Laparoscopic adjustable gastric banding in the treatment of obesity: A systematic literature review

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Background. *We attempted to compare the safety and efficacy of laparoscopic adjustable gastric banding with vertical-banded gastroplasty and gastric bypass. Morbid obesity presents a serious health issue for Western countries, with a rising incidence and a strong association with increased mortality and serious comorbidities, such as diabetes, hyperlipidemia, and cardiovascular disease. Unfortunately, conservative treatment options have proven ineffective. Surgical interventions, such as vertical-banded gastroplasty (stomach stapling), Roux-en-Y gastric bypass, and, more recently, laparoscopic gastric banding have been developed with the aim of providing a laparoscopically placed device that is safe and effective in generating substantial weight loss.*

Methods. *Electronic databases were systematically searched for references relating to obesity surgery by (1) laparoscopic adjustable gastric banding (LAGB), (2) vertical banded gastroplasty (VBG), and (3) Roux-en-Y gastric bypass (RYGB).*

Results. *Only 6 studies reported comparative results for laparoscopic gastric banding and other surgical procedures. One study reported comparative results for all 3 surgical procedures, and this study was only of moderate quality. In total, 64 studies were found that reported results for LAGB and 57 studies reported results on the comparative procedures. LAGB was associated with a mean short-term mortality rate of approximately 0.05% and an overall median morbidity rate of approximately 11.3%, compared with 0.50% and 23.6% for RYGB, and 0.31% and 25.7% for VBG. Overall, all 3 procedures produced considerable weight loss in patients up to 4 years in the case of LAGB (the maximum follow-up available at the time of the review), and more than 10 years in the case of the comparator procedures.*

Conclusions. *The Australian Safety and Efficacy Register of New Interventional Procedures-Surgical Review Group concluded that the evidence base was of average quality up to 4 years for LAGB. Laparoscopic gastric banding is safer than VBG and RYGB, in terms of short-term mortality rates. LAGB is effective, at least up to 4 years, as are the comparator procedures. Up to 2 years, LAGB results in less weight loss than RYGB; from 2 to 4 years there is no significant difference between LAGB and RYGB, but the quality of data is only moderate. The long-term efficacy of LAGB remains unproven, and evaluation by randomized controlled trials is recommended to define its merits relative to the comparator procedures. (Surgery 2004;135:326-51.)*

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THE INCREASING WEIGHT OF AUSTRALIANS over the past 40 years represents one of the greatest challenges confronting social scientists and health administrators in this country.[1] This increase in weight reflects the trend in the Western world generally and has been attributed to an abundance of food combined with a disposition toward less physical activity in the course of our daily existence.[2] Diminished physical activity stems not only from changing employment patterns, but also from the many aids available to the average householder, the ubiquitous motor car, and trends in the design of our buildings and cities.[3]

In many instances a modest degree of excess weight is simply a cosmetic issue and is associated

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with few adverse medical consequences. However morbid obesity (body mass index: [BMI] >35 $kg.m^{-2}$) is associated with a range of adverse health effects, including insulin-resistant diabetes mellitus, hypertension, dyslipidemia, osteoarthritis, and increased risk of cardiovascular disease.[4] These effects are particularly evident in men with increased intra-abdominal accumulation of fat.[5] Nevertheless, morbid obesity in women is also associated with excess mortality from cardiovascular disease, with a relative risk of 4.1 among nonsmokers demonstrated by the Nurses' Health Study in the United States.[6] In addition to these physical effects, there are significant psychosocial manifestations including depression, poor self-esteem, sexual dysfunction, and unemployment.[7]

Various strategies have been used to control obesity. These include dietary advice, behavior therapy, and pharmacologic intervention. There is no doubt that caloric intake is important. When calorie intake is reduced below expenditure, there is a predictable rate of weight loss related to the energy deficit.[8] Furthermore, this weight loss is largely independent of the dietary composition despite wide variations in protein, carbohydrate, and total fat intake.[8] Unfortunately, weight loss for an individual patient is more difficult to predict. In a study by Garrow,[9] the variation in weight loss of women hospitalized for 3 weeks on a metabolic ward while eating an 800 kcal/day diet (3.4 megajoule [MJ]/day diet) varied from 1 kg to more than 10 kg. Maintaining weight after a successful diet is also problematic. Stunkard[10] demonstrated that the nadir of weight is achieved at the 4-month point on a very low calorie diet, and after this, weight tended to increase. This tendency is improved (but not abolished) by the addition of behavior modification therapy. Ultimately each of these conservative strategies is associated with only a very modest degree of temporary weight reduction.[10] Better understanding of the metabolic controls of body fat is likely to result in improved interventions in the future.[11] However, at present, surgery remains the only effective option for the management of morbid obesity.[12]

The current surgical options can be broadly classified as gastric restrictive, malabsorptive procedures, or a combination of these two.[12] Jejunoileal bypass is the archetype malabsorptive procedure but has been largely abandoned because of profound adverse metabolic consequences that include renal calculi, vitamin deficiency, hypokalemia, hepatic dysfunction, and osteoporosis.[13] Combined restrictive/malabsorptive procedures result in the greatest sustained weight loss but are also the most technically demanding, constitute the greatest assault upon the patient, and are associated with the most profound rearrangement of the normal gastrointestinal anatomy. Virtually all weight control operations have been applied with a laparoscopic approach, but the complexity of some of these procedures is daunting, and the anatomic alterations are identical to the open surgery. With the development of restrictive bands that can be placed around the upper stomach to partition a small proximal pouch, surgeons and patients alike have embraced what is perceived to be a minimally invasive intervention. Initially nonadjustable and designed for open placement, refinement of these devices has resulted in an adjustable appliance that can be placed laparoscopically. The major benefits are considered to be minimally invasive placement, adjustability, and preservation of normal gastrointestinal integrity.

A typical laparoscopic adjustable gastric banding (LAGB) procedure might proceed thus:[14] after establishment of pneumoperitoneum and insertion of the trocars, dissection begins at the greater curvature of the stomach by opening the peritoneal reflection from the fundus to the diaphragm. The position for the band may be determined by using a calibration tube inserted into the stomach by the anesthetist. The balloon on the end of the tube is filled with 15 ml of saline and is drawn up against the gastroesophageal junction. The initial dissection point is at the equator of the balloon to make a small pouch above the band and to keep the band above the peritoneal reflection of the lesser sac (although some procedures actually penetrate the lesser sac). A tunnel is then made through the retrogastric attachments, starting from the lesser curvature dissection. A long atraumatic instrument is passed through this tunnel. The band is introduced, attached to the end of this instrument, which is then drawn back through the tunnel. The band is positioned using the same calibration tube as previously, and is then closed. The anterior and lateral surfaces of the stomach are then sutured over the band to prevent band migration (any tunnel through the retrogastric attachments also assists in this process). To avoid any vomiting in the initial postoperative period, most surgeons currently defer band adjustment until the first review visit. If the stoma is too wide, then weight loss will be impaired, but if it is too tight, there is the risk of postoperative food intolerance. The injection reservoir, which will allow adjustments of the band, is filled with saline and attached by tubing to the band. It is then implanted on the anterior rectus sheath and fixed with sutures.

METHOD AND MATERIALS

Australian safety and efficacy register of new interventional procedures-surgical (ASERNIP-S) review process. A surgeon familiar with the topic of review (protocol surgeon) and an ASERNIP-S researcher worked together to draft the protocol for the systematic review and determined the studies to be included. The ASERNIP-S researcher assessed these publications and produced a systematic review, which was critiqued by the review group. The review group comprised 3 surgeons familiar with obesity surgery (the advisory, protocol, and invited surgeons), a nominated surgeon from the upper GI section of the Royal Australasian College of Surgeons (RACS), a surgeon from another specialty, and an ASERNIP-S researcher. The review group considered the review documentation, recommendations, and ASERNIP-S classifications put forward by the ASERNIP-S researcher. Once consensus was reached on the recommendations and classifications, they were presented to the ASERNIP-S management committee and, subsequently, to the RACS council for ratification.

Search strategy. Original published studies on LAGB, vertical banded gastroplasty (VBG), and Roux-en-Y gastric bypass (RYGB) were identified by searching Medline between 1988 and August Week 3 2001, Current Contents between 1993 and Week 35 2001, Embase between 1988 and Week 34 2001, HealthStar between 1988 and June 2001, and The Cochrane Library 2001 Issue 2. The following search terms were used:

(laparoscopic and [gastric banding] or LAGB or Swedish adjustable gastric band [SAGB] or [Lap-band®] or [adjustable band] and obesity)

OR

([gastric bypass] or [vertical banded] or [VBG] and [obesity])

Only full, peer-reviewed articles were included because abstracts did not provide adequate detail on patient selection, allocation, study design, outcome, and measurement methods to allow an accurate, unbiased assessment and comparison of the study results.

Inclusion criteria. Papers were selected for inclusion if they were in English and were randomized controlled trials, controlled clinical trials, or case series. In the case of VBG, where the volume of literature was very large, case series data were only considered if they represented multicenter trials, or if the patient follow-up exceeded 5 years, and/or if the total number of patients exceeded 500. Only human studies were included, and only if the patients were considered to be morbidly obese (eg, with a BMI >35 kg.m^{-2}). For technical reasons, papers were excluded if they confounded outcomes for either the new or comparative interventions with other obesity controlling procedures such as nonadjustable gastric banding. Papers were included if they provided information on at least one of the following outcomes: weight loss, complications, psychosocial effects, change in comorbidity rates, mortality rates, or cost effectiveness.

Data extraction. The protocol surgeon and ASERNIP-S researcher assessed articles for suitability using the inclusion criteria. Unsuitable and duplicate studies were deleted from the literature database.

Data analysis. All relevant studies were assessed as to their level of evidence.[15] The studies were tabulated and methodologically evaluated, including appropriateness of study exclusion criteria, quality of reporting, and possible confounding variables. All data and results of statistical tests were extracted from the papers. When the extracted comparative data contained sufficient detail, additional statistical tests were performed. No meta-analyses were performed.

For particular outcomes of interest, papers were only included in the analysis if they specifically reported on the item of interest, and no assumptions were made from the presence of missing data. For example, with complication rates, papers that did not report a complication rate were not assumed to have reported a zero rate of complications, but were treated as if the data were missing, and were thus excluded from morbidity analyses.

RESULTS

After exclusions, the literature search resulted in 64 laparoscopic gastric banding studies being retrieved, and 57 additional studies reported on VBG, RYGB, or both of these procedures. The principal problem with the studies is the lack of comparative data for LAGB versus alternative surgical methods. There are moderate or even good data for comparing VBG with RYGB, but the necessary types of studies have not been performed for LAGB.

Other faults of many studies included lack of prospectivity and an almost overwhelming misuse or complete underreporting of measures of variance, principally by reporting population or outcome means with ranges but without standard deviations or standard errors. Occasionally papers reported medians with standard deviations.[16] These types of errors degrade the quality of the aggregated data. Other faults include presenting

Table I. Mortality rates

Operation	*N*	*Short-term deaths*	*Long-term deaths*	*Total*
LAGB	5780	3 (0.05% [95% CI - 0.01–0.11])	10 (0.17%)	13 (0.22%)
RYGB	9258	46 (0.50% [95% CI 0.36–0.64])	45 (0.49%)	91 (0.98%)
VBG	2858	9 (0.31% [95% CI 0.11–0.52])	13 (0.45%)	22 (0.77%)

weight loss (or other) data in graphical form without precisely detailing point values or including any precise measure of variance. Even though it is easy to take in at a glance and superficially informative, this method of data presentation made it difficult to extract precise outcomes from the relevant studies. Some studies inappropriately aggregated outcome data for different procedures, such as nonadjustable gastric bands or gastroplasty combined with laparoscopic gastric banding procedures. A small number either violated the "intent to treat" principle by excluding converted subjects from outcomes reporting, or made explicit errors in reporting population or outcome data. Another possible confounding variable was the inclusion in certain cases of other procedures along with the gastric surgery, such as simultaneous cholecystectomy or treatment of hiatal hernia.

Only 5[17-21] comparative studies used contemporaneous controls comparing outcomes for LAGB with some other procedure. Only 1 of these randomized patients,[17] and 1 included an obsolete comparative procedure,[18] whereas another included a non-obesity comparative procedure that was not of interest to this study.[20] The other studies that used contemporaneous controls compared alternative obesity procedures with one another. None of these studies included blinding for the operative procedures, although this is unremarkable considering the nature of the techniques used.

The single level II LAGB study[17] was limited by small patient numbers (n = 60), and the 2 groups were treated differently with regard to costs, with gastroplasty being performed free but not gastric-banding. It is certainly unclear what, if any, effect this may have had on patient outcomes. This study also reported zero rates of complications, yet noted that an unspecified number of patients suffered from continuous vomiting. There remains the possibility that rates of certain minor complications may not have been reported.

One of the 4 level III-2 LAGB studies enrolled only very small numbers of patients into the LAGB group (n = 11).[18] As it only included those patients who had an uninterrupted 3-year follow-up, bias may have been introduced because those patients who were not followed up may have possessed very different characteristics from those who remained within the study. In particular, there is the concern that they may have been less satisfied with the outcome of the surgery. Only 65 of 300 non-adjustable and 11 of 25 adjustable gastric banding patients were followed up for 3 years. The study gave no reasons for why all patients were not included; it may be that they did not meet the 3-year follow-up criterion (in which case all relevant patients were included), or it may be that large numbers could not be contacted or refused to participate in the study. The authors reported performing statistical tests, but these were not specified, nor were probability values reported.

The only study that reported on all 3 of the comparator procedures of interest to this review used patient matching, rather than randomization, in addition to being prospective and conducted across 2 centers.[19] Additionally it performed statistical tests on its results. Unfortunately, it drew on a relatively small number of patients (n = 30 in each group), and although all the RYGB and VBG operations were performed by 1 surgeon, the LAGB procedures were performed by another, which may be a source of bias. It also failed to report any safety data.

One level III-2 LAGB study enrolled a large number of patients (n = 165).[21] Statistical tests were performed on some of the data, but this was not done on weight loss information (although comparative weight loss outcome was not a principal aim of the study). Safety data were not reported at all. Also, the statistical tests used were not specified.

There were 11 level III-3 LAGB studies.[22-32] Generally these studies were reports of surgeons' experience with laparoscopic adjustable gastric banding compared with their earlier experience with one or more alternative procedures; patients in the earlier series were treated as historical controls. Also, 2 studies were earlier and later reports of the same series,[27,28] with the later paper adding more patients to the experimental (lap-banding) group. Only data from the later of these 2 studies are referred to in this section, except where unique elements were reported in the earlier study.

Several of the studies suffered from additional faults or biases. One compared psychological outcomes in patients undergoing either laparoscopic

Table II. Overall morbidity rates by procedure: LAGB

Study	*Lap-band®*		*Swedish band*		*Both bands*	
	%	N	%	n	%	n
De Witt et al[114]	68.0	17/25				
Morino et al[54]	60.0	9/15				
Schlumpf et al[56]	50.0	7/14				
Berrevoet et al[22]	48.3	14/29				
*Belachew et al[14]	40.0	36/90				
Forestieri et al[51]	40.0	4/10				
Silva et al[110]	27.8	5/18				
Abu-Abeid et al[42]	27.8	5/18				
De Jonge et al[48]	27.5	25/91				
Suter et al[115]	24.7	37/150				
Holeczy et al[116]	20.0	5/25				
Doldi et al[50]	16.5	18/109				
Berrevoet et al[22]	16.0	8/50				
Bakr et al[45]	15.4	6/39				
Niville et al[28]	15.0	6/40				
O'Brien et al[94]	14.6	44/302				
Weiner et al[38]	13.0	24/184				
Angrisani et al[44]	11.3	143/1265				
Nehoda et al[20]	11.3	9/80				
Niville et al[28]	9.2	12/131				
Abu & Szold[117]	8.3	79/950				
Dargent et al[47]	8.2	41/500				
Paganelli et al[118]	7.7	12/156				
De Luca et al[49]	7.7	4/52				
Cadiere et al[46]	7.2	47/652				
Fielding et al[16]	7.2	24/335				
Gambinotti et al[52]	6.8	11/162				
Busetto et al[23]	6.7	2/30				
Rubin et al[119]	6.4	7/109				
Toppino et al[31]	5.8	18/311				
Favretti et al[35]	5.4	14/260				
Furbetta et al[120]	4.0	8/201				
*Belachew et al[14]	3.8	10/260				
Ashy et al[17]	0	0/30				
†Fried et al[18]			36.4	4/11		
Victorzon[121]			18.3	11/60		
Berrevoet et al[22]			12.2	5/41		
Hauri et al[122]			12.1	25/207		
Hallerbäck et al[123]			8.8	5/57		
†Fried et al[26]			6.6	1/15		
Catona et al[124]			4.7	4/85		
Taskin et al[125]			4.0	2/50		
Nowara et al[55]					13.0	14/108
Miller & Hell[53]					8.3	13/156
Median	11.3		10.5		10.7	

*May be an underestimate; 2 early complications could not be placed by procedure.
†Same series, but first listed is a later report with patients restricted to those available after 3-year follow-up (from a total sample of unknown size with unknown numbers of patients added to the second listed series). The first listed was excluded from total.

gastric banding or Roux-en-Y bypass, but admitted that gastric banding patients tended to be of higher socioeconomic status than the others, as only they could afford the Lap-band®.[24] Also, whereas few of these studies had large numbers of patients enrolled in their LAGB groups, patient populations ranged to as low as 15 individuals.[26]

The remainder of the studies included in this review were level IV evidence. A number of studies appeared to report on the same series, although at differing time periods: 4 studies by Chelala et al[33] and Favretti et al,[34-36] and 4 studies by Weiner et al.[37-40]

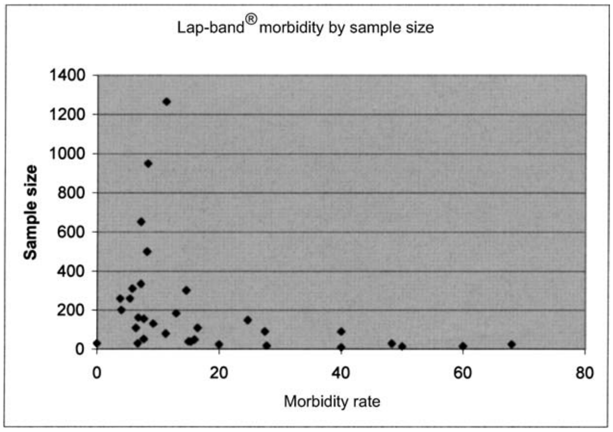
A problematic issue relates to sample size and learning curves. The great majority of the LAGB studies are reports dating from surgeons' initial experience with the laparoscopic gastric band and thus incorporate learning curve data, which would be expected to have a greater impact on morbidity rates in smaller, rather than larger, series. This makes aggregation of data from case series particularly difficult. On the positive side, many of the studies used very similar inclusion criteria for their patients, typically recruiting only persons with a BMI ≥ 35 kg.m^{-2}, who had no overt psychologic problems, endocrine disease, or drug or alcohol addictions, who were adults, and for whom conservative treatment of their obesity had failed. Thus, there is a certain homogeneity to the patient pool.

Safety. In this section such data as mortality, overall morbidity, and specific morbidity rates were considered. As vomiting and food intolerance are frequent sequelae to gastric restrictive procedures, these complications were dealt with separately from other specific morbidities that were less common.

Mortality. Many studies did not explicitly report mortality rates, and when it was not perfectly obvious from other reported results that zero mortality was experienced, these studies were judged as providing no mortality data. Generally, when studies did explicitly report mortality data, this was usually of perioperative mortality.

The single study with contemporaneous controls that reported mortality data for LAGB and VBG found a 0% rate in both groups of patients[17] (see Table I for overall results for mortality rates). Note that follow-up was generally longer for the comparative procedures (up to 14 years), which would tend to inflate the death rate when compared to LAGB (up to 4 years' follow-up). Many of the long-term deaths reported here are also possibly unrelated to bariatric surgery.

Because of the considerable variation in long-term follow-up times between the different procedures and the dubious relationship of some of these events to the obesity surgery, a comparison of the relative long-term risks would seem inadvisable. Hence no confidence intervals were calculated for these statistics. On the other hand, the confidence intervals for the short-term risk of death indicates that LAGB is associated with a decrease in operative risk,[14,16,20,28,30,31,33,35,38,40-56] at least when compared to RYGB.[57-83] The relative risks for short-term deaths from LAGB versus VBG[30,31,58-62,64,65,84-92]



Graph 1. Lap-band® morbidity by sample size.

(0.16 [95% CI 0.04-0.61]) and RYGB (0.10 [95% CI 0.03-0.33]) were also significantly in favor of the LAGB at $P = .0001$ and $P = .007$, respectively.

Morbidity. In this section, overall and specific morbidity rates for laparoscopic adjustable gastric banding are discussed. Rates of food intolerance and vomiting are discussed separately; some authors apparently did not consider this rather common side effect of bariatric surgery to be reportable, whereas others did. Thus, the overall rates from one series would be suspect when compared with rates from other series if this type of complication was reported along with the others. Also, for those studies that did report vomiting and food intolerance, which appear to be relatively common sequelae of surgical control of obesity, the high rates sustained by the patient pool might tend to swamp the incidence of other less common and dangerous morbidities.

Overall morbidity. Overall morbidity rates for LAGB varied widely, ranging from 68% down to 0% (Table II). The source of this variation can only be speculated on: it might reflect varying sensitivities of different authors to what constitutes a reportable complication, or it might reflect a broad variability in surgical technique or experience. The larger series of patients were all associated with relatively low morbidity rates, whereas the higher morbidity rates were found in smaller series (Graph 1). Few studies reported overall morbidity rates above 20%.

Only 2 LAGB studies with contemporaneous controls reported morbidity rates, and neither performed statistical comparisons between LAGB and the comparator. The single randomized controlled trial found zero morbidities in both the LAGB and VBG groups,[17] and the single nonrandomized comparative study reported an

Table III. Overall morbidity rates by procedure: VBG and RYGB (and LAGB comparative)

		VBG		*RYGB*		*LAGB*	
Study	*Level*	%	*n*	%	*n*	%	*n*
Ashy & Merdad[17]	II	0	0/30			0	0/30
Hall et al[58]	II	11.3	12/106	19.2	19/99		
MacLean et al[60]	II	42.6	23/54	36.5	19/52		
Sugerman et al[61]	II	10.0	2/20	30.0	6/20		
VBG v RYGB Total		20.6	37/180	25.7	44/171		
Capella & Capella[62]	III-2	9.1	30/328	14.8	83/560		
Cariani et al[126]	III-2	5.7	39/680	20.0	5/25		
Fox et al[100]	III-2	40.0	30/75	61.4	35/57		
Kalfarentzos et al[64]	III-2	22.9	8/35	29.1	16/55		
Suter et al[93]	III-2	80.7	159/197				
Van Gemert et al[101]	III-2	30.2	35/116	0	0/20		
Toppino et al[31]	III-3	5.9	7/119			2.6	8/311
Choi et al[102]	III-3	23.5	4/17	25.0	3/12		
Fried et al[26]	III-3	46.2	24/52			6.6	1/15
Brolin et al[57]	IV			20.0	9/45		
Fobi et al[127]	IV			50.0	25/50*		
Freeman et al[63]	IV			44.6	54/121		
Nguyen et al[66]	IV			32.9	23/70		
Urbain et al[84]	IV	50.5	56/111				
		32.1†	251/782				
Alper et al[85]	IV	71.0	213/300				
Balsiger et al(a)[68]	IV			38.2	73/191		
Balsiger et al(b)[86]	IV	45.2	33/73				
Baltasar et al[69]	IV			33.3	9/27		
Curry et al[82]	IV			17.0	8/47		
Hernandez-E. et al[88]	IV	16.4	11/67				
Higa et al(b)[70]	IV			14.2	148/1040		
MacLean et al[72]	IV			43.2	105/243		
Mason et al[89]	IV	0	0/47				
Matthews et al[73]	IV			39.6	19/48		
Naslund et al[90]	IV	40.4	80/198				
Oh et al[75]	IV			18.1	35/193		
Papavramidis et al[91]	IV	23.8	38/160				
Pories et al[76]	IV			65.0	392/608		
Ramsey-Stewart et al[92]	IV	93.3	56/60				
Rutledge[77]	IV			5.2	66/1274		
Schauer et al[78]	IV			4.7	130/275		
Smith et al[79]	IV			7.3	15/205		
Strauss et al[128]	IV			20.0	2/10		
Sugerman et al[81]	IV			76.7	1502/1959		
Wittgrove & Clark[83]	IV			12.6	63/500		
Wyss et al[103]	IV	22.0	22/100				
Median		23.6		27.4		2.6	

*Number of patients with morbidities; some with multiple morbidity.
†VBG and VBG minilap.
Note: Vomiting, diarrhea, and weight regain not included as morbidities in these calculations.

overall morbidity rate of 36% for LAGB compared to 23% for nonadjustable gastric banding (RRR of −0.58 [95% CI 0.36, −2.87]).[18] This difference in risk is non-significant and is based on very small numbers of LAGB patients (n = 11) who represent the surgeon's initial experience with the Swedish adjustable gastric band (SAGB).

In the near absence of appropriate randomized controlled trials of LAGB with either VBG or RYGB, the comparator data available have been considered as case series data here (Table III). Overall morbidity rates for VBG ranged from 93% down to 0%, and for RYGB from 77% down to 0%. Unlike LAGB, significant morbidity rates were reported for

Table IV. Specific complications across all studies reporting complications*

	LAGB (n = 8,504)		*VBG (n = 3,849)*		*RYGB (n = 9,413)*	
Complication	*n*	*Percent*	*n*	*Percent*	*n*	*Percent*
Incisional hernia	13	0.15	197	5.12	840	8.92
Nutrient deficiency/anemia/anorexia			13	0.34	566	6.01
Stenosis	10	0.12	76	1.97	448	4.76
Wound infection	24	0.28	150	3.90	421	4.47
Marginal ulcer/ulcer disease	1	0.01	5	0.13	386	4.10
Dilatation	338	3.97	12	0.31		
Staple line disruption			113	2.94	229	2.43
Seroma/hematoma	13	0.15	101	2.62	46	0.49
Occluded/kinked stoma	12	0.14	69	1.79	11	0.12
Cholelithiasis/cholecystectomy	16	0.19	6	0.16	164	1.74
Clinical failure/failure to lose weight			66	1.71	3	0.03
Respiratory complications	24	0.28	63	1.64	37	0.39
Displacement of band	138	1.62				
Gastrogastric fistula			53	1.38	24	0.25
Oesophagitis	12	0.14	43	1.12	9	0.10
Small bowel obstruction/necrosis			1	0.03	99	1.05
Gastritis	1	0.01	8	0.21	89	0.95
Pulmonary embolism	14	0.16	36	0.94	20	0.21
Port rotation/movement	74	0.87				
Enlarged stoma			31	0.81	2	0.02
Catheter rupture/disconnection/leak	68	0.80				
Erosion	50	0.59	10	0.26	6	0.06
Debilitating panniculus					52	0.55
Wound dehiscence			17	0.44	2	0.02
Bleeding (inc. GI)	4	0.05	11	0.29	36	0.38
Anastomotic/gastric leak			12	0.31	36	0.38
Infection of band or reservoir	31	0.36	2	0.05		
Diarrhea			2	0.05	33	0.35
Gastric/internal hernia	1	0.01	8	0.21	26	0.28
Defective/leaking/broken/damaged band	8	0.09	10	0.26		
Subphrenic abscess/abscess	4	0.05	6	0.16	18	0.19
Infection (other, inc. sepsis)	16	0.19	1	0.03		
Hypokalemia					15	0.16
Urinary tract infection	4	0.05	6	0.16	12	0.13
Psychological problems	5	0.06	6	0.16		
Enterocutaneous fistula			6	0.16		
Candidiasis			6	0.16		
Painful port site	11	0.13				
Biological pancreatitis			5	0.13		
DVT	1	0.01	2	0.05	5	0.05
Phlebitis					5	0.05
Bleeding/discharge/necrosis at incision	4	0.05	1	0.03		
"Miscellaneous"	35	0.41	22	0.57	44	0.47

*Excluding vomiting and food intolerance (Table VI).

even very large series of VBG with, for example, Naslund et al[90] recording a rate of 40.4% in 198 cases, Alper et al[85] recording a rate of 71.0% in 300 cases, and Suter et al[93] recording a rate of 80.7% in 197 cases. This was not a situation to which RYGB was immune either, with the largest series of 1,959 patients[81] recording a morbidity rate of 76.7%, another series of 608 patients[76] recording a morbidity rate of 65.0%, and another of 243 patients[72] recording a morbidity rate of 43.2%. It seems plausible that these operations are more invasive than the LAGB, an argument supported by the work of Urbain et al[84] who compared the regular VBG with a minimally invasive form of the operation. They found significantly higher rates of pulmonary embolism, wound infection, and incisional hernia, among others, in the regular VBG. This study was unfortunately flawed by the

Table V. Iatrogenic complications

Complication	LAGB (n = 8,504) n	LAGB Percent	VBG (n = 3,849) n	VBG Percent	RYGB (n = 7,454) n	RYGB Percent
Gastric perforation/injury	68	0.80	6	0.16	4	0.05
Spleen injury/splenectomy	1	0.01	7	0.18	26	0.35
Evisceration			5	0.13		
Liver injury/bile leak	4	0.05	2	0.05	1	0.01
Incomplete transection of stomach					4	0.05
Band positioned incorrectly	3	0.04				
Tube stapling/accidental removal			1	0.03	2	0.03
Pancreas stapling			1	0.03		
Esophageal tear					2	0.03
Fracture of perianastomotic drain					1	0.01
Injury to pleura	1	0.01				
Stapler malfunction	1	0.01			1	0.01
Insufficient pneumoperitoneum	1	0.01				

use of historic VBG data and, as previously mentioned, there is a lack of properly constituted concurrently controlled trials comparing LAGB with VBG or RYGB to unambiguously clarify this issue.

It is problematic aggregating data from case series, and any results drawn from such a process should be treated with the utmost caution. However, some suggestive results are produced in this instance. From Tables II and III, it can be seen that the median morbidity rate for Lap-band® is approximately 11.3% (range, 0-68.0); for VBG it is approximately 23.6% (range, 0-93.3) and for RYGB it is approximately 27.4% (range, 0-76.7). This would seem to suggest that in the hierarchy of risk, LAGB is least associated with morbidity, whereas RYGB and VBG are associated with a higher risk of morbidity. Of course, this analysis makes no distinction between the types of morbidity associated with each procedure.

Specific morbidities. Across all studies for which morbidity data could be calculated, excluding multiple reports of the same study (unless additional complications were reported), the most common types of complications related to LAGB were pouch dilatation (4.0%) and displacement of the band (1.6%) (Table IV). Other types of complications were reported in much smaller numbers, although they were very diverse. In comparison, the most commonly reported complications for VBG were incisional hernia (5.1%), wound infection (3.9%), staple line disruption (2.9%), seromas and hematomas (2.6%), and stenosis (2.0%) or other pouch outlet problems (1.8%). The most common complications associated with RYGB were incisional hernias (8.9%), followed by nutrient deficiencies, or anemia or anorexia (6.0%). Other more commonly reported complications were stenosis of the pouch outlet (4.8%), wound infection (4.5%), marginal ulcer (4.1%), and staple line disruption (2.4%).

Almost certainly the rates reported here are underestimates, as not every study that reported complications reported all complications.

Iatrogenic morbidities include the sorts of complications associated with surgical errors (Table V). The most common type of iatrogenic morbidity associated with LAGB is gastric perforation or injury to the stomach, of which 68 cases were reported. The next most common morbidity was injury to the liver or bile ducts, with only 4 cases reported. That gastric perforation is the most common of these types of injuries by such a large margin is perhaps not surprising considering the intricate maneuvering of the adjustable band and instruments around the stomach that the procedure requires. In contrast, both the comparator procedures recorded much lower rates of iatrogenic complications, the most common being injury to the spleen, which occurred in 26 cases of RYGB. Whatever the complications, together they were reported in less than 1% of all cases.

Vomiting as a complication of obesity surgery was mentioned in many studies, but actual rates of vomiting and food intolerance were reported less often. A total of 20 studies produced data on this complication (Table VI). The data are by no means clear and show a broad range of rates of vomiting and food intolerance, with LAGB rates varying from 0% up to 60%, those for VBG ranging from 0.8% up to 76.5%, and RYGB from 4.7% to 68.8%. There is the suggestion that VBG is associated with a consistently higher rate of vomiting and food intolerance, simply because the majority of VBG studies reported higher rates. Several of the LAGB studies reported

Table VI. Incidence of vomiting and food intolerance (studies ranked from low to high rates)

Study	*n*	*Rate of vomiting*	*Rate of food intolerance*	*Follow-up*
Ashy & Merdad[17]	LAGB: 30 VBG: 30	LAGB: none reported VBG: unknown n continuous vomiting		6 months
Busetto et al[23]	LAGB: 30	*0%, 0%, 3.3%	Lap: 3.3%	3, 6, 12 months
Fried et al[18]	SAGB: 11	SAGB: 9.1%, 0%, 0%		1, 2, 3 years
Toppino et al[31]	VBG: 119		0.8%	Up to 1 year
Catona et al[124]	LAGB: 85	3.5%		1 year
Cadiere et al[46]	LAGB: 652		3.8%	Up to 2 years
Schauer et al[78]	RYGB: 275	4.7%		Mean, 9.4 months
Fobi et al[127]	RYGB-S: 25 RYGB-T: 25		RYGB-S: 8% RYGB-T: 8%	6 years
Victorzon & Tolonen[121]	LAGB: 60	8.3%		2 years
Fox et al[100]	RYGB: 57 VBG: 75	RYGB: 10% VBG: 7%		
Belachew et al[14]	LAGB: 350		13.1%	Up to 41 months
Urbain et al[84]	VBG: 111 VBG minilap: 782		VBG: 19.74% VBG minilap: 4.87% P = 0.000004	Up to 96 months
Silva et al[110]	LAGB: 18	27.8%		18 months
Berreveot et al[22]	Lap I: 50 Lap II: 29 SAGB: 41	Lap I: 32% Lap II: 31%, SAGB: 7.3%		Up to 3 months
Van de Weijgert et al[65]	RYGB: 75 VBG: 78	RYGB: 40% ≥ once per week VBG: 64% ≥ once per week		9.9 ± 1.6 years 7.2 ± 0.8 years
Alper et al[85]	VBG: 300	49.3%		5.2 ± 2.2 years
Wyss et al[103]	VBG: 100	24 "failures": 58.3% 65 "successes": 46.1%		60 ± 2.5 months
Hernandez-E et al[88]	VBG: 67	56.2% @ 2 years 54.7% @ 5 years	76.5% @ 2 years 70.0% @ 5 years	Up to 5 years
Morino et al[54]	LAGB: 15		60%	20† 12-30 months
Mitchell et al[74]	RYGB: 70	68.8%	42.7%	Up to 15 years

*High frequency of vomiting.
†Measure of variance could not be determined.
SAGB, Swedish adjustable gastric band; *NAGB*, nonadjustable gastric band; *ASGB*, adjustable silicone gastric banding (placed via laparotomy); *Lap*, Lap-band®.
Note: (±) = Standard deviation.

vomiting statistics across time, and most of these demonstrated a reduction in incidence. This could possibly be attributed to the adjustable nature of the band, as it is part of the technique that if the patient demonstrates unacceptable rates of vomiting the band is deflated, at least partially, to reduce the symptoms. However, studies that reported results for nonadjustable stoma techniques, such as the nonadjustable gastric band[18] and VBG,[88] also reported reductions (even if sometimes slight) in the incidence of vomiting and food intolerance over time.

Three of the LAGB studies were comparative, but only the 2 studies using historic controls used any statistical analysis between the experimental and control groups. The latter reported a significantly lower rate of vomiting in the Lap-band group when compared to patients who had first generation INAMED adjustable bands fitted by laparotomy,[23] and a significantly lower rate of vomiting associated with the SAGB when compared with the Lap-band®.[22] With regard to the comparator procedures, Urbain et al[84] reported a significantly lower rate of vomiting in VBG patients treated through a minimally invasive approach than those treated through the normal open route. However, the Silastic ring was enlarged for the minimally invasive approach from 4.5 cm to 5.0 cm, and this would plausibly explain the reduction in incidence of vomiting in this group.

Table VII. Studies comparing Lap-band® or SAGB with VBG and/or RYGB

Study	*LoE*	*Procedures*	*N*	*Follow-up*	*Weight loss data*	*Statistics*
Ashy & Merdad[17]	II	LAGB	30	6 months	BMI: 38.46; EWL: 50%	None
		VBG	30		BMI: 33.33; EWL: 87%	
Hell et al[19]	III-2	LAGB	30	39.7 ± 7.6 months	BAROS weight loss points: 1.5	RYGB v LAGB and VBG, $P < .05$.
		VBG	30	40.1 ± 8.3 months	BAROS weight loss points: 1.6	
		RYGB	30	60 ± 8.2 months	BAROS weight loss points: 2.7	
Wolf et al[21]	III-2	LAGB	50	20 months	*88 | 54 | 18 | 6	NS‡
		VBG	115		*87 | 65 | 32 | 11	
Fried et al[26]	III-3	SAGB	15	24 months	Weight lost: 37.2 kg	NS
		VBG	52		Weight lost: 40.5 kg	
Suter et al[30]	III-3	LAGB	76	24 months	BMI: higher; EWL: less; %IW: more	All NS at 24 months†
		VBG	197		BMI: lower; EWL: more; %IW: less	
Toppino et al[31]	III-3	LAGB	361	12 months	EWL: 41.9%	None
		VBG	120		EWL: 58%	

*% losing 25% | 50% | 75% | 100% of excess weight; *NS*, no significant statistical difference.
†Significant differences were found in favor of VBG at earlier time periods.
‡Statistical tests were not performed in the original study, but were performed post hoc as part of this review (LAGB vs VBG, Fisher's P, 2-tailed, $P = 1.000$ for 25% excess weight lost, $P = .222$ for 50% excess weight lost, $P = .088$ for 75% excess weight lost, $P = .396$ for 100% excess weight lost.
LoE, Level of evidence; *BMI*, body mass index; *EWL*, excess weight lost; *IW*, ideal weight.

Efficacy. The efficacy of a procedure, although naturally related to safety issues, is principally concerned with how effectively the surgical intervention achieves the technical goals that are not directly related to issues of safety. In this particular section the question is dealt with in terms of weight loss, operative outcomes such as duration of operation, conversion rates, and postoperative factors such as discharge from hospital and reoperation rates, and psychosocial effects of the operation.

Weight loss. The most commonly reported measures were weight loss (Table VIII), reduction of BMI (Table IX) and percentage of excess weight lost (Table X), and provide a broad perspective on long-term weight reduction achieved by LAGB and its comparators. All studies reported achieving weight loss in their overall patient populations with both the Lap-band® and the SAGB, as well as in patients treated with the comparator procedures. The most extensive follow-up periods were reported for the comparator procedures, with some studies reporting follow-up data of up to 14 years for RYGB[76] and 10 years for VBG.[86,89] In comparison, the most extensive follow-up available for LAGB was 4 years in 3 studies.[44,94,95]

Of the 6 studies[17,19,21,26,30,31] that compared weight loss between patients undergoing LAGB and those treated with VBG or RYGB, only 3 attempted statistical analysis of the results (Table VII). Of the 2 of these studies that used historic controls, one found no significant difference in weight loss between patients undergoing VBG and SAGB up to 24 months,[26] whereas the other found VBG significantly more effective than LAGB at reducing weight up to 18 months, but producing comparable effects at 24 months, which was the maximum extent of that study's follow-up.[30]

The third of the studies that applied statistical testing used contemporaneous (but not randomized) controls to compare weight loss outcomes among all 3 of the procedures finding no statistically significant differences in weight loss outcomes between the VBG and LAGB groups, but reported that RYGB produced significantly greater weight loss than either of the other 2 procedures.[19] This study also reported the longest follow-up period of all the LAGB comparative studies. A limitation of this study is that all the RYGB procedures were performed by one surgeon, all the VBG and LAGB procedures by another, the procedures were performed in different countries, and the data pattern suggests selection bias.

Another of these comparative studies, although reporting no statistical tests itself, provided sufficient detail to allow testing for this review (Table VII). Using contemporaneous controls, it found no significant difference in weight loss outcomes between the LAGB and VBG groups after 20 months.[21]

Table VIII. Weight loss over extended follow-up

Study *Weight loss kg/lb/%*	*n*	*Follow-up in months* *Base*	*6*	*12*	*18*	*24*	*36*	*48*	*60*	*72*	*84*
LAGB											
De Luca et al[49]											
Lap	17	124		25		39	44				
Converted	5	125		25		39	43				
Fried et al[18]	‡11	140					38				
Miller & Hell[53]	102	136		≈120		≈98	≈90				
	54‡	134		≈120		≈105	≈88				
Weiner et al[40]	178		28	54		58					
[b]Fried et al[26]	‡15	140				37					
Hallerbäck et al[123]	‡57			25		32					
Victorzon & Tolonen[121]	60		20	30		31					
§Fielding et al[16]	335	†138		37 ± 10	41 ± 18						
Berrevoet et al[23]											
Lap I	50		14	24	28						
Lap II	29		19	22							
SAGB*	‡41										
De Wit et al[114]	25	152 ± 31		35							
Busetto et al[23]	30	111 ± 14		25 ± 10							
Peternac et al[29]											
Transbursal	17	123 ± 23		24 ± 11							
Suprabursal	66	133 ± 20		25 ± 11							
Schlumpf et al[56]	14	120 ± 22	16 ± 5	23 ± 9							
RYGB											
Freeman et al[63]											
Short limb	40	127 ± 3		30 ± 2%		34 ± 2%	35 ± 2%	25 ± 2%	30 ± 4%	13 ± 1%	28 ± 2%
Long limb	81	130 ± 2		35 ± 1%		40 ± 1%	38 ± 1%	35 ± 2%	41 ± 0%	. . .	. . .
‖Fobi et al[127]											
Stapled pouch	25	129 ± 25		≈110 lb		≈128 lb	≈126 lb	≈110 lb	≈110 lb	≈100 lb	
Transected pouch	25	130 ± 25		≈110 lb		≈110 lb	≈110 lb	≈110 lb	≈110 lb	≈100 lb	
Smith et al[80] (lb)	1039	262	79	101		99	93	85	78	78	
Brolin et al[57] (lb)											
Short limb	22	393 ± 64	88 ± 23	118 ± 35	133 ± 40	117 ± 38	115 ± 49	140 ± 63			
Long limb	23	404 ± 61	104 ± 37	140 ± 41	161 ± 51	168 ± 52	165 ± 50	159 ± 70			
Balsiger et al[68]†	39	146		51		56	52	51			
¶Sugerman et al[61] (lb)	20			96 ± 25		96 ± 34	91 ± 28				
Fox et al[100]	57	126	40	52	57	56	57				
Kalfarentzos et al[64]											
Short limb	38	131		36%		38%	38%				
Long limb	17	155		32%		35%	. . .				
Sjostrom et al[96]	42					33 ± 10%					
**Trostler et al[129]	8 ♂	127 ± 5	37 ± 3	43 ± 2	47 ± 11						
	11 ♀	119 ± 4	35 ± 2	41 ± 2	54 ± 1						
Matthews et al[73] (lb)	48			115							
††Choi et al[102]	12			47							
VBG											
‡‡Balsiger et al[86]	73	138 ± 3									28 ± 4
[a]Mason et al[89]	47	139 ± 28							34 ± 19		28 ± 20
Urbain et al[84]										≈35	
Conventional	111										
Minilaparotomy	782									≈35	
Fox et al[100]	75	125	33	35	36	37	38	35			
¶Sugerman et al[61] (lb)	20			71 ± 24		67 ± 27	60 ± 32				
Kalfarentzos et al[64]	35	121		31%		31%	25%				
[b]Fried et al[26]	52	136				41					

(continued)

Table VIII. *(continued)*

Study *Weight loss kg/lb/%*	*n*	*Follow-up in months* *Base*	*6*	*12*	*18*	*24*	*36*	*48*	*60*	*72*	*84*
Sjostrom et al[96]	534					23 ± 10%					
**Trostler et al[129]	7 ♂	137 ± 1	30 ± 3	39 ± 2	40 ± 3						
	29 ♀	113 ± 4	29 ± 1	38 ± 3	42 ± 2						
††Choi et al[102]	17			39.3							

*4 months. †Median. ‡Swedish adjustable gastric band. §Change in BMI. ||Baseline in kg, weight lost in lb. ¶All weight loss data significant $P < 0.001$. **Results male/female; RYGB vs VBG, $P < 0.05$. ††RYGB vs VBG, P = NS. ‡‡At >10 years. [a]Last column is at 10 years. [b]LAGB vs VBG, P = NS.
Note: Figures with (±) are means with standard deviations.

In all these studies that compared weight loss from LAGB with that from VBG or RYGB, the mean results for LAGB were inferior to those of either of the comparators. However, 2 of these studies were reporting on follow-up periods of 12 months or less,[17,31] and considering that the LAGB procedure involves leaving the band deflated immediately after the operation with only gradual adjustments thereafter whereas VBG results in immediate gastric restriction, the results of these 2 studies cannot be considered to be meaningful. With regard to the remaining 4 comparative studies, all of which had longer follow-up periods, the differences between LAGB and VBG outcomes tended to be small and nonsignificant. Therefore, although it seems possible that VBG produces superior weight loss outcomes than LAGB in the shorter term, these differences are small and of uncertain clinical significance. However, LAGB appears to result in significantly inferior weight loss when compared to RYGB, at least in the short term.

Five studies performed statistical comparisons of weight loss data between the two comparators. Four of these found RYGB to be significantly more effective at producing weight loss than VBG for follow-up periods of 2 years,[96] 3 years,[61] and 5 years,[59,62] whereas another found RYGB to be significantly more effective at producing weight reduction in men, but not women, at 18 months, which was the total length of the follow-up.[97] Another study reported significantly greater weight loss for patients treated with RYGB when compared with patients receiving conservative management of their obesity alone.[98]

Despite there being a large amount of weight loss data available (Tables VIII to X), it is difficult to make unambiguous assertions of the advantages or disadvantages, or even the comparability of one technique in relation to another in the longer term (ie, at least up to 4 years). All 3 operations—LAGB, VBG, and RYGB—clearly result in long-term weight loss, although the evidence for LAGB is necessarily not so extensive as that for the older comparative procedures. At 4 years—the maximum extent of follow-up for LAGB—mean BMI was reduced in 2 studies by 24%[95] and 27%,[44] whereas those studies that reported weight reduction in terms of excess weight lost found that 44%[95] and 68%[94] of excess weight was lost. These latter data compare across the same 4-year period for excess weight lost with RYGB studies reporting ranges from 50% to 67%,[62,63,68,75,79] and VBG studies reporting ranges from 40% to 77%.[62,86,91,93,99,100]

Operative factors. A broad range of operating times was reported for each of the procedures and, considering the dissimilar operative performances of each procedure, it does not seem meaningful to compare them. With regard to LAGB, reported conversion rates ranged from 0 up to 25%, although the highest rate from the larger series (those having more than 100 patients) was only 5.3%. Because the smaller series reported both the highest and lowest conversion rates, it is uncertain whether the "learning curve" can be invoked as a possible explanation for the highest conversion rates, and some other obscure factor(s) may be at play. Two studies also reported abandoning procedures because of hypertrophic liver in 1.9%[35] and 0.6%[53] of cases.

Postoperative recovery

Reoperation rate and band removal. A number of studies reported reoperation rates; details of these reoperations are summarized in Table XI. Broadly, the tabulated data would seem to suggest that LAGB is associated with a lower risk of reoperation than either of the comparator procedures, and that the greatest risk pertains to VBG. Most of the LAGB studies reported reoperation rates of 8% or less. Only 1 RYGB study[71] and 1 VBG study[31] recorded comparable reoperation rates, and they were the lowest reoperation rates of all the studies listed in Table XI. Out of the larger series (those with over 100 patients), reoperation rates of between 20% and 53% were recorded only by VBG studies.[85,87,90,93]

Table IX. Reduction in BMI over extended follow-up

Study BMI (kg. m^{-2})	n	Follow-up in months: Base	6	12	18	24	36	48	60	72	84
LAGB											
De Maria et al[95]	37	45 ± 4		37 ± 6		37 ± 7	36 ± 6	34			
Angrisani et al[44]	1265	44		35	33	30	32	32			
O'Brien et al[94]	302	45	≈37	≈34	≈32	≈31	≈31	≈30			
De Luca et al[49]											
Lap/Converted	17/5	48/48		40/40		38/38	37/37				
‖Suter et al[115] (some †)	150	45		≈33	≈33	≈33	≈33				
Miler & Hell[53] († n = 54)	156	L:45/†:43		34(24-48)		30(21-39)	28(20-35)				
¶De Jonge et al[48]	91	44		35	35	35					
Nowara[55] (some †)	108	49		37		34					
*Victorzon & Tolonen[121]	60	45	39	35		33					
Furbetta et al[120]	201	43	37	35	33	33§					
Hallerbäck et al[123]	†57	41		33		30					
Weiner et al[38]	184	48	38	32	30	28					
Abu-Abeid et al[41]	391	43	34	32	30						
Silva et al[110]	18	50 ± 9	39 ± 6	32 ± 5	30 ± 4						
‡Fielding et al[16]	335	*47		−12 ± 2	−16						
De Wit et al[114]	25	51 ± 10		40 ± 9							
**Peternac et al[29]	1: 14	47 ± 8		38 ± 7							
	2: 54	48 ± 7		39 ± 7							
Schok et al[107]	74	45 ± 6		36 ± 5							
Hauri et al[122]	207	43 ± 5	37 ± 5	35 ± 5							
Catona et al[124]	85	44		33							
††Gambinotti et al[52]	162	43 ± 9		32 ± 9							
Elias et al[25]	35	39	34	31							
Belachew et al[14]	350	43		30-33							
†Taskin et al[125]	50	50 ± 8		29 ± 6							
Favretti et al[36]	30	40 ± 9	32 ± 8	27 ± 7							
‡‡Rubin et al[119]	109	44	36	34							
Ashy et al[17]	30	49	38								
Bakr & Fahim[45]	39	44	37								
RYGB											
[a]Pories et al[76]	608	50		32					34		35/35
[b]Jones[71]	352	48,43,43		28					32		30
Smith et al[79]	205	45	33	29		29	30	32	31	34	35
Freeman et al[63]											
Short limb	40	45 ± 2		32 ± 2		31 ± 1	27 ± 2	35 ± 1	37 ± 2	41 ± 0	33 ± 1
Long limb	81	46 ± 2		32 ± 2		29 ± 1	30 ± 1	32 ± 1	33 ± 0	. . .	. . .
Fobi et al[127]	25	47 ± 9		≈28		≈29	≈29	≈28	≈30	≈31	
Stapled pouch											
Transected pouch	25	47 ± 8		≈28		≈30	≈30	≈29	≈29	≈30	
Capella & Capella[62]	560	52 ± 9					32 ± 6	32 ± 6	34 ± 6		
[c]Brolin et al[57] (lb)	22	63 ± 10	49 ± 9	44 ± 8	42 ± 11	45 ± 13	45 ± 14	43 ± 10			
Short limb											
Long limb	23	62 ± 9	46 ± 8	40 ± 9	38 ± 7	35 ± 5	37 ± 6	37 ± 11			
*Balsiger et al[68]	191	49		≈31		≈30	≈33	34 ± 1			
Smith et al[112]	188	♀ 43		27		27	28	30			
		♂ 45		32		31	29	26			
*Oh et al[68]	193	45		28		28	29	29			
Kalfarentzos et al[64]											
Short limb	38	49		32		33	35				
Long limb	17	60		41		38	. . .				
‖Schauer et al[78]	275	48	35	31	30	27	28				
[d]Choban et al[104]	107	51 ± 10				35 ± 8					
[e]Stahl et al[67]	31	49	≈38	≈33	≈30						
21 mm outlet											
25 mm outlet	19	49	≈38	≈32	≈33						
Baltasar et al[69]	27	43		28	31						
Torstler et al[129]	8 ♂	43 ± 4	37 ± 3	27 ± 2	24 ± 2						
	11 ♀	43 ± 6	28 ± 4	26 ± 4	27 ± 3						

(continued)

Table IX. *(continued)*

Study *BMI (kg. m^{-2})*	*n*	*Follow-up in months*									
		Base	*6*	*12*	*18*	*24*	*36*	*48*	*60*	*72*	*84*
[f]Cowan et al[109]											
♀	61	46 ± 1		33 ± 1							
♂	21	52 ± 2		35 ± 2							
[g]Choi et al[102]	12			−18							
[g]Matthews et al[73]	48	52		−19							
Dymek et al[105]	32	57 ± 12	39 ± 7								
VBG											
[h]Mason et al[89]	47	48 ± 7							36 ± 6		39 ± 7
[h]Balsiger et al[86]	73	49 ± 1			36 ± 1			39 ± 1			39 ± 1
[i]Baltasar et al[87]	100	48				32			33		33
De Witt hamer et al[99]	40	43 ± 11		30 ± 11		30 ± 10	31 ± 11	31 ± 11	32 ± 11	33 ± 13	34 ± 15
Naslund et al[90]	198	44	≈35	≈33		≈33		33	34	≈34	≈34
Suter et al[93]	197	43	≈32	≈29		≈29	≈32	≈31	≈34	≈34	≈32
Papavramidis et al[91]	160	53		30 ± 4		29 ± 5	28 ± 5	28 ± 3	29 ± 4	32 ± 7	31 ± 4
Capella & Capella[62]	328	52 ± 9					39 ± 9	40 ± 9	40 ± 9		
[j]Alper et al[85]	300	46 ± 8							33 ± 7		
Hemandez-E. et al[88]	67	48							≈35		
Kalfarentzos et al[64]	35	44		31		31	34				
Trostler et al[129]	7 ♂	45 ± 7	33 ± 6	29 ± 4	28 ± 7						
	29 ♀	42 ± 8	31 ± 7	29 ± 7	29 ± 7						
[g]Choi et al[102]	17			−13							
Ashy et al[17]	30	54	33								

*Median. †SAGB. ‡Change in BMI. §Follow-up at 22 months. ||Last column 30 months. ¶Follow-up mean 21 months. **1:25 mL pouch; 2:15 mL pouch. ††Follow-up 15 months. ‡‡Maximum follow-up at 9 months. [a]Last column 10 and 14 years follow-up. [b]Preop BMI for 1, 5, 10 years; last column in 10 years follow-up. [c]24 months, $P < 0.01$. [d]Maximum follow-up is based on mean 23 ± 5 months. [e]1 = 21 mm stoma; 2 = 25 mm stoma; [f]Male vs Female, $P < 0.01$. [g]Mean decrease in BMI, P = NS. [h]Final column 10 year follow-up. [i]Follow-up at 2.5, 5, 9.5 years. [j]5 year follow-up is a mean follow-up time. Figures with (±) are means with standard deviations. Figures with ranges alone are medians.

Four comparative studies performed statistical tests on reoperation rates or related elements, none of which contradict the findings above. In a randomized controlled trial, Hall et al[58] reported a significantly greater likelihood of operative "success" (measured by several factors) for patients treated with RYGB (66.7% success rate) than those treated with VBG (48.1% success rate, $P < .001$). Van Gemert et al[101] performed a Kaplan-Meier analysis on revision rates between VBG and RYGB, finding that 56% of VBGs require revision over a 12-year period compared with 12% of patients treated with RYGB ($P < .01$). No studies have compared reoperation rates between LAGB and RYGB or VBG. However, 1 comparative study, which compared 3 groups treated sequentially with different LAGB techniques, found that patients treated with the SAGB were reoperated significantly less often ($P = 0.02$) than either of the alternative Lap-band® groups (2.4% vs 16.0% and 17.2%).[22] However, both of the Lap-band® groups were operated on earlier in this series; hence, this result may merely be a measure of the learning curve rather than of some intrinsic benefit associated with SAGB. Another study related that the site of the placement of the band affected the likelihood of a requirement for reoperation, with patients who have the band placed in a "suprabursal" position (ie, through the hepatogastric ligament) significantly less likely to require reoperation than if the band penetrates the lesser sac.[29] A fault with this study, however, was that the outcomes for those patients who had the band placed through the lesser sac represent the first patients in the series, after which the technique was abandoned and the "suprabursal" technique developed. This may indicate a learning curve effect.

When band removal and revision rates as a subset of reoperation rates are considered alone, similar conclusions can be reached (Table XII). Although several small series of LAGB operations recorded the highest rates of operative reversal (from 41% to 71%), these all represented the initial experience of these groups with the LAGB. As mentioned above, 1 group (reporting 71%) modified its technique and subsequently reported significantly lower rates of reoperation,[29] another appeared to regret their involvement with the technology after 15 cases and returned to VBG as the operation of choice,[54] whereas the third series represents the first experience of the authors with the LAGB.[95] In contrast to this, and similar to the

Table X. Percent of excess weight lost over extended follow-up

Study *Excess Wgt Lost %*	*n*	*Follow-up in months* *Base*	*6*	*12*	*18*	*24*	*36*	*48*	*60*	*72*	*84*
LAGB											
O'Brien et al[94]	302			51 ± 17		58 ± 20	62 ± 2	68 ± 21			
De Maria et al[95]	36			35 ± 20		36 ± 23	38 ± 27	44			
Dargent et al[47]	500		45 (6-72)	56 (7-121)		65 (6-121)	64 (6-122)				
De Luca et al[49]											
Lap	17			43		50	59				
Converted	5			41		48	52				
*Suter et al[115]											
some†	150			≈55	≈55	≈55	≈55				
Morino et al[54]	15		49	66		67					
Cadiere et al[46]	652		28	38		62					
Victorzon & Tolonen[121] (kg)	60		‡35	‡51		‡51					
§Fielding et al[16]	335			52	62						
Niville et al[27]											
LAGB	40		34	48	58						
LAEGB	86		27								
Berrevoet et al[22]											
Lap I	50		28	50	53						
Lap II	29		31	41							
SAGB	41										
Favretti et al[36]	30		42 ± 15	71 ± 40							
Belachew et al[14]	350			‖							
Catona et al[124]	85			54							
Busetto et al[23]	30			47 ± 20							
Paganelli et al[118]	156		36 ± 17	43 ± 22							
Toppino et al[31] some†	361		28	42							
Schlumpf et al[56]	14		27 ± 10	36 ± 15							
Peternac et al[29]											
Transbursal	17			20 ± 14							
Suprabursal	66			20 ± 15							
Ashy et al[17]	30		50								
RYGB											
¶Pories et al[76]	608			69					58		55/49
**Jones[71]	352			78					59		62
Freeman et al[63]											
Short limb	40			60 ± 3		67 ± 3	69 ± 3	50 ± 3	53 ± 5	24 ± 1	55 ± 3
Long limb	81			68 ± 3		77 ± 2	73 ± 2	64 ± 3	71 ± 0	...	...
Smith et al[79]	205		58	72		70	66	56	62	53	55
Fobi et al[127]											
Stapled pouch	25			≈75		75	72	74	72	70	
Transected pouch	25			≈75		81	80	74	72	68	
††Howard et al[59]	20								≈70%		
‡‡Capella & Capella[62]	560						70 ± 19	67 ± 21	62 ± 17		
‡Balsiger et al[68]	39			68		72	66	63			
‡Oh et al[75]	193			69		71	70	56			
Fox et al[100]	57		66	86	86	89	89				
*Schauer et al[78]	275		53	69	72	83	77				
Kalfarentzos et al[64]											
Short L	38			64		65	63				
Long L	17			51		53	...				
[a]Sugerman et al[61]	20			S:69 ± 17		62 ± 19	59 ± 17				
				N: 67 ± 17		75 ± 19	71 ± 21				
Rutledge[77]	1274		51	68		77					
[b]Choban et al[104]	107					63 ± 23					
Trostler et al[129]	8 ♂		77 ± 2	84 ± 2	80 ± 7						
	11 ♀		65 ± 6	75 ± 1	70 ± 4						
[c]Stahl et al[67]											
21 mm outlet	31		45	65	64						
25 mm outlet	19		40	67	69						

(continued)

Table X. *(continued)*

Study *Excess Wgt Lost %*	*n*	*Follow-up in months* *Base*	*6*	*12*	*18*	*24*	*36*	*48*	*60*	*72*	*84*
Baltasar et al[69]	27			79	72						
Murr et al[130]	43				58 ± 5						
Nguyen et al[66] (lb)											
Open	35			62							
Lap	35			69							
Higa et al[70]	1040			70							
VBG											
[d]Baltasar et al[87]	100					61			54		53
**Mason et al[89]	47								46 ± 22		39 ± 26
**Balsiger et al[86]	73							40 ± 3			37 ± 5
Papavramidis et al[91]	160			69 ± 12		78 ± 10	76 ± 15	77 ± 14	76 ± 12	68 ± 10	70 ± 10
Suter et al[93]	197		≈58	≈68		≈67	≈58	≈58	≈49	≈57	≈52
De witt hamer et al[99]	40			63 ± 44		63 ± 41	59 ± 41	56 ± 44	54 ± 43	48 ± 46	46 ± 50
[e]Alper et al[85]	300								59 ± 40		
††Howard et al[59]	22								≈37%		
‡‡Capella & Capella[62]	328						48 ± 23	45 ± 23	47 ± 23		
Fox et al[100]	75		54	59	61	65	64	62			
Kalfarentzos et al[64]	35			62		61	50				
[a]Sugerman et al[61]	20			S:36 ± 13		35 ± 14	32 ± 18				
				N:57 ± 18		53 ± 22	50 ± 21				
Murr et al[130]	23			44 ± 5			33 ± 6				
Trostler et al[129]	7 ♂		57 ± 1	72 ± 4	74 ± 3						
	29 ♀		52 ± 2	63 ± 1	81 ± 3						
Toppino et al[31]	120		52	58							
Ashy et al[17]	30		87								

*Last column 30 months. †Swedish adjustable gastric band. ‡Median. §Change in BMI. ||80% of patients lost 60%. ¶Last column 10 & 14 years follow-up. **Final column 10 year follow-up. ††RYGB vs VBG, $P < 0.05$. ‡‡RYGB vs VBG, $P < 0.0001$. [a]RYGB sweet eaters (S) vs VBG sweet eaters (S), $P < 0.0001$; Non-sweet eaters (N) vs Non-sweet eaters (N), P = NS. VBG (S) vs VBG (N), $P < 0.05$. [b]2-year follow-up is a mean figure of 23 ± 5 months. [c]1 = 21 mm stoma; 2 = 25 mm stoma. [d]Follow-up at 2.5, 5, 9.5 years. [e]5 year follow-up is a mean figure.
Figures with (±) are means with standard deviations. Figures with ranges alone are medians.

results reported for reoperation rates in general, among the larger series (over 100 patients), the highest rates of revision were associated with VBG, with all such series that reported revision rates of over 10% and up to 30% being for this class of operation. RYGB on the other hand is clearly associated with very low revision rates, with 1 small series of 20 patients reporting the highest rate at 10% and the largest such series of 560 patients recording a rate of 0.2%.

Discharge. The mean reported postoperative duration of hospital stay for LAGB ranged from 1.2 days up to 11.8 days (range, 0 to 55); for RYGB (open, not laparoscopic) from 1.6 days up to 8.4 days (range, unknown − 64); and for VBG (open, not laparoscopic) from 2.9 days up to 11.4 days (range, unknown − 90) (Table XIII). No statistical analysis of this data seems plausible.

However, 4 comparative studies performed statistical analyses on hospital discharge data. Two compared historical VBG data with prospective LAGB data, both finding a significant difference in favor of LAGB, with mean discharge times of 9.2 versus 2.4 days in 1 series and 11.4 versus 3.5 days in the other.[26,30] One of the 2 remaining studies that used historical controls found no significant differences in discharge times between 3 different methods of LAGB, including Lap-band® and SAGB.[22] The other study that used historic controls reported that patients treated with laparoscopic RYGB were discharged significantly sooner than patients treated by open RYGB (mean, 4.0 ± 3.7 days vs 8.4 ± 3.2 days).[30]

Psychosocial effects. Only 1 study compared quality of life outcomes for all 3 of the procedures examined in this report, and it appears to be of moderate quality, using contemporaneous (if nonrandomized) controls and performing a statistical analysis of its results.[19] This study used the BAROS system to evaluate patients across a range of indices, including weight loss, improvement in medical conditions, and quality of life. Overall, patients treated with RYGB reported significantly higher scores than those treated with either VBG or LAGB; there were no statistical differences between either of these groups. However, 1 surgeon performed all the RYGB operations and another performed all the VBG and LAGB operations; it is

Table XI. Reoperation rates (lowest to highest)

Study	Operation	Reoperation rate	n
Toppino et al[31]	VBG	0.8%	120
Jones[71]	RYGB	1.4%	352
Toppino et al[31]	LAGB	1.7%	361 (14*)
Hallerbäck et al[123]	LAGB	*1.8%	57
Rubin et al[119]	LAGB	2.8%	109
Fielding et al[16]†	LAGB	3.6%	335
Paganelli et al[118]	LAGB	3.8%	156
Angrisani et al[44]	LAGB	4.9%	1265
Favretti et al[35]	LAGB	5.3%	260
Weiner et al[40]	LAGB	5.6%	178
Gambinotti et al[52]	LAGB	5.6%	162
Hauri et al[122]	LAGB	6.3%	207
Niville et al[27]	LAGB	6.3%	126
Abu-Abeid et al[41]	LAGB	6.6%	391
Victorzon & Tolonen[121]	LAGB	6.7%	60
Miller et al[53]	LAGB	*& Lap 7.1%	156
Hernandez-Estefania et al[88]	LAGB	7.5%	67
Holeczy et al[116]	LAGB	8%	25
Hall et al[58]	RYGB	8.1%	99
Papavramidis et al[91]	VBG	8.1%	160
Fried et al[18]	LAGB	*9.1%	11
Schauer et al[78]	RYGB	9.8%	275
Belachew et al[14]	LAGB	13.1%	350
Higa et al[131]	RYGB	13.8%	400
Hall et al[58]	VBG	14.2%	106
Baltasar et al[69]	RYGB	14.8%	27
Berrevoet et al[22]	LAGB	Lap I: 16.0%	50
		Lap II: 17.2%	29
		*SAGB: 2.4%	41
Balsiger et al[68]	RYGB	16.2%	191
De Witt Hamer et al[99]	VBG	17.5%	40
Suter et al[115]	LAGB	18%	150
Van de Weijgert et al[65]	RYGB	18%	78
Balsiger et al[86]	VBG	20%	73
Naslund et al[90]	VBG	20.7%	198
De Jonge et al[48]	LAGB	22.0%	91
Alper et al[85]	VBG	22.1%	300
MacLean et al[60]	RYGB	23.1%	52
Baltasar et al[87]	VBG	25%	100
MacLean et al[60]	VBG	42.6%	54
Van de Weijgert et al[65]	VBG	43%	75
(1) Suter et al[93]	VBG	53.3%	197
Morino et al[54]	LAGB	66.7%	15

Rates do not include cholecystectomies, fat trimming.
*Swedish adjustable gastric band (SAGB).
†Gastric herniation patients only. Lap = Lap-band® (I = no retro-gastric tunneling; II = retro-gastric tunneling). (1) Marlex band sig. lower reoperation rate (30%, $P < 0.001$) than silastic band or adjustable VBG band.

possible this may explain the differences. Another study with contemporaneous controls (again nonrandomized) reported a higher degree of "very satisfied" (75%) patients among the RYGB group than among the VBG group (54%).[100] No statistical analysis was performed on these data.

Three other studies compared historical data. One compared satisfaction with operative outcome between VBG and RYGB patients, relating that all 12 RYGB patients were "satisfied" and 16 of 17 VBG patients also "satisfied."[102] Another reported that patients undergoing a minimally invasive form of VBG were more satisfied than those treated with the regular large incision.[84]

The third of these historical studies performed a more comprehensive analysis of quality of life

Table XII. Revision rates (lowest to highest)

Study	*Operation*	*% bands removed*	*n*
Capella & Capella[62]	RYGB	0.2%	560
Miller et al[53]	LAGB	*0.6%	156
Abu-Abeid et al[41]	LAGB	1.3%	391
Fielding et al[16]	LAGB	1.5%	335
Weiner et al[38]	LAGB	1.6%	184
Weiner et al[40]	LAGB	1.7%	178
Ramsey-Stewart[92]	VBG	1.7%	60
Hallerbäck et al[123]	LAGB	*1.8%	57
Furbetta et al[120]	LAGB	2.0%	201
O'Brien et al[94]	LAGB	2.0%	302
Gambinotti et al[52]	LAGB	2.5%	162
Fox et al[100]	RYGB	3%	57
Bakr & Fahim[45]	LAGB	3.6%	39
MacLean et al[60]	RYGB	3.8%	95
Urbain et al[84]	VBG-minilap	4.30%	782
Victorzon & Tolonen[121]	LAGB	5%	60
Cucchi et al[132]	RYGB	5%	100
Naslund et al[90]	VBG	5.6%	198
Suter et al[115]	LAGB	6%	150
†Peternac et al[29]	LAGB-supra	6%	66
Berrevoet et al[22]	LAGB	Lap I: 6.0%	50
		Lap II: 6.9%	29
		*SAGB: 0%	41
Hall et al[58]	RYGB	6.1%	99
Mason et al[89]	VBG	8.5%	47
MacLean et al[60]	VBG	9.3%	54
Van Gemert et al[101]	RYGB	10%	20
Fox et al[100]	VBG	11%	75
Silva et al[110]	LAGB	11.1%	18
Suter et al[93]	VBG	11.8%	197
Wyss et al[103]	VBG	12%	100
Hall et al[58]	VBG	14.2%	106
Sugerman et al[61]	VBG	15%	20
Urbain et al[84]	VBG	19.74%	111
‡Van Gemert et al[101]	VBG	31%	116
De Maria et al[95]	LAGB	41.2%	36
Morino et al[54]	LAGB	66.7%	15
†Peternac et al[29]	LAGB-trans	71%	17

*Swedish adjustable gastric band (SAGB). Lap = Lap-band® (I = no retro-gastric tunneling; II = retro-gastric tunneling) †Sig difference between LAGB treatment groups, $P < 0.001$. ‡Kaplan-Meier analysis suggests 56% of VBG will require revision over 12-year period.

outcomes between RYGB and LAGB patients.[24] At 2-year follow-up, it found that patients treated with LAGB were significantly more likely to report a greater disparity between their current weight and their ideal weight, and scored more poorly on a range of measures. Additionally, they had a significantly less positive evaluation of the surgery when compared to the RYGB group; scored significantly worse on the Eating Disorder Inventory Scales of Drive for Thinness, Bulimia, and Body Dissatisfaction; and possessed a greater self-reported capacity to consume mixed fruit, hamburger, ice cream, and pancakes.

A large number of case series reported postoperative increases in quality of life or satisfaction with operative outcomes for VBG[85-87,91] (particularly for those patients who could be counted as operative successes[103]), RYGB,[74,78,104-106] and LAGB.[37,38,40,107]

Resolution of comorbidities. Numerous studies have documented the benefits patients receive in terms of improvements in their comorbidities after obesity surgery, whether in regard to asthma (after RYGB,[57,78] RYGB and VBG,[58] LAGB[37,108]), diabetes (after RYGB,[57,68,76-79,83] RYGB and VBG,[58] LAGB,[37,42] VBG[91]), hypertension

Table XIII. Duration of hospital stay (shortest to longest)

Study	*Operation*	*Mean duration in days*	*Range in days*	*n*
Furbetta et al[120]	LAGB	95% discharged day 1		201
Niville et al[27]	LAGB	1.17	1-6	126
Rubin et al[119]	LAGB	1.2	1-5	109
Abu-Abeid et al[41]	LAGB	1.2	0-8	391
Fielding et al[16]	LAGB	*1.4	0-4	335
Catona et al[124]	LAGB	1.5	1-3	85
Rutledge[77]	RYGB-Lap	1.5 ± 1.6	. . .	1274
Higa et al[131]	RYGB	No mjr comp. 1.6		400
		Mjr complication 2.7		
Ashy et al[17]	LAGB	. . .	1-2	30
Favretti et al[35]	LAGB	2	1-10	260
Hallerbäck et al[123]	LAGB	†2	1-5	57
Westling et al[133]	LAGB	†*Lap: 2	1-4	47
		Converted: 4	3-7	16
Nowara[55]	LAGB	2.2	. . .	108
Paganelli et al[118]	LAGB	2.3 ± 0.9	. . .	156
Fried et al[18]	LAGB	†2.4		11
Bakr et al[45]	LAGB	2.7	2-7	39
Gawdat[134]	VBG	2.9	. . .	21
Cadiere et al[46]	LAGB	3	2-10	652
Victorzon & Tolonen[121]	LAGB	*3	2-53	60
Angrisani et al[135]	LAGB	3 (± 1)		6
Urbain et al[84]	VBG-minilap	3.0	2-30	782
Toppino et al[31]	LAGB	3.1	1-11	361 (14†)
Fox et al[100]	VBG	3.2	. . .	75
Nehoda et al[20]	LAGB	3.4	2-5	80
Suter et al[30]	LAGB	3.5	2-11	76
Berrevoet et al[22]	LAGB	Lap I: 3.7		50
		Lap II: 3.3		29
		†SAGB: 3.4††		41
Doldi et al[50]	LAGB	3.8	3-6	109
Fox et al[100]	RYGB	3.8	. . .	57
O'Brien et al[94]	LAGB	3.9 (± 0.9)	1-7	Last 140
Nguyen et al[66]	RYGB-Lap	4.0 ± 3.7	. . .	35
Matthews et al[73]	RYGB	4	2-11	48
Taskin et al[125]	LAGB	4	3-9	50
Dargent et al[47]	LAGB	4.2		500
Miller et al[53]	LAGB	Lap-band®: 4.3	2-10	156 (total)
		†SAGB: 3.3	2-8	
Schlumpf et al[56]	LAGB	4.6 ± 2.1	3-8	14
Holeczy et al[116]	LAGB	4.68	3-7	25
Silva et al[110]	LAGB	5	4-6	18
Urbain et al[84]	VBG	5.1	4-90	111
Weiner et al[38]	LAGB	5.5		184
Gawdat[134]	RYGB	5.8	. . .	4
De Wit et al[114]	LAGB	5.9	4-10	25
Toppino et al[31]	VBG	6.5	2-25	120
De Jonge et al[48]	LAGB	*7	5-55	91
Morino et al[54]	LAGB	7.2	5-14	15
Papavramidis et al[91]	VBG	7.94 ± 4.2	. . .	160
	VBAP	6.92 ± 3.2	. . .	
Hall et al[58]	VBG	*8	5-68	106
	RYGB	*8	6-29	99
Balsiger et al[68]	RYGB	*8	4-64	191
Balsiger et al[86]	VBG	8	6-29	73
§Nyugen et al[66]	RYGB-open	8.4 ± 3.2	. . .	35

(continued)

Table XIII. *(continued)*

Study	Operation	Mean duration in days	Range in days	n
Fried et al[18]	VBG	9.2	. . .	52
Suter et al[93] & Suter et al[30]	VBG	11.4	6-45	197
Hernandez-Estefania et al[88]	LAGB	11.8 ± 5.4	. . .	67
Ashy et al[17]	VBG	. . .	7-10	30

*Median.
†Swedish adjustable gastric band (SAGB).
††Nonsignificant difference between groups. Lap = Lap-band® (I = no retro-gastric tunneling; II = retro-gastric tunneling). (±) = standard deviation.
§Lap vs Open, $P < 0.05$.

(after RYGB,[57,68,76-78,83,109] RYGB and VBG,[58] LAGB,[37,42,110] VBG[91]), hyperlipidemia (after RYGB,[57,77,78,83,109] LAGB and VBG,[21] VBG[91]), osteoarthritis (after RYGB,[57,77,78,83] RYGB and VBG,[58] LAGB[42,110]), sleep apnea (after RYGB,[57,77,78,83] LAGB[42,110,111]), venous stasis (after RYGB[57]), congestive heart failure (after RYGB[57]), cardiac arrhythmia (after RYGB[57]), reflux (after RYGB,[77,83,112] LAGB[113]), dependence on anti-inflammatories (after RYGB[68]), Pickwickian syndrome (after VBG[91]), and others.[77,78,83,91,110] There have, however, been few comparative studies, and only 1 was found for this review that performed any statistical analysis, finding no significant differences between LAGB, VBG, and RYGB in terms of improvement in medical conditions.[19] Another study reported improvements in a range of comorbidities in patients treated with VBG or RYGB, although no statistical analysis was performed.[64] Niville et al[27] varied the LAGB technique by raising the placement of the band to create "laparoscopic adjustable esophageal gastric banding," with the result that patients suffering reflux symptoms declined from 4 of 10 to 0 of 27. Again no statistical analysis was performed on this result.

DISCUSSION

It is unfortunate that so few studies comparing LAGB with other obesity procedures exist, but even given this lack of high-quality data, the sheer volume of evidence now being collected regarding LAGB and its alternatives allows some light to be shed on the issue of its safety and efficacy. Despite the clear lack of almost any comparative safety data, the abundant case series suggest that there is no increased risk of short-term harm associated with LAGB when compared with either VBG or RYGB. Indeed, to the contrary, there is a reasonable volume of evidence to suggest that in the short term, LAGB is safer than its comparator procedures with regard to both mortality and morbidity. This is not surprising, considering the minimally invasive nature of the surgery and preservation of normal gastrointestinal continuity. This also seems to be supported by evidence from larger LAGB series, in which morbidity rates remain uniformly low, whereas RYGB and VBG would seem to be procedures that retain a higher risk of morbidity than LAGB, even with considerable numbers of patients treated.

Additionally, the types of morbidities associated with each procedure appear to reflect what would be expected: that LAGB is associated with complications relating to misplacing or inadequately securing the device to the stomach; VBG and RYGB are both associated with "large incision" type complications as well as breakdowns in the staple-line formed by partitioning the stomach; and patients undergoing RYGB appear to be at higher risk of the sorts of metabolic derangements that are associated with malabsorption.

The evidence is abundant, but it is of low quality. The longer term follow-up for many of the comparator procedures may explain, at least in part, some of the higher mortality and morbidity rates reported here; simply with more time to measure, there is a greater risk of things going wrong. With follow-up periods up to almost three times the duration of those available for LAGB, the comparators may be demonstrating that patients who have undergone obesity surgery may be at an incrementally accumulating risk. Certainly there is good evidence that patients treated with VBG are at significantly higher risk of requiring the reversal or revision of the procedure with lengthening time. RYGB patients do not seem to be as prone to this shortcoming and LAGB patients would appear to be somewhere in between, although there are, of course, only shorter follow-up periods available for LAGB morbidities.

Regardless, the length of follow-up would not explain the apparent short-term safety benefit that appears to accrue to LAGB.

With regard to weight loss, it is clear that all 3 procedures examined here are capable of producing sustained weight loss, at least over 4 years in the case of LAGB and up to 10 and 14 years in the case of VBG and RYGB, respectively.

As to their respective merits, there appears to be some overlap in potential, but the few comparative data available would suggest that RYGB offers superior weight loss in the first 2 years compared with either of the alternatives, which appear more or less equivalent. In all the papers in which LAGB and VBG are compared, there is no suggestion of LAGB's superiority at achieving weight loss in comparison to VBG. Admittedly, the very short-term comparative results for LAGB and VBG (fewer than 18 months) are probably not meaningful since the gastric band is only gradually inflated in the short term. But even if the 4 studies with the longest follow-up periods of 20 months (Wolf et al[21]), 24 months (Fried et al[26] and Suter et al[30]), and 40 months (Hell et al[19]) are considered, there is no case in which the mean weight loss for LAGB is superior to that achieved by VBG. In none of these cases was there any significant difference in the weight loss scores for LAGB and VBG. Indeed, in each case the mean weight loss score for LAGB was nonsignificantly less than that achieved for VBG; Hell et al[19] report a mean BAROS weight loss points of 1.5 for LAGB compared with 1.6 for VBG at 40 months. Fried et al[26] report a mean weight loss of 37.2 kg for LAGB compared with 40.5 for VBG at 24 months; Suter et al[30] report higher mean BMI, less excess weight lost, and a less satisfactory percentage of ideal weight being reached by LAGB patients when compared with VBG patients. Wolf et al[21] found a higher proportion of VBG patients lost larger percentages of excess weight than LAGB patients at 20 months. Because none of these results is statistically significant, they suggest at best a cautious statement of equivalence between VBG and LAGB in terms of weight loss outcomes within the first couple of years.

Across all studies in which VBG and RYGB are compared, there is strong evidence of RYGB's superiority at achieving weight loss in comparison to VBG. Five studies conducted statistical analysis of weight loss outcomes for VBG compared only with RYGB. Four of these found RYGB to be significantly more effective at producing weight loss than VBG for follow-up periods of 2 years (Sjostrom et al[96]), 3 years (Sugerman et al[61]), and 5 years (Howard et al,[59] and Capella and Capella[62]). The fifth study, with a follow-up period of only 18 months, found a significant weight reduction benefit for RYGB in men, if not women.[97] In addition, of course, there is also Hell et al's[19] study comparing all 3 surgical procedures, and which also reported a statistically significant superiority for RYGB over VBG.

It seems logical that if LAGB is less effective than or equally effective as VBG at producing weight loss, and VBG is significantly less effective than RYGB at producing weight loss, then LAGB is less effective than RYGB. This would at least appear to be the case at 2 years.

Considering the increased risk of morbidity associated with VBG, along with the high likelihood of surgical failure and the requirement for the procedure to be revised, it would seem preferable to use either the LAGB or RYGB, the former for its safety (at least in the short term) and the latter for its efficacy. A caveat to this observation is the lack of comparable long-term data available for the LAGB. The device may demonstrate an equal or greater requirement for surgical revision as VBG in the future, although there is inadequate published evidence at the moment to lend this speculation any weight. LAGB's potential for sustained weight loss after 4 years is also unclear, and it may possibly disappoint. Equally, it may prove to be efficacious in producing weight loss at least as effectively as VBG.

ASERNIP-S rating. The ASERNIP-S review group allocated the following evidence, safety and efficacy classifications for laparoscopic adjustable gastric banding:

- Level of evidence is considered to be average for up to 4 years' follow-up.
- LAGB is safer than VBG and RYGB, in terms of short-term mortality rates.
- LAGB is effective in achieving weight loss, at least up to 4 years, as are the comparator procedures. Up to 2 years, the laparoscopic gastric band results in less weight loss than RYGB; from 2 to 4 years, there is insufficient evidence to conclude that Roux-en-Y remains more effective than LAGB.
- Recommendations: Long-term efficacy of LAGB remains unproven and further evaluation by randomized controlled trials is recommended to define its merits relative to the comparator procedures.

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