and range	39.1 (13-81)	33.0 (11-49)	0.30
Hospital stay (d), median and range	5.5 (3-19)	9.0 (7-52)	0.08

Table 18: Weight loss at different follow-up points after LSG

Follow-up period (months)	*Patients (n)*	*Mean EWL (%)*	*SD*	*Patients with EWL >50% (%)*
12	83	81.51	24.27	92.9
24	62	75.00	17.82	89.5
36	44	83.75	32.89	87.0
48	33	72.88	22.60	85.7
60	27	71.30	29.59	64.3
72	23	55.91	25.55	54.5

Table 19: Improvement of medical comorbidities after LSG

Aggravated	*Unchanged*	*Improved*	*1 major comorbidity resolved, others improved*	*All major comorbidities resolved, others improved*
4	19	8	31	21

Table 20: Resolution or improvement of comorbidities after LSG

Comorbidity	*Improved (no of patients)*	*Period (months[a])*	*Resolved (patients: n)*	*Period (months[a])*	*Improved/resolved [patients: n(%)]*
T2DM	1/10	3	4/10	4 (2-6)	5/10 (50)
HT	2/22	4(3-5)	18/22	5 (2-12)	20/22 (90.9)
OSA	–	–	7/7	12 (2-12)	7/7 (100)
DL	3/36	9(7-16)	25/36	8 (2-11)	28/36 (77.7)

T2DM: Type 2 diabetes mellitus; HT: Arterial hypertension; OSA: Obstructive sleep apnea; DL: Dyslipidemia; [a]Expressed as median (range)

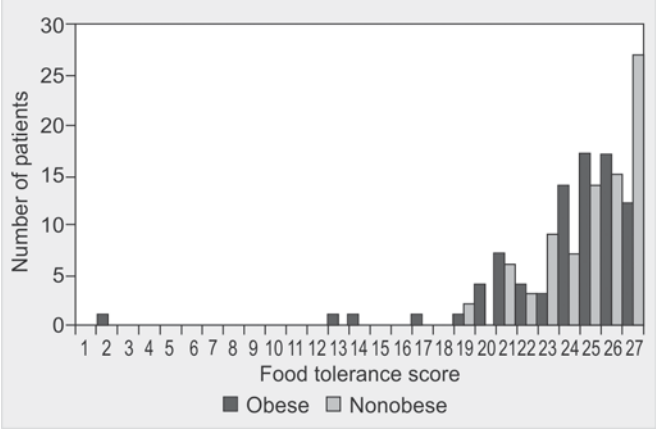


Fig. 13: Comparison of food tolerance of 83 patients after LSG with 83 nonobese nonsurgical patients

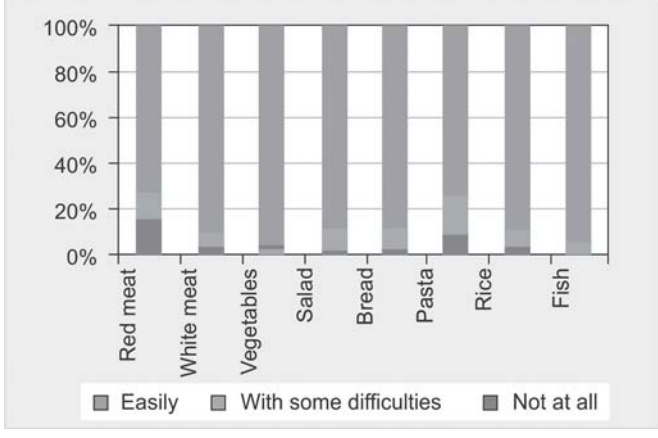


Fig. 14: Tolerance for different types of food

Introduced as a stepwise mode of treatment, the procedure reduced the previously high mortality rates in high-risk patients (>6% with a BMI >60 kg/m^2). As single-step procedure, it was convincing because of its low complication (about 9%) and mortality rates (<1%) as well as its low rate of gastrointestinal long-term side effects.[71-73] In trials, sleeve gastrectomy was found to achieve a mean excess weight loss of 33 to 83%, 1 year after surgery.[74] Despite this wide range, it may be assumed that even in the midterm, the procedure is associated with a similar marked

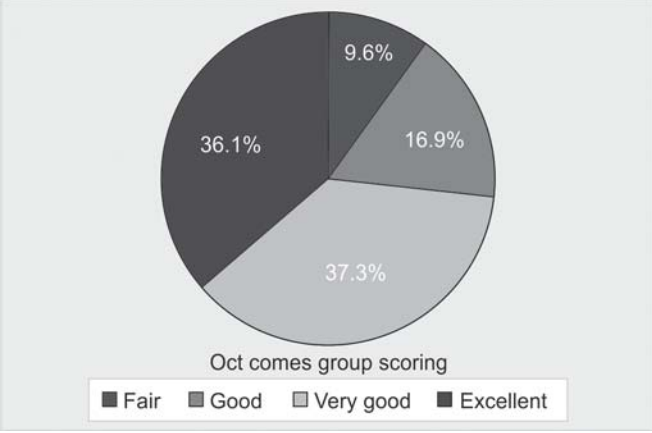


Fig. 15: BAROS score at median follow-up point of 49 months

reduction of weight as the usual procedures while reducing obesity-associated concomitant diseases.[75,76] If additional weight reduction is required subsequently, the procedure can be performed in a two-step manner with a malabsorptive component (gastric bypass or biliopancreatic diversion), either in a combined manner or a repeat sleeve gastrectomy can be conducted.[77,78]

However, sleeve gastrectomy is also not the ideal solution. We should consider the fact that longitudinal gastric resection on the side of the greater curvature is an irreversible step and is associated with placement of a long row of stapler sutures along a gastric wall of varied structure.[74,79] The most frequent surgical complications of the procedure are leaks (about 0.9%), strictures (about 0.7%) and postoperative bleeding (about 0.4%). Revision rates are reported to be around 4%.[71,72] In addition to intraoperative inspection of the sutures, for instance by endoscopy or the use of methylene blue, several authors recommend oversewing the row of clip sutures or the use of clip reinforcement.[83,84,80] However, procedures of suture reinforcement or oversewing are controversially discussed. Some authors express apprehensions about suture weakening, do not necessarily attribute the reduction of insufficiency rates to suture reinforcement or warn against strictures due to oversewing.[79,81] Other authors recommend laparoscopic greater curvature plication in order to avoid gastric resection and associated complications.[82]

Although, a growing number of studies have been focused on the use of sleeve gastrectomy as a single-step procedure and report convincing results, adequate evaluable long-term results (>5 years) are not yet available.[83,73,85] Moreover, sleeve gastrectomy is not performed in a standardized manner. Various tube diameters and calibration probes (32-60 French) are used.[70,86] Besides, the extent of resection, especially of the antrum varies.[84,87] Intraoperative measurement of the volume of the resected stomach is of great importance. A removed volume <500 cm^3 is apparently associated with an early weight regain.[84] Thus, the results of various workgroups must be compared with caution. The experience of the surgeon also is a substantial factor influencing the outcome of the procedure at present.

Bariatric surgery is a domain of complex interventions in high-risk patients. An ideal procedure does not exist and the key to successful treatment lies in a careful assessment of the individual risk jointly by the surgeon and the patient, as well as in providing intensive care and information before the operation and particularly in the long-term after a bariatric operation.[88] Eating habits, baseline weight, the anticipated weight loss, comorbidities, gender, age and compliance are some of the numerous factors that must be taken into account.[89] A team experienced in handling a wide spectrum of bariatric operations with confidence is indispensable to perform successful obesity surgery with sustained enhancement of QoL and life expectancy.[90]

LSG should not be viewed as a universal procedure. It is definitely a good treatment option as the excess weight loss is comparable to that of malabsorption procedures and has the advantage of lower rate of complications similar to that of restrictive procedures. However, it should be performed in a more standardized manner and with due regard to future long-term results.

CONCLUSION

LSG is a safe and effective weight loss procedure. Resolution of comorbidity, health-related QoL and food tolerance were comparable with that of RGB with lower incidence of complications comparable to gastric banding. However, there is need for standardization of the procedure and long-term results are yet to be analyzed.

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