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ORIGINAL CONTRIBUTIONS

Scientific Evidence for the Updated Guidelines on Indications for Metabolic and Bariatric Surgery (IFSO/ASMBS)

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Abstract

The 2022 American Society of Metabolic and Bariatric Surgery (ASMBS) and International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) updated the indications for Metabolic and Bariatric Surgery (MBS), replacing the previous guidelines established by the NIH over 30 years ago. The evidence supporting these updated guidelines has been strengthened to assist metabolic and bariatric surgeons, nutritionists, and other members of multidisciplinary teams, as well as patients. This study aims to assess the level of evidence and the strength of recommendations compared to the previously published criteria.

Keywords Obesity · Metabolic and bariatric surgery · IFSO · ASMBS · Guidelines · Indications

Abbreviations

AAHKS	American Association for Hip and Knee Surgeons
ACS-NSQIP	American College of Surgeons National Surgical Quality Improvement Program
AGB	Adjustable gastric banding
ASMBS	American Society for Metabolic and Bariatric Surgery
BMI	Body mass index
BPD	Bilio-pancreatic diversion
EAES	European Association for Endoscopic Surgery
EASO	European Association for the Study of Obesity
EBMIL	Excess of BMI loss
EWL	Excess weight loss
GI	Gastrointestinal
GRADE	Grading of Recommendations, Assessment, Development and Evaluations
HF	Heart failure
HTN	Hypertension
IFSO	International Federation for the Surgery of Obesity and Metabolic Disorders
LOS	Length of stay
LVAD	Left ventricular assist device
LVEF	Left ventricular ejection fraction
MACE	Major adverse cardiovascular event
MAFDL	Metabolic dysfunction–associated liver disease
MBS	Metabolic bariatric surgery
MBSAQIP	Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program
MDT	Multidisciplinary team
NIH	National Institute of Health
OAGB	One anastomosis gastric bypass
OSA	Obstructive sleep apnea
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses

This paper was jointly developed by the American Society for Metabolic and Bariatric Surgery and International Federation for the Surgery of Obesity and Metabolic Disorders and jointly published in Surgery for *Obesity and Related Diseases* and *Obesity Surgery*. The articles are identical except for minor stylistic and spelling differences in keeping with each journal's style. Either citation can be used when citing this article.

Extended author information available on the last page of the article

PWS	Prader Willi syndrome
RCT	Randomized controlled trial
RWG	Recurrent weight gain
RYGB	Roux en Y gastric bypass
SADI-S	Single anastomosis duodeno-ileal bypass with sleeve gastrectomy
SBO	Small bowel obstruction
SG	Sleeve gastrectomy
SOT	Solid organ transplantation
T2DM	Type 2 diabetes mellitus
TKA	Total knee arthroplasty
TWL	Total weight loss
VHR	Ventral hernia repair
WHO	World Health Organization

Introduction

Since its inception in the mid-1950s, gastrointestinal surgery to treat excess adiposity and associated medical conditions has significantly changed [1]. Weight loss surgery, in its early history, lacked regulation, was associated with a high risk of adverse events, and had a high rate of recurrent weight gain (RWG). There were no uniform guidelines for patient selection, preoperative work-up, procedure selection, and long-term follow-up. These deficiencies contributed to the high rates of suboptimal outcomes.

To create uniform criteria for bariatric surgery, in 1991, the National Institute of Health (NIH) in the USA held a consensus conference on gastrointestinal (GI) surgery for the treatment of severe obesity [2]. A multidisciplinary panel of "experts" reviewed the available peer-reviewed literature and patient experience and created the first criteria for the practice of metabolic bariatric surgery (MBS). However, since 1991, there have been dramatic changes in the field of MBS, including fellowship training, accreditation of MBS centers of excellence, development of MBS registries, the introduction of minimally invasive surgery, and new procedures such as sleeve gastrectomy (SG), and dramatic improvements in perioperative and long-term patient care and safety. Despite these improvements in surgical techniques and perioperative care for patients undergoing MBS, the reliance on the 1991 NIH criteria for determining patient candidacy for surgery remained unchanged, and surprisingly, it is still in wide use more than 33 years later.

In 2022, a group of metabolic bariatric surgeons and other clinicians caring for people with obesity recognized that the 33-year-old guidelines based on expert opinion in the era of open surgery did not reflect the current published literature or state of the field. There was a growing interest in revisiting the 1991 NIH criteria and revising it to reflect MBS's current practice.

The two largest MBS organizations in the world, the American Society for Metabolic and Bariatric Surgery (ASMBS) and the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO), agreed to partner to create new guidelines that would be evidence-based and rely on the most up to date high quality published literature along with current expert global practice. The group searched the literature for high-level evidence using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [3]. Without supportive literature, a Delphi survey of experts in the field was performed [4]. Systematic reviews were performed on 13 topics highlighted in the recently published MBS guidelines. This study aimed to determine the level of evidence and the grade of the recommendations of these 13 previously published criteria [5, 6]. Tables 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and 13

Methods

In order to methodologically support the previously published ASMBS/IFSO guidelines, two international teams of writers were created.

One team of seven researchers (MDL, GM, AI, GP, ST, SC, AV) performed a systematic search of high-level evidence for different items, according to the PRISMA (see *PRISMA Prospect*). Two independent researchers analyzed each article, first by title and abstract and subsequently by the full text, and extracted the relevant data. In case of disagreement, a third researcher (MDL) was consulted.

Eventually, 12 different systematic reviews from the 13 PRISMA were carried out. PRISMA on item 2 (BMI 35–40 kg/m^2 without obesity-associated medical problems) produced no studies.

The level of evidence and grade of recommendation are categorized in Table 14.

The second team (MDL, MK, ST) was tasked to resolve any issues not answered by the systematic reviews. For these situations, a Delphi survey was constructed and consisted of two consecutive rounds. Forty-nine recognized MBS experts from 18 countries participated in this Delphi survey to address nine statements that did not have strong backing from the literature search (Table 2 and Table 15). Consensus was reached when the agreement/disagreement rate was equal to or greater than 70%. An online platform (Survey Monkey on https://www.surveymonkey.com/r/MBS-Criteria) was used. Seven statements reached consensus in the first round, and two reached consensus in the second round of voting (Table 2 and Table 15). Statements 1 to 5 referred to item 2 (body mass index [BMI] 35–40 kg/m^2 without comorbidities), and statements 6 to 9 referred to item 6 (joint arthroplasty).

Results

BMI criteria for MBS

1. MBS for BMI 30–34.9 kg/m^2 [7–35]
   PRISMA Appendix 1 [PubMed, Cochrane, Embase]
   Systematic Review Table 1

Table 1 MBS Indications for Individuals with BMI 30-34.9

First author year)	Study design	Quality assessment (NOS)	Asian/non-Asian	Number of surgical patients	BMI	Comparison to non-surgical treatment	Number of non-surgical patients	Intervention	Operative time (min)	Length of stay (days)	Weight loss	Complication Clavien Dindo 1–2	Complications Clavien Dindo 3–4	Complications Clavien Dindo 5 (surgical related mortality)	Nutritional complications
Billeter AT et al. (2022) [7]	Prospective	Good quality	Non-Asian	20	25<BMI<35	NO	N/A	RYGB	Not reported	Not reported	8.3 Δ BMI	5%	5%	0%	Not reported
Chaturvedi et al. (2022) [8]	Retrospective/simulation	N/A	Non-Asian	347	30<BMI<35	NO	N/A	RYGB, SG	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported
Altieri et al. (2022) [9]	Retrospective	Fair quality	Non-Asian	1296	30<BMI<35	NO	N/A	RYGB, SG	Not reported	Not reported	30% BMI loss	Not reported	Not reported	Not reported	Not reported
Singh et al. (2022) [10]	Retrospective	Fair quality	Non-Asian	20	30<BMI<35	NO	N/A	SG	Not reported	Not reported	18% TWL; 70.3% EWL	Not reported	0%	0%	0%
Baldwin et al. (2021) [11]	Retrospective	Fair quality	Non-Asian	30	BMI<35	NO	N/A	RYGB, SG	Not reported	Not reported	20–21% TWL; 83–94% EWL	Not reported	Not reported	Not reported	Not reported
Gupta et al. (2020) [12]	Retrospective	Fair quality	Non-Asian	132	30<BMI<35	NO	N/A	LAGB to RYGB	Not reported	Not reported	44% EWL	7.8%	23.4% <30 days; 50% >30 days	0%	Not reported
Varban et al. (2020) [13]	Retrospective	Fair quality	Non-Asian	1073	BMI<35	NO	N/A	SG	Not reported	3	22% TWL; 71% EWL	0.7%	3.4%	0%	Not reported
Navarette Aulestia et al. (2020) [14]	Prospective	Fair quality	Non-Asian	16	30<BMI<35	NO	N/A	OAGB	70	2	87.6% EWL	0%	0%	Not reported	Not reported
Gamme et al. (2019) [15]	Retrospective	Good quality	Non-Asian	9094	30<BMI<35	Comparison to Class II	9094	RYGB, SG	82	1.6	Not reported	0.9%	3.9%	0%	Not reported
Feng et al. (2019) [16]	Retrospective	Good quality	Non-Asian	8628	30<BMI<35	NO	N/A	RYGB, SG	80	1.6	Not reported	0.6%	0.7%	0%	Not reported

Table 1 (continued)

First author year)	Study design	Quality assessment (NOS)	Asian/non-Asian	Number of surgical patients	BMI	Comparison to non-surgical treatment	Number of non-surgical patients	Intervention	Operative time (min)	Length of stay (days)	Weight loss	Complication Clavien Dindo 1–2	Complications Clavien Dindo 3–4	Complications Clavien Dindo 5 (surgical related mortality)	Nutritional complications
Vitiello et al. (2019) [17]	Retrospective	Fair quality	Non-Asian	56	30<BMI<35	YES	20	LAGB, RYGB, SG	Not reported	Not reported	69% BMI loss	0%	7%	7%	Not reported
Noun et al. (2016) [18]	Prospective	Fair quality	Non-Asian	541	30<BMI<35	NO	N/A	SG	74	1.7	24% TWL	1.8%	0%	0%	0%
Maiz et al. (2015) [19]	Retrospective	Fair quality	Non-Asian	1119	BMI<35	NO	N/A	RYGB, SG	70	3	107% EWL	3.8%	0.7%	0%	Not reported
Kaska et al. (2014) [20]	Retrospective	Poor quality	Non-Asian	30	30<BMI<35	Comparison to Class II	82	RYGB	Not reported	Not reported	5 Δ BMI	20%	3%	0%	3.6%
Walker et al. (2014) [21]	Prospective	Fair quality	Non-Asian	52	30<BMI<35	NO	N/A	LAGB to RYGB	105	3	3 Δ BMI	5%	20%	0%	Not reported
Boza et al. (2014) [22]	Prospective	Fair quality	Non-Asian	100	BMI<35	NO	N/A	RYGB	110	3	93% EWL	5%	9%	0%	Not reported
Scopinaro et al. (2014) [23]	Retrospective	Fair quality	Non-Asian	10	30<BMI<35	NO	N/A	BPD	Not reported	Not reported	6 Δ BMI	40%	40%	0%	Not reported
Serrot et al. (2011) [24]	Retrospective	Fair quality	Non-Asian	17	30<BMI<35	YES	17	RYGB	Not reported	Not reported	70% EWL	11.7%	11.7%	0%	0%
Gianos et al. (2011) [25]	Retrospective	Fair quality	Non-Asian	42	30<BMI<35	YES	17	LAGB, RYGB, SG	Not reported	Not reported	7–8 Δ BMI	Not reported	Not reported	Not reported	Not reported
Choi et al. (2010) [26]	Retrospective	Fair quality	Non-Asian	66	30<BMI<35	Comparison to Class II	438	AGB	Not reported	Not reported	40% EWL	4.5%	1.5%	0%	Not reported
Varela et al. (2011) [27]	Retrospective	Fair quality	Non-Asian	10	30<BMI<35	Comparison to Class II	20	AGB	118	1.3	20% TWL	0%	0%	0%	Not reported

Table 1 (continued)

First author year)	Study design	Quality assessment (NOS)	Asian/non-Asian	Number of surgical patients	BMI	Comparison to non-surgical treatment	Number of non-surgical patients	Intervention	Operative time (min)	Length of stay (days)	Weight loss	Complication Clavien Dindo 1–2	Complications Clavien Dindo 3–4	Complications Clavien Dindo 5 (surgical related mortality)	Nutritional complications
Scopinaro et al. (2011) [28]	Retrospective	Fair quality	Non-Asian	40	25<BMI<35	NO	N/A	BPD	Not reported	Not reported	5 Δ BMI	0%	2.5%	0%	2.5%
De Maria et al. (2010) [29]	Retrospective	Fair quality	Non-Asian	235	BMI<35	NO	N/A	AGB, RYGB	Not reported	Not reported	4 Δ BMI	10%	1.3%	0%	Not reported
Parikh et al. (2010) [30]	Prospective	Fair quality	Non-Asian	93	30<BMI<35	NO	N/A	AGB	Not reported	Not reported	54% EWL	1%	3.2%	0%	Not reported
Sultan et al. (2009) [31]	Prospective	Fair quality	Non-Asian	53	30<BMI<35	NO	N/A	AGB	Not reported	Not reported	69.7% EWL	7.6%	1.9%	0%	Not reported
Cohen et al. (2006) [32]	Retrospective	Fair quality	Non-Asian	33	30<BMI<35	NO	N/A	RYGB	56	3	81%	0%	0%	0%	0%
Angrisani et al. (2004) [33]	Retrospective	Fair quality	Non-Asian	225	BMI<35	NO	N/A	AGB	Not reported	Not reported	5.2%	2.8%	0%	0%	Not reported
Cevallos (2021) [34]	Prospective	Fair quality	Non-Asian (Latinos)	51	30<BMI<35	NO	N/A	RYGB	Not reported	Not reported	25% TWL; 74% EWL	0%	1.9% <30 days; 7.8% >30 days	0%	0%
Espinosa (2018) [35]	Prospective	Fair quality	Non-Asian (Latinos)	23	30<BMI<35	NO	N/A	RYGB	168	3.2	24% TWL	13%	0%	0%	Not reported
				23,452											

Forty-three articles were included in the present review, 29 (69%) were conducted on non-Asian patients [7–35] and 13 (31%) on Asian patients.

Nine retrospective (31%) and 20 (69%) prospective studies reported MBS results. All articles had a good/fair quality. Two articles investigated the effects of surgery on patients with BMI <30 kg/m^2, four papers compared outcomes in low BMI with results in patients with severe obesity, and three other studies made a comparison with lifestyle intervention.

Seventeen articles reported results after Roux-en-Y gastric bypass (RYGB), 11 after SG, 1 after one anastomosis gastric bypass (OAGB), 2 after biliopancreatic diversion (BPD), 7 after adjustable gastric banding (AGB), and 2 after revisional surgery from AGB to RYGB with an overall medium follow-up of 29.3 [12–120] months.

Operative time and length of stay (LOS) appeared comparable to available data in the literature for MBS in BMI ≥35 kg/m^2. All articles reported satisfactory weight loss with no mortality. Clavien–Dindo complications grades 3–4 ranged from 0 to 40% (40% in a paper on BPD complications). A higher complication rate was reported after revisional surgery. Remission from type 2 diabetes mellitus (T2DM) and hypertension (HTN) ranged from 33 to 100% and from 28 to 100%, respectively.

Recommendation

- *MBS is recommended for patients with T2DM and a BMI of 30–34.9 kg/m^2.*
- *MBS is recommended for patients with a BMI of 30–34.9 kg/m^2 and one obesity-associated medical problem.*
- *MBS should be considered in patients with a BMI of 30–34.9 kg/m^2 who do not achieve substantial or durable weight loss or co-morbidity improvement using nonsurgical methods.*

Level of Evidence 2a
Grade of recommendation B

2. MBS for BMI 35–40 kg/m^2 without obesity-associated medical problems

PRISMA Appendix 2 [PubMed, Cochrane, Embase] not enough studies

No Systematic Review Delphi Table 2

Although previous studies support the superiority of MBS compared to non-surgical therapy in patients with BMI ≥35 kg/m^2 with no obesity-associated complications, there is a lack of high-grade evidence to support this item. Considering the lack of data from the literature, the leaderships of IFSO and ASMBS have convened a Delphi survey. According to the survey results of 49 experts, MBS is indicated in patients with class II obesity, a BMI of 35–40 kg/m^2, with no associated medical problems in all groups of ages following a comprehensive multidisciplinary team (MDT) assessment. The consensus also supported the fact that MBS is cost-effective in patients with class II obesity when compared to non-surgical therapy.

Recommendation

- MBS is recommended for patients with a BMI ≥35 kg/m^2 regardless of the presence, absence, or severity of obesity-related complications.

Level of Evidence 5
Grade of recommendation D

3. BMI thresholds in the Asian population [36–54]

PRISMA Appendix 3

Systematic Review Table 3

Seven retrospective (54%, 2 multicenter) and 6 (46%) prospective studies reported the results of MBS on the Asian population. All articles have a good/fair quality. The articles investigated the effects of surgery on patients with BMI <30 kg/m^2.

Eight articles reported results after RYGB, 5 after SG, 2 after OAGB, and one study after SADI-S with an overall medium follow-up of 33.4 [12–84] months. Operative time and LOS appeared comparable to data already published in the literature for MBS in patients with a BMI >35 kg/m^2.

All articles reported satisfactory weight loss with no mortality. Clavien–Dindo complications grades 3–4 ranged from 0 to 7.3%. Higher long-term nutritional complications were recorded after hypoabsorptive procedures. Remission from T2DM and HTN ranged from 38 to 100% and 30 to 83%, respectively.

Recommendations

- Clinical obesity in the Asian population is recognized in patients with BMI ≥25 kg/m^2. Access to MBS should not be denied solely based on the traditional BMI criteria.

Level of Evidence 2a
Grade of recommendation B

Extreme of Age

4. MBS in the older population [55–72]

PRISMA Appendix 4 [PubMed, Cochrane, Embase]

Systematic Review Table 4

Eighteen papers have been retrieved [55–72] for qualitative analysis. One RCT [56] and one prospective multicenter paper [62] have been found. Papers were categorized as comparative [55, 56, 62–65, 68, 69, 72] and non-comparative [57–61, 66, 67, 70, 71]. In the comparative group, two

Table 2 IFSO/ASMBS Delphi Results of MBS indications individuals with class II obesity with no associated medical problems

Statement	Round 1	Round 2	Final result
1. Metabolic and bariatric surgery (MBS) is indicated in 18–65-year-old individuals with Class II obesity with no associated medical problems (body mass index of ≥ 35 kg/m^2)	95.7% Agree	–	CONSENSUS (AGREE)
2. MBS is indicated in <18-year-old individuals with Class II obesity with no associated medical problems (body mass index of ≥35 kg/m^2)	76.6% Agree	–	CONSENSUS (AGREE)
3. MBS is indicated in >65-year-old individuals with Class II obesity with no associated medical problems (body mass index of ≥35 kg/m^2)	85.1% Agree	–	CONSENSUS (AGREE)
4. MBS is indicated for individuals with Class II obesity and have no associated medical problems following comprehensive multidisciplinary team (MDT) assessment (body mass index of ≥35 kg/m^2)	54.1% Agree	100% Agree	CONSENSUS (AGREE)
5. MBS is cost-effective in individuals with Class II obesity compared to non-surgical therapy	97.8% Agree	–	CONSENSUS (AGREE)

Table 3 BMI thresholds in the Asian population for MBS

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)
Mazidi, 2017 [36]	Prospective	5	152 type II diabetic obese; all RYGB
Osman, 2019 [37]	Prospective	5	17 type II diabetic obese, all SAGB
Ma, 2022 [38]	Retrospective	5	49 T2DM, all SG
Park, 2021 [39]	Prospective non-randomized controlled	5	17 T2DM BMI 30–35 vs 115 medical therapy; 7 RYGB, 10 SG
Luo, 2020 [40]	Retrospective	5	87 T2DM patients, 25 SG, 62 RYGB
Nautiyal, 2019 [41]	Retrospective	5	113 T2DM
Huang, 2020 [42]	Retrospective multicenter db	5	1199 patients BMI >25
Malapan, 2014 [43]	Prospective	5	29 T2DM RYGB
Zuo, 2020 [44]	Retrospective	5	17 RYGB, 3 SG
Zhao, 2018 [45]	Retrospective	5	78 T2DM, RYGB
Fan, 2014 [46]	Retrospective	5	19 BMI <35 lap band
Kim, 2014 [47]	Retrospective	5	107 BMI <30, SAGB
Zhang, 2017 [48]	Retrospective	5	25 T2DM BMI <30 and 28 T2DM BMI <28
Kwon, 2017 [49]	Prospective non-randomized	6	15 T2DM BMI 23–30 RYGB
Du, 2018 [50]	Retrospective	5	58 T2DM BMI 27.5–32.5, RYGB
Liang, 2018 [51]	Retrospective	5	54 BMI <30 T2DM, RYGB
Widjaja, 2020 [52]	Retrospective	5	18 BMI 27.5–30, SG
Yu, 2021 [53]	Retrospective	5	90 RYGB, 22 SG BMI <32.5 T2DM
Mazidi, 2017 [54]	Retrospective	5	209 RYGB

subgroups have been identified: older [age ≥ 65 years old] versus younger age [55, 65, 68, 69, 72]. SG, RYGB, and AGB were more representative surgical operations in these studies [56, 62–64]. The other studies were not comparative.

Five studies compared the intra- and post-operative complications of MBS between the elderly and non-elderly populations [55, 65, 68, 69, 72]. Despite the high-risk populations evaluated, the studies found no differences in postoperative complications, weight loss, and comorbidities resolutions.

Five studies evaluated the efficacy of AGB [57, 60, 61, 65, 71]. Despite its low peri-operative complication rates, all studies concluded that other procedures, such as SG or the RYGB, have better post-operative outcomes regarding weight loss and comorbidity resolution or improvement.

According to Gondal et al. [73], rather than age alone, frailty is independently associated with higher rates of postoperative complications following MBS. Furthermore, when considering MBS in older patients, the risk of surgery should be evaluated against the morbidity risk of obesity-related problems. Thus, there is no evidence to support an age limit on patients seeking MBS, but a careful selection that includes an assessment of frailty is recommended.

Two systematic reviews that included studies with elderly groups aged more than 60 years were found in the literature

Table 4 MBS in the older population

Author, year [ref]	Study design	Quality assessment	Number of patients	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications
Athanasiadis DI, 2021 [55]	Retrospective comparative	9 (MINORS)	29 (LRYGB72.4%/LSG) VS 997 (LRYGB74.6%/LSG)	(72±1.7) VS (44.5±11.5)	48	(41.1±6.8) VS (46.2±8)	NR	BMI loss - 9.6+7.5 VS 10.2+6.5	DM (50%) - HT (92.9%) - HC (84.6%) - OSAS (62.5%) VS DM (37.5%) - HT (66.2%) - HC (41.7%) - OSAS (44.9%)	DM (41.38%) - HT (82.8%) - HC (69%) - OSAS (44.8%) VS DM (20%) - HT (44.9%) - HC (23.4%) - OSAS (12%)	NR	8% VS 6%	NR	38% VS 23% reoperation during 4-year FU
Pajecki D, 2021 [56]	RCT	3 (JADAD)	18 (LSG) VS 18 (LRYGB)	67 (65–69) VS 67 (65–68)	12	41.9 (38–47.1) VS 47.6 (43.1–51.3)	NR	EWL 29.4% - TWL 31.4% VS EWL 60% - TWL 68%	DM (72%) - HT (100%) VS DM (77.7%) - HT (88.9%)	DM (46.15%) - HT (−1 pts) VS DM (85.7%) - HT (−2 pts)	Reported in previous paper	Reported in previous paper	NR	NR
Nor Hanipah Z, 2018 [57]	Retrospective non-comparative	8 (MINORS)	19 (LRYGB 2/LSG 11/LAGB 4/LGP 2)	76 (75–81)	48 (12–120)	41.4 (35.8–57.5)	32.8 (3–5 years)	EWL 5 years 31.4%	DM (58%) - HT (89%) - heart disease (58%) - HC (74%) - COPD (26%) - OSAS (58%)	DM (6/8) - HT (7/8) - HC (0/7)	0	3 FA	0	1-year FU (2 FA and 1 poor intake)

Table 4 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications
Hammond JB, 2020 [58]	Retrospective non-comparative	7 (MINORS)	23 (LRYGB)	72 (70–80)	12	43.3 (37.3–56)	NR	%TWL 29(13–46) - EWL 60 (21–105)	DM (17/23) - HT (22/23) - HC (17/23)	DM (16/17) - HT (27%) - HC (16/17)	NR	1 (aspiration pneumonia)	0	1 poor intake
Gholizadeh B, 2021 [59]	Retrospective non-comparative	7 (MINORS)	61 (OAGB)	67.62±2.03	(12–60)	46.42±5.46	NR	%TWL 60 months (29.56+0.54) - %EWL (70.53+11.87)	DM (60.65%) - HT (72.13%) - HC (45.9%) - GERD (19.67%) - OSAS (18.03%)	12 months DM (70%) - HT (63.41%) - HC (56%) - GERD (100%) - OSAS (100%)	0	4 (2 bleeding - 1 leak - wound infection) - 4 readmission	0	7 (3 hypoalbuminemia - 2 marginal ulcer - 2 perforation of marginal ulcer
Ramirez A, 2012 [60]	Retrospective non comparative	8 (MINORS)	42 (LRYGB (19%)/LSG (28.6%)/LAGB (52.4%))	73.5 (71–80)	12	44 (34–81)	NR	%EWL (LRYGB - 63.6+32.2) - (SG - 34.9+15.4) - (LAGB - 32.8+17)	DM (38.5%) - HT (66%) - HC (57%) - MI (19%) - OSAS (26%)	DM (53%) - HT (56%) - HC (54%) - OSAS (33%)	2 (accidental colotomy)	9	0	NR

Table 4 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications
Daigle CR, 2015 [61]	Retrospective non-comparative	7 (MINORS)	30 (LRYGB 16/ LSG 6/LAGB 8)	67.1±2.7	37 (6–95)	55.9±3.9	42.3±6.7	%EWL (45.1+21.2)	DM (30%) - HT (90%) - HC (53.3%) - OSAS (46.7%)	DM (40%) - HC (50%)	NR	16.7% (Overall 5 - 1 anastomotic leak after LRYGB - 1 FA after LSG- 1 delayed gastric emptying after LAGB - 1 lower limb deep vein thrombosis after LSG - 1 pulmonary embolism after LRYGB)	NR	0
Casillas RA, 2017 [62]	Prospective multicenter	11 (MINORS)	177 (LRYGB) VS 252 (LSG)	(67.5) VS (67.6)	48	(42.6) VS (42.5)	NR	%EWL (66.1%) VS %EWL (42.3%)	DM (57%) - HT (86%) VS DM (53%) - HT (85%)	NR	NR	6 VS 11 (major complications) 12 VS 12 (minor complications)	0 (30 days) 3 LRYGB VS 0 LSG (90 days)	10 VS 20 (major complications) 11 VS 11 (minor complications)

Table 4 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications
Frieder JS, 2021 [63]	Retrospective comparative	12 (MINORS)	244 (LSG) VS 321 (LRYGB)	(71.1±4) VS (71.7±4.54)	24	(40.5±5.5) VS (43.7±7.22)	34.3±6.6 VS 29.6±5.1	%EBMIL (43.9+32.2) VS %EBMIL (77.4+26.1)	DM (67.2%) - HT (61.1%) VS DM (38.6%) - HT (31.8%)	NR	NR	9.4% VS 27.7%	0	NR
Quebbemann B, 2005 [64]	Retrospective comparative	11 (MINORS)	13 (LRYGB) VS 14 (LAGB)	68 (66–73) VS 68 (66–73)	12	(45.8±8.6) VS (48.78±5.7)	NR	%EWL (75) VS %EWL (46)	4.1% VS 3.9%	2.2% left VS 2.8% left	NR	1 (Anastomotic stricture) VS 2 (conversion to LRYGB; port fracture)	0	NR
Quirante FP, 2017 [65]	Retrospective comparative	10 (MINORS)	1220 (252 LRYGB/726 LS/34 LAGB) VS 393 (130 LRYGB/164 LS/43 LAGB)	(<65) VS (>65)	NR	42.2 (IQR 37.8–47.6) VS 41.6 (IQR 37.8–46.1)	NR	NR	DM (59%) - HT (59%) - HC (33%) - GERD (52%) - OSAS (43%) VS DM (59%) - HT (85%) - HC (44%) - GERD (42%) - OSAS (56%)	NR	NR	448 VS 42	NR	NR

Table 4 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications
Lainas P, 2018 [66]	Retrospective non-comparative	8 (MINORS)	54 (LSG)	68 (65–75)	36 (14–62)	43 (35.1–59)	30.7 (23.6–39)	%EWL (76.3 ± 16.5)	DM (70.3%) - HT (90.7%) - HC (42.6%) - OSAS (75.9%)	DM (17.8% left) - HT (10.7% left) - HC (10.7% left) - OSAS (21.4 left)	0	1 (Intra-abdominal hematoma) - 2 (staple line leak) - 2 (other)	0	NR
Danan M, 2019 [67]	Retrospective non-comparative	7 (MINORS)	93 (LSG)	68.8 (65–78)	12	43.6±5.4	30.2 ± 5.7	%EWL (67.1)	DM (20) - HT (51) - HC (17) - OSAS (33)	DM (65%) - HT (72.5%) - HC (47.1%) - OSAS (65%)	NR	1	0	NR

Table 4 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications
van Rutte PW, 2013 [68]	Retrospective comparative	12 (MINORS)	73 (LSG) VS 50 (LSG) VS 12 (LSG)	57 (55–59) VS 62 (60–64) VS 66 (65–70)	14.6	43.8 (29.8–65.1) VS 44.2 (29.8–64.8) VS 45.8 (31.9–65.1)	33.6±6.2 VS 35±5.2 VS 34.2±5	%EWL (55.2%) VS (52.2%) VS (59.9%)	DM (53.4%) - HT (61.7%) - HC (38.4%) - GERD (26%) - OSAS (30.1%) VS DM (54%) - HT (82%) - HC (42%) - GERD (18%) - OSAS (38%) VS DM (58.3%) - HT (100%) - HC (58.3%) - GERD (8.3%) -OSAS (41.7%)	DM (62.3%) - HT (49%) - HC (35.7%) - GERD (36.2%) - OSAS (59.1%) VS DM (25.9%) - HT (53.7%) - HC (47.6%) - GERD (66.7%) - OSAS (60%) VS DM (42.9%) - HT (33.3%) - HC (28.6%) - GERD (0%) - OSAS (60%)	NR	6 (3 Bleeding - 1 leakage - 1 dehydration - 1 cardiac complication) VS 6 (1 Bleeding - 2 Dysphagia - 2 Cardiac complication - 1 pulmonary complication) VS 3 (1 bleeding - 1 dehydration - 1 sepsis)	0	2 (1 Dehydration - 1 incisional hernia) VS 3 (1 dehydration - 2 dysphagia) VS 1 (dysphagia)

Table 4 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications
O'Keefe KL, 2010 [69]	Retrospective comparative	11 (MINORS)	157 (LRYGB) VS 37 (LAGB) VS 6 (LSG)	67.3±2.3	12	48.5±6.6 (157 PTS) VS 45.9±6.9 (34 PTS) VS 50.0±12.0 (6 PTS)	32.7±5.9 (125 PTS) VS 39.4±7.0 (22 PTS) VS 42.0±8.4 (4 PTS)	%EWL (59.8+14.6) VS (33.5+15.8) VS (34.3+19.5)	NR	NR	NR	9 (1 Obstruction - 4 gastrointestinal bleeding - 1 postoperative respiratory failure - 1 pneumonia - 2 myocardial infarction) VS 2 (2 obstruction) VS 2 (1 obstruction - 1 pneumonia)	2 VS 0 VS 0	NR
Garofalo F, 2017 [70]	Retrospective non-comparative	7 (MINORS)	30 (LSG)	67.2 (65–74)	>24	45.1±5.6	NR	% EWL (52.9±21.8) - %TWL (24±9.9)	DM (56.7%) - HT (86.7%) - HC (56.7%) - OSAS (56.7%)	NR	NR	5 (3 minor complications - 2 major complications)	NR	NR

Table 4 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications
Loy JJ, 2014 [71]	Retrospective non-comparative	8 (MINORS)	55 (LAGB)	72.4±2.5	>36	45±6.2	36±6.7 at 2 years	Global mean BMI at 3 years 35+5.6	DM (7%) - HT (89%) - HC (73%) - IMA (29%) - OSAS (56%)	DM (35%) - HT (27%) - HC (28%)	NR	0	0	3 (1 slippage - 1 band intolerance - 1 incisional hernia in port site)
Nevo N, 2019 [72]	Retrospective comparative	11 (MINORS)	66 (LSG) VS 65 (LSG)	(67.6±2.6) VS (38.4±11)	21	(44.2±7) VS (42.7±5.4)	34.2±5.4 VS 29.3±4.7	%EBMIL (77.3) VS (53.5)	DM (63.6%) - HT (75.8%) - HC (53%) - OSAS (31.8%) VS DM (23.1%) - HT (24.6%) - HC (23.1) - OSAS (16.9%)	DM (66.6%) - HT (56.2%) - HC (33.3%) VS DM (59.5) - HT (44%) - HC (74.2%)	0	3 (2 Bleeding - 1 other) VS 3 (1 bleeding - 1 leak - 1 other)	0	8 (5 GERD - 3 stricture) VS 6 (3 GERD - 2 stricture - 1 incisional hernia)

Table 5 MBS for the pediatrics and adolescents

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Paul E. O'Brien, 2015 [76]	RCT	3 (JADAD)	25 (LAGB) VS 25 (lifestyle modification)	(16.5+1.4) VS (16.6+1.2)	24	(42.3+6.1) vs (40.4+3.1)	NR	%EWL 78.8% VS 13.2%	63 total (27HT - 35 HC - 1 glucose intolerance)	LAGB (all solved) - lifestyle 9	0	0	0	8 LAGB (6 proximal gastric enlargement - 2 needle stick injury to tubing)	In this study, gastric banding proved to be an effective intervention leading to a substantial and durable reduction in obesity and to better health. The adolescent and parents must understand the importance of careful adherence to recommended eating behaviors and of seeking early consultation if symptoms of reflux, heartburn, or vomiting occur. As importantly, they should be in a setting in which they can maintain contact with health professionals who understand the process of care. This study indicates that, in such a setting, the laparoscopic adjustable gastric banding process can achieve important improvements in weight, health, and quality of life in severely obese adolescents

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Carbajo M, 2019 [77]	Retrospective non-comparative	8 (MINORS)	39 (OAGB)	17.8 ± 2 (13–19)	60	48.2 ± 5.7	25.9 ± 5.3	%EWL 94.7 ± 17.9 - %TWL 38.8 ± 12.7	DM (7.9%) - HT (10.3%) - HC (23.1%) - joint pain (30.8%) - OSAS (38.5%) -GERD (23.1%) - liver steatosis (38.5%)	DM (100%) - HT (100%) - HC (100%) - GERD (100%)	0	0	0	1 severe anemia due to iron deficiency	OAGB is a valid alternative for long-term weight loss and remission of comorbidities in childhood and adolescence. There are no cases of malnutrition and the scarce vitamin or mineral deficiencies can be controlled with specific supplementation, without affecting normal growth. The measurement of the total bowel length is essential to perform a safe technique and to achieve adequate long-term results

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Dobritoiu D, 2019 [78]	Retrospective non-comparative	7 (MINORS)	64 (2 RYGB - 62 LSG)	Range 12–18	12	39/5	24/92	WL% 36.38	DM (6) - glucose intolerance (6) - HT (6) - HC (27) - OSAS (3) - GERD (14) - liver steatosis (12)	DM (66.6%) - glucose intolerance (100%) - HT (100%) - HC (88.88%) - OSAS (100%) - GERD (64.28%) - liver steatosis (100%)	0	1 prolonged dysphagia	0	Constipation 22 - iron deficiency 6 - folate deficiency 4 - temporary hair loss 12	Bariatric surgery is already an important part of the management of adolescents with obesity. Among techniques available, laparoscopic sleeve gastrectomy proves to be, again and again, a procedure with lower risks and multiple advantages. Like with every surgical procedure, even lower risks appear when patients are managed in centers of excellence, where multidisciplinary team, with pediatrician and pediatric surgeon included, addresses the patient as a whole and collaborates for best results, in the best interest of the patient

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Elhag W, 2017 [79]	Retrospective non-comparative	8 (MINORS)	102 (LSG)	15.99 ± 1.07 (13-17)	24	46.04±5.99	28.3±6.07	%EWL 81.08±19.65	DM (10) - glucose intolerance (17)	DM (80%) - glucose intolerance (100%)	NR	NR	NR	NR	Our findings confirm that, among obese adolescents, LSG achieves significant weight loss and improves anthropometric parameters and 10 cardio-metabolic risk factors, without the development of trace element deficiency after surgery. Conversely, the preoperative nutritional deficiencies (vitamin D, anemia, and hypoalbuminemia) persisted or worsened postoperatively
Elhag W, 2021 [80]	Retrospective non-comparative	8 (MINORS)	146 (LSG) - 12 (REDO)	16.51 ± 1.29	108	46.95 ± 7.28	30.20 ± 3.92	%EWL 136.78 ± 38.69	DM (8) - glucose intolerance (38) - HT (1) - HC (53) - OSAS (0) - GERD (2) - liver steatosis (39) - asthma (13) - depression (1) - hypothyroidism (3)	DM (100%) - glucose intolerance (100%)	NR	NR	NR	NR	The findings of current study represent the first contribution to start an evidence base of the long-term outcomes of LSG among adolescents. LSG resulted in marked and durable weight loss and cardiovascular risk reduction, e.g., amelioration of prediabetes, T2DM, hypertension, dyslipidemia, elevated liver enzymes, and hyperuricemia

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Raziel A, 2014 [81]	Prospective non-comparative	8 (MINORS)	32 (LSG)	16.7 (14–18)	60	43.2 (35–54)	NR	%EWL 101.6	34 [DM (2) - HT (7) - HC (8) - joint pain (10) - asthma (5) - OSAS (2)]	28 [DM (2) - HT (5) - HC (6) - joint pain (10) - asthma (3) - OSAS (2)]	0	1 leak	0	1 cholecystitis	Research evaluating the treatment of morbidly obese adolescents has improved in terms of quality and quantity in the past several years; however, it is still questionable. LSG seems to be an excellent, safe, and efficient bariatric procedure for the treatment of morbid obesity in adolescents
Yitzhak A, 2006 [82]	Retrospective non-comparative	6 (MINORS)	60 (LAGB)	16 (9–18)	39.5	43 (35–61)	30 (20–39)	NR	18 [DM (2) - HT (3) - Asthma (3) - OSAS (10)]	All solved	0	0	0	8 Band slippage	

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Holterman A-X, 2012 [83]	Prospective comparative	10 (MINORS)	18 (11 Morbidly obese VS 7 Superobese) LAGB	16 ± 1 VS 16.6 ± 0.8	18	44 ± 4 VS 61 ± 7.5	NR	%EBMIL 20.5% ± 10.3% VS 22.8% ± 11.6%	Insulin resistance 82% - HC 82 % - NAFLD 91% VS insulin resistance 100% - HC 86% - NAFLD 86%	Insulin resistance 78% - HC 67% - NAFLD NR VS insulin resistance 29% - HC 17% - NAFLD NR	NR	NR	NR	NR	These short-term outcome data of bariatric adolescent patients demonstrating differential and delayed metabolic response of SO adolescents in a gastric banding–based weight loss program despite weight loss provide the rationale for early referral for timely intervention of obesity in adolescents before they progress to the SO state to optimize their metabolic response to bariatric interventions
Holterman A-X, 2010 [84]	Prospective non-comparative	9 (MINORS)	26 (LAGB)	16 ± 1	29 ± 9	50 ± 10	40.6±4.6	%EWL 41 ± 27%	DM 90% - HT 45% - HC 80% - fatty liver 88%	DM 39% - HT 33% - HC 27%	0	0	0	3 wound infection - 2 laparoscopic revisions for 1 band malfunction and 1 hiatal hernia repair	

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Inge TH, 2004 [85]	Prospective non-comparative	6 (MINORS)	20 (RYGB -18 laparoscopic 2 open)	NR	24	NR	NR	%EWL NR	NR	Reported as all pre-operative comorbidities solved	NR	1 gastric remnant leak	NR	1 Roux limb obstruction	Carefully designed clinical studies should be performed to better define the safety of RYGBP in this population and identify which patients will benefit most from gastric bypass, what factors might predict postoperative complications, and what postoperative management approaches are most helpful for adolescents
Jaramillo JD, 2017 [86]	Retrospective non-comparative	8 (MINORS)	38 LSG	16.8 + 1.3	12	46.7 + 5.7	35/5	%EWL 47.7	DM 11 - insulin resistance 9 - HT 13 - HC 22 - fatty liver 5 - OSAS 24	DM 10 - insulin resistance 4 - HT 13 - HC 18 - fatty liver 5 - OSAS 22	0	0	0	0	
Conroy R, 2011 [87]	Prospective non-comparative non-randomized	9 (MINORS)	88 LAGB	16.8±0.1	12	45.9±1	NR	%EWL 17.1 ± 2.2%	NR	NR	NR	NR	NR	NR	

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Riquin E, 2018 [88]	Retrospective comparative	6 (MINORS)	16 LAGB vs 35 lifestyle modification	15.3 ± 1.2	24	40.6±4.4 VS 39.9±4.5	NR	%EWL 42.8% vs 51%	DM 8 - HT 3 - joint pain 7 - OSAS 2 - NAFLD 5 VS endocrine and metabolic 20 - musculoskeletal 17 - respiratory 19	NR	0	0	0	0	In conclusion, this study highlights the usefulness of laparoscopic adjustable gastric band (LAGB) for weight loss and also shows the significant psychiatric vulnerability of severely obese adolescents. Given the vulnerability of the patients in this cohort, we argue that lengthy and close psychiatric follow-up before surgery is necessary
Loy JJ, 2015 [89]	Retrospective non-comparative	8 (MINORS)	52 LAGB	16.1 (14–17.8)	24	48.8±7	36.8±8.2	%EWL 45.7±23.1%	NR	NR	0	0	0	4 slippage	LAGB in suitably selected and counseled adolescents is safe and effective. The excess weight loss observed and the resolution of the components of the metabolic syndrome were significant and seen at 1 year postoperatively. These improvements were sustained at 2 years

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Manco M, 2016 [90]	Retrospective comparative	9 (MINORS)	20 LSG - 20 BIB - 53 lifestyle modification	16.71 (1.44) VS 14.13 (2.12) VS 14.67 (1.89)	12	48.56 (4.15) VS 40.24 (5.02) VS 40.40 (3.55)	38.54 (3.51) VS 38.93 (4.67) VS 39.61 (3.71)	nr	DM 25% - HT60% - HC 60% - OSAS 45% VS DM 20% - HT45% - HC 40% - OSAS 30% VS DM 15 - HT 39.6 - HC 36.3 - OSAS22.6	Left: DM 0% - HT 0% - HC 5% - OSAS 15% VS DM10 - HT 40% - HC 25% - OSAS 20% VS DM 13.6% - HT 22.7 - HC -36.3 - OSAS 27.27	0	0	1 Pneumonia after LSG	0	LSG reverted steatohepatitis and reduced hepatic fibrosis in morbidly obese adolescents with NAFLD 1 year after surgery. It was also beneficial for resolving hypertension and ameliorating dyslipidemia and OSAS. In contrast, lifestyle intervention, alone or in combination with IGWLD, was not able to induce a sustained weight loss and therefore was less effective in reverting liver histology and metabolic abnormalities
Nadler E, 2009 [91]	Prospective non-comparative	9 (MINORS)	54 LAGB	16.1 ± 1.2	24	48.1 ± 6.4	35.8 ± 7.9	%EWL 46.8 ± 21.9	DM 9 - HT 11 - HC 17 - OSAS 5 - GERD 2	DM 9 - HT 11 - HC 12 - OSAS 1 - GERD 2	NR	NR	NR	NR	In summary, we found that the LAGB provides an excellent option for weight loss in the morbidly obese adolescent population. The EWL after LAGB in morbidly obese adolescents is approximately 45% at 1- and 2-year follow-up, with the majority of weight loss consisting of android fat

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Zeller MH, 2009 [92]	Retrospective non-comparative	8 (MINORS)	31 LRYGB	16.4 (1.4)	12	63.5 (10.6)	39.4+7.8	NR	NR	NR	NR	NR	NR	NR	
Xiao N, 2015 [93]	Retrospective comparative	8 (MINORS)	22 Severe obese VS 44 lean	16.5 (15.0, 17.4) VS 16.5 (14.5, 17.0)	12	48.4 (42.0, 51.7)	32.2 (28.6, 37.1)	NR	DM 1 - HT 4	All solved	NR	NR	NR	NR	This study demonstrated that adolescents with severe obesity have sub-clinical kidney injury in the presence of normal kidney function and absence of microalbuminuria. The study also determined that sub-clinical kidney injury persists 1 year after significant weight loss induced by bariatric surgery
Sarwer D, 2017 [94]	Prospective comparative	9 (MINORS)	119 Surgery VS 169 lifestyle modification	17 ± 1.5 vs 15 ± 1.4	24	52 ± 8.9 VS 37 ± 5.2	37.7+8.4 VS 35.8+4.8	%TWL 31.6+1 VS 0.3+0.9	NR	NR	NR	NR	NR	NR	The study had several limitations. Our two groups differed in age, race, gender, and BMI. Since the start of this study, a number of investigations have raised concerns about the accuracy and validity of information that adolescents provide in these interviews, as noted above. (48–51). We also experienced some attrition. While this did not appear to be systematic, it may have biased the results

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Ryder J, 2016 [95]	Prospective non-comparative	8 (MINORS)	206 (139 LRYGB - 56 LSG - 11 LAGB)	17.1 (1.57)	24	51.7 (8.5)	NR	%EBMIL 40.3%	NR	NR	NR	NR	NR	NR	Bariatric surgery in adolescents with severe obesity significantly improves resting HR, completion time of a standardized 400-m walk test, and immediate post-test HR response, and reduces walking-related musculoskeletal pain complaints at 6 months post-surgery. These meaningful improvements were maintained up to 2 years post-surgery. Whether these positive changes in functional mobility and musculoskeletal pain persist over the long-term and lead to further improvements in cardiometabolic risk requires evaluation

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Alqahtani AR, 2016 [96]	Retrospective comparative	9 (MINORS)	24 LSG in PW vs 72 LSG non-PW	NR	60	46.4 ± 12.0 VS 46.4 ± 11.7	35.9 ± 12.5 VS 25.1 ± 7.0	%EWL 38.4 ± 25.6 VS 75.4 ± 28.3	Only in PW (DM 6 - HT 10 - HC 15 - OSAS 24)	DM 6 - HT 7 - HC 9 - OSAS 21	0	0	0	0	In our experience, LSG is a well-tolerated, effective treatment option for severely obese PWS patients. The surgical procedure similarly resulted in significant weight loss and maintained resolution of co-morbidities in both study participant groups (PWS and non-syndromic obese patients), particularly with limited other options for treatment of marked obesity. Nevertheless, long-term studies are needed to confirm the durability of this weight loss, the co-morbidity resolution, and long-term complications
Reiter-Purtill J, 2020 [97]	Retrospective comparative	9 (MINORS)	139 Surgery (88 LRYGB - 50 LSG - 3 LAGB) VS 83 lifestyle modification	16.86±1.39 VS 16.11±1.40	24	51.52±8.32 VS 46.85±6.12	36.01±8.55 VS 48.65±8.37	NR	NR	NR	NR	NR	NR	NR	The inclusion of patient-reported outcomes such as QOL is vital to fully understand the “success” of bariatric surgery, with promotion of QOL identified as a primary goal of Healthy People 202

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Xanthakos S, 2020 [98]	Prospective comparative	10 (MINORS)	226 (161 LRYGB - 65 LSG)	16.6 (1.6) VS 16.4 (1.6)	60	53.7 (9.6) VS 50.2 (8.3)	39.0 (32.0, 48.2) VS 37.0 (32.1, 40.8)	NR	(DM16% - HT 46% - HC 79% - GERD 12% - liver steatosis 44%) VS (DM11% - HT 36% - HC 70% - GERD 16% - liver steatosis 28%)	NR	NR	NR	NR	NR	In a prospective study of adolescents who underwent RYGB or VSG, we observed nutritional deficiencies by 5 years after the procedures—particularly in iron and vitamin B_{12} after RYGB

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Nehus EJ, 2017 [99]	Prospective non-comparative	8 (MINORS)	242 (140 LRYGB - 52 LSG - 14 LAGB)	17/1	36	50.5 (45.2, 58.3)	36.2 (30.2,44.9)	NR	DM 30 - HT 104 - HC 179	DN 29 - HT 75 - HC 125	NR	NR	NR	NR	In conclusion, we report 3-year kidney outcomes of the largest study to date of adolescents undergoing bariatric surgery. Kidney function and albuminuria improved following weight loss surgery in those participants with evidence of pre-operative kidney disease. Furthermore, BMI levels of greater than 40 kg/m^2 at follow-up were associated with a progressive decline in kidney function. These data support the addition of kidney dysfunction as a selection criterion for bariatric surgery in adolescents who reach a BMI of 40 kg/m^2 to optimize chances for reversal of severe obesity and kidney risks

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Kaar J, 2021 [100]	Retrospective non-comparative	8 (MINORS)	81 (LSG)	16.9 ± 2.0	36	47.9 ± 7.3	37.2 ± 5.1 in 15 pts with OSAS remission	TWL −27% in patient with OSAS remission and −25% in patient without OSAS remission	DM 16 - HT 20 - OSAS 44	OSAS 15	NR	NR	NR	NR	Over half of our adolescents with severe obesity undergoing MBS had a diagnosis of OSA. Of those adolescents who had completed a post-operative PSG, almost two-thirds had remission of OSA following surgery. Those with higher baseline BMIs may be less likely to achieve remission. Obtaining both pre- and post-MBS PSGs is recommended for routine clinical care to accurately identify patients with OSA to promote positive health outcomes
Derderian SC, 2020 [101]	Prospective comparative	9 (MINORS)	192 (140 LRYGB - 52 LSG) (114 greater weight loss VS 78 small weight loss)	16.7 (1.56) VS 16.1 (1.60)	60	52.6 (9.40) VS 53.2 (10.0)	NR	%TWL 34.1 ± 9.5% VS 25.6 ± 7.9% (at 1-year follow-up) 33.8 ± 9.2% VS 8.6 ± 9.5% (at 5 years)	(DM 12 - HT 37 - HC 87) VS (DM 13 - HT 29 - HC 57)	(DM 10 - HT 27 - HC 62) Vs (DM 8 - HT 17 - HC 28)	NR	NR	NR	Weight regain in lower weight loss group	These results emphasize the metabolic benefit of bariatric surgery. Whether modest weight loss (5–10% total body weight loss) achieves similar metabolic benefits is an area of future research

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Nobili V, 2017 [102]	Prospective non-comparative	8 (MINORS)	20 (LSG)	16.71 ± 1.44	12	49.3 ± 4.8	37.5 ± 5.3	NR	20 NAFLD						In conclusion, our findings suggest a mechanistic explanation of the beneficial effect of LSG-associated weight loss on liver histology in adolescent NAFLD and highlight that the histologic improvement induced after LSG is associated with the activation state of local cellular compartment and their crosstalk
Kalra M, 2005 [103]	Retrospective non-comparative	7 (MINORS)	35 (LRYGB)	17.57 ± 1.82	12	60.8 ± 11.07	41.6 ± 9.5	%EBMIL	OSAS 19	OSAS 10	NR	NR	NR	NR	In summary, our study indicated that OSA was highly prevalent in extremely overweight adolescents meeting eligibility criteria for bariatric surgery. The significant weight loss after bariatric surgery was associated with either the resolution of OSA in a majority or a significant reduction in OSA severity

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Watanabe Y, 2022 [104]	Retrospective comparative	8 (MINORS)	122 Childhood obesity VS 183 post-puberty obesity (LSG)	<13years VS >13years	36	43.8 (38.6–50.6) VS 40.3 (36.7–45.7)	−13.9±0.6 VS −12.9±0.5	%TWL (30.1±11.7 VS 29.7±10.6)	(DM 60.7% - HT 73.7% - HC 98.4% - OSAS 68.9%) VS (DM 67.2% - HT 81.8% - HC 95.1% - OSAS 75.4%)	(DM 83.6% - HT 47.4% - HC 57.7% - OSAS 58.4%) VS (DM 77.1% - HT 32.1% - HC 65.6% - OSAS 66.2%)	NR	NR	NR	NR	In conclusion, this study suggests that severely obese patients with childhood onset tend to have more severe and subcutaneous fat-dominant obesity compared to those with post-puberty onset, and subcutaneous fat predominance may be associated with lower HbA1c in those with childhood onset
Hjelmesæth J, 2020 [105]	Prospective comparative	10 (MINORS)	39 (LRYGB) VS 96 (lifestyle intervention)	16.7 (1.0) vs 15.6 (1.3)	12	45.6 (4.4) VS 43.3 (4.1)	31.5 (4.4) VS 42.7 (5.2)	%TWL −30 (−33 - −27) VS 1 (−1 - 3)	(DM 9 - HT 8 - HC 22 - NAFLD 17) VS (DM 15 - HT 19 - HC 65 - NAFLD 43)	(DM 9) vs (DM 8)	0	2 MINOR SURGICAL COMPLICATION	0	Hypovitaminosis (10% anemia - 21% iron deficiency - 10% vitamin B_{12} deficiency)	

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Tashiro J, 2022 [106]	Retrospective comparative	8 (MINORS)	76 (LSG with parent history of bariatric surgery) 184 (without)	16.4 (2.07) VS 16.8 (1.81)	12	50.3 (10.9) VS 47.8 (8.47)	−21.0 (18.1) VS −24.5 (14.7)	%EBMIL 53.4 (19.6) VS 59.6 (25.8)	NR	NR	NR	NR	NR	NR	Programs offering adolescent bariatric surgery, as well as insurance companies, should consider eliminating their minimum age requirement for surgery. Although there were no differences in weight loss outcomes for those patients whose parents have or have not had bariatric surgery themselves, given their heavier size at age of surgery, there may be benefit in ensuring even earlier access to care for these children and adolescents
Lee DY, 2012 [107]	Retrospective comparative	10 (MINORS)	32 (LRYGB) VS 23 (LAGB)	18.6±0.6 VS 17.2±1.5	24	50.6±7.0 VS 47.0±7.4	NR	%EWL 83.4±20.5 VS 29.7±18.9	(DM 3 - HT 6 - HC 2 - OSAS 5) VS (DM 0 - HT 2 - HC 2 - OSAS 3)	(DM 3 - HC 2) VS (HC 1)	0	0	0	1 Gastro-gastric fistula and 1 dehydration in LRYGB 5 iron deficiency 13 vitamin D deficiency VS 2 band removal for slippage 2 IRON DEFICENCY 2 VIT D DEFICENCY	LRYGB achieved superior weight loss in adolescents compared to LAGB in a short-term follow-up in our series. Randomized studies with long-term follow-ups will be needed before definitive recommendations can be made on the appropriate operation for this age group

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Cozacov Y, 2014 [108]	Retrospective non-comparative	8 (MINORS)	18 (LRYGB and LSG)	17/5	54	47.2	30.1		(DM 1 - HT 2 - HC 1 - GERD 4 - OSAS 6)	(DM 1 - HT 2 - HC 1 - GERD 3 - OSAS 3)	0	0	0	1 Heartburn (LSG)	LSG and RYGB are safe and effective, as the long-term success of this study shows, in treating the morbidly obese adolescent population
Peña AS, 2017 [109]	Prospective cohort study	9 (MINORS)	21 (LAGB)	17.4 [16.5–17.7]	45.5 [32–50]	47.3 ± 8.4	35 [32–51]	%BMIL 15 [7.24] - %TWL 16 [7.24]	NR	NR	0	1 Hematoma - 2 food intolerance - 1 infection	0	2 Food intolerance - 7 band removal	We have shown in the longest prospective post-LAGB study in Australian adolescents with severe obesity that LAGB improves BMI in the majority of adolescents with minimal complications. LAGB may be the preferred ‘initial’ operation for adolescents with severe obesity as part of a “stepped up” surgical management plan

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Dumont PN, 2017 [110]	Prospective cohort study	9 (MINORS)	97 (LAGB)	17.2 ± 0.7	56.0 ± 22.0	44.9 ± 6.1	NR	%EWL 46.6 ± 39.5	DM 1 - HT 8 - HC 7 - OSAS 5	DM 1 - HT 8 - HC 1 - OSAS 3	NR	NR	NR	19 Band removal	The effectiveness of LAGB appears to improve over the long term in adolescents. LAGB is a reliable, reversible technique that may be an appropriate and ethical first-line surgical option for obese youth. In the current study of adolescents undergoing LAGB, the procedure was safe and there was a significant positive correlation between excess weight loss and follow-up duration (mean 56.0 ± 22.0 months); overall excess weight loss was 46.6%

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Lainas P, 2019 [111]	Retrospective non-comparative	8 (MINORS)	84 (LSG)	17 [15–17]	24	43.7 [31.5–74.9]	28.8 [21–38.6]	%EWL 79.1 ± 15.5 %TWL 29.1 ± 5.4	DM 88 - HT 12 - HC 5 - GERD 4 - OSAS 22	DM 85 - HT 6 - HC 1 - GERD 2 - OSAS 8	0	1 (Pulmonary complication)	0	NR	This study suggests that LSG is safe and effective for patients under 18 years old, resulting in significant weight loss, comorbidity remission, and QoL improvement. Weight loss is associated with a marked metabolic improvement, depicted in this series by the disappearance of insulin resistance in all but one patient
Mohammed MR, 2021 [112]	Retrospective non-comparative	8 (MINORS)	72 (LSG)	17.4 ± 1.85	12	47.9 ± 7.1	31.76 ± 6.15	%EWL 73.5 ± 22.1%. - %TWL 34.9 ± 9.35	DM 6 - HT 5 HC 1 -OSAS 3	DM 6 - HT 4 - HC 1 -OSAS 3	0	0	0	1 Severe dysphagia - 1 vitamin B deficiency associated with sensory neuropathy	SG is an effective and safe procedure in adolescent patients with severe obesity. SG achieved satisfactory weight loss in the majority of patients along with excellent remission in comorbidities, namely, DM. The complication rate of SG in adolescents is acceptably low, yet nutritional deficiencies warrant strict follow-up

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Teeple EA, 2012 [113]	Retrospective non-comparative	7 (MINORS)	15 (LRYGB)	NR	24	58.8 ± 10.7	34.9 ± 5.6	%EWL 62.2 ± 14.6	Non-extractable data	Non-extractable data	0	1 Ileus - 1 anastomotic leak - 1 anastomotic bleeding	0	1 port site hernia - 1 gastrojejunal stricture	In conclusion, bariatric surgery is a safe and efficacious treatment option for morbidly obese adolescents with significant obesity-related comorbid conditions
Tuna T, 2020 [114]	Retrospective non-comparative	8 (MINORS)	16 (LSG)	15–19	36	48.6 (42–56.4)	29.6 (24.5–33.2)	%EWL 79.3 ± 20.5	DM 13 - HT 3 - HC 5 - OSAS 8 - NAFLD 13	DM 13 - HT 2 - HC 3 - OSAS 8 -NAFLD 8	0	0	0	0	Laparoscopic sleeve gastrectomy results in significant weight loss and leads to resolution of comorbidities in most patients, with a low rate of complications or re-intervention. Although current evidence points to MBS as a safe and effective option for treatment of morbidly obese adolescents, our limited sample and the short FU period do not allow definitive conclusions to be drawn, particularly concerning long-term safety

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
White B, 2017 [115]	Prospective comparative	10 (MINORS)	29 (18LSG - 11 LRYGB) VS 21 lifestyle change	16.1 (1.3) VS 15.9 (1.3)	48	51.3 (7.8) VS 51.1 (7.4)	Non-extractable data	Non-extractable data	(DM 3 - HT 10 - HC 6) VS (DM 2 - HT 7 - HC4)	Non-extractable data	0	1 Gastric perforation (LRYGB)	0	1 Gastric perforation - 2 gastrojejunal stricture - 7 GERD	Adolescent bariatric surgery in an NHS service compares favorably to international cohorts and shows promise as an effective treatment for severe obesity. Further work is needed to improve patient selection, reduce age at surgery, and reduce attrition
Messiah SE, 2013 [116]	Retrospective non-comparative	8 (MINORS)	890 (454 LRYGB - 436 LAGB)	18.5	12	48.5 (48.0–49.0)	37.0 (36.3–37.8)	%EWL 23.5 (22.4–24.7)	NR	NR	NR	NR	38 Gastrointestinal complication - 26 nutritional deficiency	1 Death 5 months after LRYGB	

Table 5 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean age (years)	Mean follow-up (months)	BMI basal	BMI follow-up	BMI loss/EWL/TWL/EBMIL	Pre-operative comorbidities	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative mortality	Long-term complications	Conclusion
Kaulfers AM, 2010 [117]	Retrospective non-comparative	8 (MINORS)	61 (LRYGB)	17.31.9	24	54.46.8	NR	TWL 49.22.1	DM 11% - HT 30% - NALFD 18% - OSAS 63%	NR	NR	NR	NR	NR	In our study, a 7.4% decline in WB BMC over 2 years was shown in adolescents who underwent bariatric surgery. The decrease in bone mass was associated, to a small extent (14% for BMC), with weight loss in the first year. Future studies are needed to elucidate the types of weight loss (lean versus fat mass) and molecular pathways that influence changes in bone mass, and the clinical consequences of these changes

Table 6 MBS prior to joint arthroplasty (as a bridge)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery
Choi, 2020 [120]	Retrospective	5	1327 bariatric with hip repair vs 2127 only hip repair	10 years	NA	NA	NA	NA	NA	NA	NA	NA	Hip fractur	Survival rates lower in bariatric (87.2% vs 91.8% *p* 0.048), no differences for complications rates at 30 dd, greater readmission rates for bariatric patients (OR 1.46, 95%)
Inacio, 2014 [121]	Retrospective	5	69 patients with bariatric surgery >2 years and 102 within 2 years of total joint arthroplasty	1 year	NA	NA	NA	NA	NA	NA	NA	NA	171 (hip 21%, knee 79%)	Similar post-operative complications than non-operated obese
Werner, 2015 [122]	Retrospective	5	219 patients with previous bariatric surgery vs 11,294 obese	2 years	NA	NA	NA	NA	NA	NA	NA	NA	219 total knee arthroplasty	Lower 90-day complication rate than non-operated obese, but increased than lean control

Table 6 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery
Nickel, 2016 [123]	Retrospective	5	5918 bariatric vs 26616 non-operated obese BMI >40 vs 6480 lean	2 years	NA	NA	NA	NA	NA	NA	NA	NA	5918 total knee arthroplasty	Higher 30-day complication rates for bariatric patients vs non operated obese vs lean
McLawhorn, 2018 [124]	Propensity score matched analysis	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2636 bariatric vs 2636 non-operated TKA; 792 bariatric vs 792 non-operated obese THA	Lower in-hospital complications rate in bariatric patients; similar rates of revision
Lee, 2018 [125]	Retrospective	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	35 bariatric THA, 70 bariatric TKA	Prior to THA, bariatric surgery patients were at increased risk for post-operative infections; prior to TKA were at increased risk of revision but lower risk for infections

Table 6 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery
Wang, 2019 [126]	Propensity score matched analysis	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2540 bariatric vs 2540 non-operated THA; 9803 bariatric vs 9803 non-operated TKA	Prior to THA, bariatric surgery patients were at increased risk for blood transfusion and anemia; prior to TKA were at increased risk of for blood transfusion and anemia but lower risk for pulmonary embolism
Sax, 2022 [127]	Retrospective	5	NA	6 to 12 months	NA	NA	NA	NA	NA	NA	NA	NA	1901 BS 6 months before TKA; 14,022 BS 1 year before TKA; vs 121,934 lean and 87,449 BMI >40	Lower complications than BMI >40; similar rates BS at 6months vs BS at 1 year

Table 6 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery
Ryan, 2022 [128]	Retrospective	5	64 RYGB, 9 LAGB, 8 SG, 7 NA bypass	NA	NA	NA	NA	NA	NA	NA	NA	NA	THA	BS were more likely to have reoperation and periprosthetic joint infection than lean control; 90-day complications were lower in BS than BMI >40
Martin, 2015 [129]	Retrospective	5	NA	5 years	51.1	36.5	NA	NA	NA	NA	NA	NA	91 TKA after BS vs 91 TKA high BMI and 182 low BMI	increased risk of reoperation in BS group vs high-BMI group and vs lean
Watts, 2016 [130]	Retrospective	5	47	10 years	49.7	35.3	NA	NA	NA	NA	NA	NA	47 THA after BS vs 94 THA in non-operated obese	Lower rate of reoperation and revision after BS

Table 6 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery
Liu, 2021 [131]	Retrospective	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1894 BS before TKA/THA vs 1000 obese TKA/THA	After 6 months from the primary surgery, BS patients had less complications than THA/TKA alone
Nickel, 2018 [132]	Retrospective	5	NA	NA	NA	36.5	NA	NA	NA	NA	NA	NA	1545 BS before THA vs 6918 BMI >40 vs 3697 lean	Dislocation and revision rate increased after BS; lower rate at 90-day complications BS vs BMI >40
Dowsey, 2022 [133]	RCT	8	39 LAGB	12 months	43.8	36.5	20%	NA	NA	NA	NA	NA	29 BS before TKA vs 39 obese TKA	Peri-operative complications were lower in BS group
Ighani Arani, 2021 [134]	Retrospective	5	SG and RYGB	12 months	43	31	NA	NA	NA	NA	NA	NA	441 BS before TKA vs 95,948 TKA same age and same BMI	Similar risk for revision and infection

Table 6 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery
Nearing II, 2016 [135]	Retrospective	5	92 RYGB and 10 SG	4.9	NA	37.6	NA	4 T2DM, 8 OSAS	NA	NA	NA	NA	49 TKA and 17 THA after BS vs 23 TKA and 13 THA before BS	Lower operative time and length of stay, similar rate of 30-day complications and reinterventions over long-term FU
Liu, 2020 [136]	Retrospective	5	NA	2 years	NA	NA	NA	NA	NA	NA	NA	NA	1478 BS before TJA, 60,259 obese before TJA, 281,973 lean before TJA	BS before TJA had increased complications, especially blood transfusion, but lower pneumonia than obese before TJA

Table 6 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery
Meller, 2019 [137]	Retrospective	5	2044 LAGB, 1671 RYGB, 1025 SG, 21,112 non-specified BS		NA	NA	NA	NA	NA	NA	NA	NA	25,852 BS before TKA vs 2,675,575 no previous BS TKA	Readmission in 90-day post-TKA was increased in BS, a low increased trend for 90-day complications was observed in BS than in non-operated
Purcell,2022 [138]	Retrospective	5	355 SG	5 years	51.4	41.3	66.3 lb	6 resolution of knee pain	NA	NA	NA	NA	27 SG before TKA vs 24 TKA/arthroscopy before SG	BS can reduce knee symptoms and the necessity to undergo knee surgery. After BS complications were lower than those who underwent first to TKA

Table 6 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidities resolution	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery
Schwarzkopf, 2018 [139]	Retrospective	5	1347	NA	NA	NA	NA	NA	NA	NA	NA	NA	330 BS before THA and 1017 BS before TKA	No association between the time of BS and arthroplasty and 90-day complication, whereas those who underwent BS less than 6 months are at increased risk for readmission
Ighani Arani, 2022 [140]	Retrospective	5	NA	1.1 years		30.6	33.6% TWL	NA	NA	NA	NA	NA	44 BS before TKA vs 3524 no BS TKA	No clinical differences in 1-year post-operative score and function score
Severson, 2012 [141]	Retrospective	5	NA	NA		37.9	NA	NA	NA	NA	NA	NA	61 BS >2 years before TKA, vs 25 BS within 2 years TKA vs 39 TKA before BS	Reduced post-operative time, similar 90-day complication

Table 7 MBS and abdominal wall hernia repair

Author, year [ref]	Study design	Quality assessment	Number of patients	Intervention	Length of stay	Concomitant hernia repair (yes/no)	Type of concomitant hernia repair	Patients with concomitant VHR	BMI basal	BMI at VHR	EWL/TWL	OR time (min)	Complications MBS
Morrell, David J et al. [143]	Retrospective	3	20	LSG	1.6 ± 0.8	No	No	0	45.6 ± 6.1	34.9	$20.7 \pm 12.3\%$ TBMIL	121.2	$n = 1$ bleeding
Moolla, Muhammad et al. [144]	MBSAQIP	2	4690 concomitant VHR vs 4648 matched	RYGB/LSG	NR	Yes $n = 4690$; no $n = 4648$	Epigastric, incisional, umbilical, Spigelian hernias	4690	46.1 ± 8.4		NR	112.6 ± 57.9 vs 93.7 ± 50, $p < 0.001$	
Krivan, Miss Sylvia et al. [145]	Retrospective	3	106	RYGB/LSG	4.1 ±1.5	Yes laparoscopic and open	Open/lps, primary closure/mesh	106	53 ± 9		25.4% at 24 month	NR	6 of 106 (omental bleedings, 2 anastomotic leak, gastrojejunostomy stenosis)
Sharma, G et al. [146]	Retrospective	3	159	105 RYGB, 50 SG, 4 GB	3 (2–4)	Yes	Umbilical, (99), incisional (52), others (16) - 144 lps, 15 open	159	48.2		56.4% (primary) and 55.9% (mesh) at 1 year	210 min (156.5–243.5)	4 major complications, 16 minor complications
Olmi, Stefano et al. [147]	Retrospective	3	Group A $n = 30$ before MBS versus group B $n = 170$ after weight loss	SG (group B $n = 170$)	Group A: 2 ± 2.7 vs group B: 2.8 ± 1.9 ($p < 0.5$)	No	All lps Parietex composite	No	Group A: 37.8 ± 5.7	Group B: 24.6 ± 4.5		OR hernia group A: 51.7 ± 26.6 vs group B 38.9 ± 21.5 ($p < 0.05$)	NR
Raziel, Asnat et al. [148]	Retrospective	3	54	SG 48, lps RYGB 2, open RYGB 2, GB 2	NR	Yes	Dual mesh during MBS	54	44.2 ± 4.5		EWL 57.7% ± 9.2 at 12 months	NR	3 leaks, 1 pulmonary embolism
Chandeze, Marie-Maelle et al. [149]	Retrospective	3	Group A after MBS $n = 30$ ($n = 14$ during MBS), group B immediate HR $n = 60$	SG 17, RYGB 18, GB 4	Group A 6.2 ± 2.6, group B 10.7 ± 9.3 ($p = 0.002$)	Yes	Continuous suture with slowly absorbable monofilament	14	46.7 ± 6.4 vs 42.4 ± 7.2	34.1 ± 6.5 vs 42.4 ± 7.2	NR	NR	NR

Table 7 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients	Intervention	Length of stay	Concomitant hernia repair (yes/no)	Type of concomitant hernia repair	Patients with concomitant VHR	BMI basal	BMI at VHR	EWL/TWL	OR time (min)	Complications MBS
Morrell, David J et al. [143]	Retrospective	3	20	LSG	1.6 ± 0.8	No	No	0	45.6 ± 6.1	34.9	20.7 ± 12.3% TBMIL	121.2	n = 1 bleeding
Praveen Raj, Palanivelu et al. [150]	Retrospective	3	156	SG 120, RYGB 36	3 (2–5)	Yes	IPOM	156	43.64± 6.8 and 42.49± 8.57		NR	SG 118.34 ± 29.88; RYGB 154.69 ± 35.54	NR
Clapp, Benjamin et al. [151]	MBSAQIP	2	5463	1908 RYGB; 3555 SG	2.4 RYGB and 1.9 SG	Yes	Mostly laparoscopic	5463	46.2 RYGB, 44.1 SG		NR	142 RYGB + hernia; 105 SG + hernia	Death <1%, reoperation 3.8% RYGB, 2.1% SG
Chan, Daniel Leonard et al. [152]	Retrospective	3	45	36 RYGB and SG, 9 GB	3.3 (0–13)	Yes	Laparoscopically	45	40.3 (31.4–57)		NR	151 (60–360)	NR
Eid, G M et al. [153]	Retrospective	3	85	RYGB	3.2 (2–5)	Yes n = 73	Primary or small intestinal submucosa	73	50.9 (36–70.9)		NR	NR	NR
Moszkowicz, David et al. [154]	National discharge summery	2	2039 VHR 2 in the 2 years before, 3388 concomitant, 6260 VHR within 2 years after MBS	Bypass and sleeve	BS first 12.1 ± 14.5 days, VHR first 9.3 ± 8 and concomitant 7.6 ± 8.2	Yes n = 3388	NR	3388	NR		NR	NR	Major complications 11.1 (VHR first), 7.8% (concomitant), 16.9 BS first
Newcomb, W L et al. [155]	Retrospective	3	27	Gastric bypass (n = 22 open, n = 5 lps)	NR	No	No	0	51 (39–69)	33 (25–37)			0
Datta, Tejwant et al. [156]	Retrospective	3	26	Gastric bypass	2.7 (VHR)	Yes n = 18	8 primary, 10 prosthetic mesh	18	NR		NR	NR	NR
Spaniolas, Konstantinos et al. [157]	ACS-NSQIP	2	503	SG (n = 70) or RYGB (n = 433)	NR	Yes	All concomitant	503	47.2		NR	NR	NR

Table 7 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients	Intervention	Length of stay	Concomitant hernia repair (yes/no)	Type of concomitant hernia repair	Patients with concomitant VHR	BMI basal	BMI at VHR	EWL/TWL	OR time (min)	Complications MBS
Morrell, David J et al. [143]	Retrospective	3	20	LSG	1.6 ± 0.8	No	No	0	45.6 ± 6.1	34.9	20.7 ± 12.3% TBMIL	121.2	$n = 1$ bleeding
Eid, George M et al. [158]	Retrospective	3	28	RYGB and SG	NR	Yes $n = 20$	NR	20	NR		NR	NR	NR
Khorgami, Zhamak et al. [159]	ACS-NSQIP	2	988 concomitant VHR matched 1:1 (988)	RYGB ($n = 544$) and SG ($n = 4444$)	2.3 ± 2.7	Yes $n = 988$	Open VHR ($n = 322$), lps VHR ($n = 666$)	988	48 ±9		NR	134.2 ± 52.8	Adverse events 4.8%, 30-day reoperation 3.3%
Praveen Raj, P et al. [160]	Retrospective	3	36	RYGB ($n = 11$), SG (25)	4.2 and 3.9 days	Yes	Concomitant mesh repair for VH	36	41.1 (RYGB) and 43.8 (SG)		NR	149 (120-210 RYGB), 122 (90-220 SG)	None
Praveenraj, Palanivelu et al. [161]	Retrospective	3	23	SG ($n = 22$), RYGB ($n = 1$)	3.3 (2–8)	Yes	IPOM	23	43.24		NR	112 (65–220)	NR
Borbely, Yves et al. [162]	Retrospective	3	15	SG	NR	No	No	0	45.3 (36.3–65.8)	33.6 (20.9–45.7)	TWL 25.7% (12.7–50.8)	62.5 (41–120) SG	1 trocar site hematoma, 1 SSI, 1 readmission for dehydration
Kaminski, D L [163]	Retrospective	3	70	Gastric restrictive procedures	NR	No	No	0	NR				
Marzouk, Ahmed M S M et al. [164]	Retrospective	3	15	SG	2	Yes	Laparoscopic intraperitoneal only mesh	15	45.2 (38.7–56.2)		NR	162.1	NR
Vitiello A. et al. [165]	Retrospective	3	20 (concomitant) vs 20 (delayed)	SG	3.6 ± 0.4	Yes	Intraperitoneal mesh after fascial closing	20	42.7 ± 4.9 and 43 ± 5.1	31 ± 4.3	NR	96 ± 17.4 versus 91.7 ± 15.2	NR

Table 7 (continued)

Author, year [ref]	Complications between MBS and hernia repair	Complications hernia repair	Early mortality	Late mortality	Long-term complications	Weight loss prior to hernia repair (kg)	Bridge to surgery yes/no	Time between hernia consultation and ultimate repair (months)	Time between MBS and hernia repair (months)	Type of hernia	Hernia repair with mesh (yes/no)	Outcomes of hernia repair	Mean follow-up after VHR (months)	
Morrell, David J et al. [143]	$n = 2$ (SBO, 1 conservative, 1 surgery)	NR	0	0	NR	Mean BMI loss 20.7 ± 12.3%	Yes	22.6 ± 12.5	13.5 ± 11.7 months	494.9 ± 221.2 cm^3	NR	No recurrence	20.9 ± 16.5	LSG in patients with complex AWH successfully
Moolla, Muhammad et al. [144]	NR	Concurrent VHR 5.8 vs 3.8%, $p < 0.001$, greater incidence of reoperation 2.3% vs 1.1%, $p < 0.001$, deep surgical site infection 0.7 vs 0.3%, $p = 0.025$ and sepsis 0.3 vs 0%, $p < 0.004$	0.3 vs 0.2%		Repeat VHR within 30 days 0.45 vs 0.006%									Elevated risk of major complications

Table 7 (continued)

Author, year [ref]	Complications between MBS and hernia repair	Complications hernia repair	Early mortality	Late mortality	Long-term complications	Weight loss prior to hernia repair (kg)	Bridge to surgery yes/no	Time between hernia consultation and ultimate repair (months)	Time between MBS and hernia repair (months)	Type of hernia	Hernia repair with mesh (yes/no)	Outcomes of hernia repair	Mean follow-up after VHR (months)	
Morrell, David J et al. [143]	$n = 2$ (SBO, 1 conservative, 1 surgery)	NR	0	0	NR	Mean BMI loss 20.7 ± 12.3%	Yes	22.6 ± 12.5	13.5 ± 11.7 months	494.9 ± 221.2 cm^3	NR	No recurrence	20.9 ± 16.5	LSG in patients with complex AWH successfully
Krivan, Miss Sylvia et al. [145]	NR	$n = 1$ adhesions between mesh and small bowel with reoperation, 6 wound infection, 6 hematoma, 4 seroma (3.8%) 5 mesh repairs	0	0	No difference between BS and BS + VHR	NR	NR	NR	NR	NR		5 mesh repairs, recurrence: 12	2 years	VHR + BS feasible with low recurrence rate
Sharma, G et al. [146]	NR	5 reoperations: SBO, sepsis, mesh dehiscence	0	0	Hernia recurrence 31% at 5 years primary repair, 34.8% at 5 years with mesh	NR	No	NR	NR	7.1 cm^2 primary repair ($n =$ 115), 12.6 cm^2 mesh repair ($n =$ 115)	44 with mesh, 115 primary	Hernia recurrence 31% at 5 years primary repair, 34.8% at 5 years with mesh	5 years	Primary and mesh repair acceptable
Olmi, Stefano et al. [147]	NR	Group A 13.3% vs group B 5.9% seroma $p < 0.05$	0	0	Recurrence 3.3% vs 2.4% and bulging 10& vs 2.4% $p = 0.23$	NR	Yes	NR	8 months–2 years	All types	Yes	Recurrence and bulging not statistically different	1 year	

Table 7 (continued)

Author, year [ref]	Complications between MBS and hernia repair	Complications hernia repair	Early mortality	Late mortality	Long-term complications	Weight loss prior to hernia repair (kg)	Bridge to surgery yes/no	Time between hernia consultation and ultimate repair (months)	Time between MBS and hernia repair (months)	Type of hernia	Hernia repair with mesh (yes/no)	Outcomes of hernia repair	Mean follow-up after VHR (months)	
Morrell, David J et al. [143]	$n = 2$ (SBO, 1 conservative, 1 surgery)	NR	0	0	NR	Mean BMI loss 20.7 ± 12.3%	Yes	22.6 ± 12.5	13.5 ± 11.7 months	494.9 ± 221.2 cm^3	NR	No recurrence	20.9 ± 16.5	LSG in patients with complex AWH successfully
Raziel, Asnat et al. [148]	NR	Two abdominal wall hematomas	0	0	1 recurrence (1.8%)	NR	No	NR	NR	23 ventral, 29 umbilical, 2 ventral and umbilical	Dual mesh	1 recurrence	12 months	Concomitant VHR feasible and safe
Chandeze, Marie-Maelle et al. [149]	No strangulations, only 30 of 41 patients underwent VHR (n = not lose enough weight)	Chronic sepsis 7% vs 2%, SBO 0 vs 5%, wound abscess 7% vs 3%	0	0	Recurrence 6.7% vs 24% $p = 0.048$	28 ± 11%	Yes		21.5 months (range 7–87)	<7 and >7 cm	Open mesh in sublay (87%) and underlay (13%)	Post-operative morbidity 37% vs 44% ($p = 0.45$)	4.6 ± 4.1 years	MBS prior to VHR decrease recurrence
Praveen Raj, Palanivelu et al. [150]	NR	Seroma 3.2%, paralytic ileus 3.84%	0	0	Recurrence 0.91%	NR	No	NR	NR	Umbilical/ periumbilical, intraumbilical, supraumbilical, Swiss cheese defect	Yes	<1% recurrence	12 months	Pro one stage treatment

Table 7 (continued)

Author, year [ref]	Complications between MBS and hernia repair	Complications hernia repair	Early mortality	Late mortality	Long-term complications	Weight loss prior to hernia repair (kg)	Bridge to surgery yes/no	Time between hernia consultation and ultimate repair (months)	Time between MBS and hernia repair (months)	Type of hernia	Hernia repair with mesh (yes/no)	Outcomes of hernia repair	Mean follow-up after VHR (months)	
Morrell, David J et al. [143]	$n = 2$ (SBO, 1 conservative, 1 surgery)	NR	0	0	NR	Mean BMI loss 20.7 ± 12.3%	Yes	22.6 ± 12.5	13.5 ± 11.7 months	494.9 ± 221.2 cm^3	NR	No recurrence	20.9 ± 16.5	LSG in patients with complex AWH successfully
Clapp, Benjamin et al. [151]	NR	NR	<1%	NR	Readmission, reinterventions and reoperations increased in concomitant VHR	NR	No	NR	NR	Ventral, epigastric, incisional, inguinal	NR	Readmission, reinterventions and reoperations increased in concomitant VHR	30 days	
Chan, Daniel Leonard et al. [152]	NR	Mesh infection 5.56%, no recurrence	0	0	Mesh infection 5.56%, no recurrence	NR	No	NR	NR	Abdominal wall	Yes	No recurrence, total rate of mesh infection 4.44%	13 months	
Eid, G M et al. [153]	NR	Wound cellulitis and seroma	NR	NR	Primary repair (59), biomaterial mash (12), deferred treatment (14)	NR	NR	NR	NR	Primary, umbilical, incisional, recurrent	Primary repair (59), biomaterial mash (12), deferred treatment (14(	22% recurrence in primary group, no recurrence biomaterial mash, SBO in deferred treatment 37.5%	26 months	All pt with SBO had originally incisional VH with omental incarceration and had undergone adhesiolysis with reduction but without defect repair!

Table 7 (continued)

Author, year [ref]	Complications between MBS and hernia repair	Complications hernia repair	Early mortality	Late mortality	Long-term complications	Weight loss prior to hernia repair (kg)	Bridge to surgery yes/no	Time between hernia consultation and ultimate repair (months)	Time between MBS and hernia repair (months)	Type of hernia	Hernia repair with mesh (yes/no)	Outcomes of hernia repair	Mean follow-up after VHR (months)	
Morrell, David J et al. [143]	$n = 2$ (SBO, 1 conservative, 1 surgery)	NR	0	0	NR	Mean BMI loss 20.7 ± 12.3%	Yes	22.6 ± 12.5	13.5 ± 11.7 months	494.9 ± 221.2 cm^3	NR	No recurrence	20.9 ± 16.5	LSG in patients with complex AWH successfully
Moszkowicz, David et al. [154]	NR	Mesh infection 1% in VHR first, 4.3% in concomitant, 1.9% BS first	NR	NR	Overall 10-year reoperation rate for VH: 23.3%, reoperation rate highest in VHR-first group 36.2%	NR	NR	NR	NR	Mixed	Mixed	Overall 10-year reoperation rate for VH: 23.3%, reoperation rate highest in VHR-first group 36.2%		
Newcomb, W L et al. [155]	3.7 previous failed hernia repairs prior staged repair	$n = 7$ concomitant with 1 dehiscence of biologic mesh	NR	NR	NR	NR	Yes	NR	1.3 years (0.9–3.1)	NR	Open modified Rives–Stoppa polypropylene, lps with mesh	One patients SBO between MBS and VHR	20 months	Complex ventral hernias!
Datta, Tejwant et al. [156]	NR	2 primary with postoperative SBO, 1 chronic pain relieved by lps transection	0	0	2 primary with postoperative SBO, 1 chronic pain relieved by lps transection	NR	Yes	NR	NR	NR	Mixed	2 primary with postoperative SBO, 1 chronic pain relieved by lps transection	14 months (4–30)	

Table 7 (continued)

Author, year [ref]	Complications between MBS and hernia repair	Complications hernia repair	Early mortality	Late mortality	Long-term complications	Weight loss prior to hernia repair (kg)	Bridge to surgery yes/no	Time between hernia consultation and ultimate repair (months)	Time between MBS and hernia repair (months)	Type of hernia	Hernia repair with mesh (yes/no)	Outcomes of hernia repair	Mean follow-up after VHR (months)	
Morrell, David J et al. [143]	$n = 2$ (SBO, 1 conservative, 1 surgery)	NR	0	0	NR	Mean BMI loss 20.7 ± 12.3%	Yes	22.6 ± 12.5	13.5 ± 11.7 months	494.9 ± 221.2 cm^3	NR	No recurrence	20.9 ± 16.5	LSG in patients with complex AWH successfully
Spaniolas, Konstantinos et al. [157]	NR	Overall morbidity 8.3%, SSI 4.6%, reoperation 3.4%	0.2%	NR	NR	NR	No	NR	NR	NR	NR	Increase in SSI during synchronous VHR	30 days	
Eid, George M et al. [158]	NR	NR	NR	NR	NR	NR	Mixed	NR	6 months in VHR first $n = 3$; $n = 3$ MBS first—one incarceration and 2 with 9 and 18 months delayed for insufficient WL			2 of 28 recurrences (7%)	2 years	4 groups: favorable anatomy symptomatic/asymptomatic–unfavorable anatomy sym/asympt

Table 7 (continued)

Author, year [ref]	Complications between MBS and hernia repair	Complications hernia repair	Early mortality	Late mortality	Long-term complications	Weight loss prior to hernia repair (kg)	Bridge to surgery yes/no	Time between hernia consultation and ultimate repair (months)	Time between MBS and hernia repair (months)	Type of hernia	Hernia repair with mesh (yes/no)	Outcomes of hernia repair	Mean follow-up after VHR (months)	
Morrell, David J et al. [143]	$n = 2$ (SBO, 1 conservative, 1 surgery)	NR	0	0	NR	Mean BMI loss 20.7 ± 12.3%	Yes	22.6 ± 12.5	13.5 ± 11.7 months	494.9 ± 221.2 cm^3	NR	No recurrence	20.9 ± 16.5	LSG in patients with complex AWH successfully
Khorgami, Zhamak et al. [159]	NR	30-day reoperation for ventral hernia repair 21.2%	0.1%	NR	NR	NR	NR	NR	NR	167 strangulated, 821 reducible hernia	CPT codes all together	More composite adverse event (2.7% vs 4.8%, $p = 0.01$), more return to OR in 30 days (3.3% vs 0.6%, $p < 0.01$), readmission (3.2 vs 5.9%, $p = 0.01$)	30 days	
Praveen Raj, P et al. [160]	NR	No recurrence, no mesh infection	NR	NR	NR	NR	No	NR	NR	NR	YES	No recurrence, no mesh infection	18 months RYGB, 11 months SG	
Praveenraj, Palanivelu et al. [161]	NR	4 seromas	NR	NR	No mesh infection, no recurrence	NR	No	NR	NR	2 previous repairs (1–5)	IPOM in recurrent ventral hernias	No recurrence, no mesh infection	3.3 years (9 months–5.5 years)	

Table 7 (continued)

Author, year [ref]	Complications between MBS and hernia repair	Complications hernia repair	Early mortality	Late mortality	Long-term complications	Weight loss prior to hernia repair (kg)	Bridge to surgery yes/no	Time between hernia consultation and ultimate repair (months)	Time between MBS and hernia repair (months)	Type of hernia	Hernia repair with mesh (yes/no)	Outcomes of hernia repair	Mean follow-up after VHR (months)	
Morrell, David J et al. [143]	$n = 2$ (SBO, 1 conservative, 1 surgery)	NR	0	0	NR	Mean BMI loss 20.7 ± 12.3%	Yes	22.6 ± 12.5	13.5 ± 11.7 months	494.9 ± 221.2 cm^3	NR	No recurrence	20.9 ± 16.5	LSG in patients with complex AWH successfully
Borbely, Yves et al. [162]	None	2 pneumonia (13%), 2 infected seroma, 3 SSI	0	0	3 reoperations: small recurrence (7%), infected seroma (7%), infected mesh (7%)	TWL 25.7% (12.7–50.8)	Yes	NR	185 days (32–640)	Repair of hernia with loss of domain in 2-step approach; recurrent incisional hernia with >2 failed repairs	Mesh intraperitoneally before fascial closure	1 reoperation for recurrence, 1 for infected seroma, 1 for infected mesh	24 months (6–68)	
Kaminski, D L [163]							Yes	NR				Body weight should be < 200 lb to decrease recurrent hernia formation (90 kg)	79 ± 18 months	When >250 lb (>113 kg) ventral hernia recurrence of 33%
Marzouk, Ahmed M S M et al. [164]	NR	1 recurrence, 4 seroma	NR	NR	1 recurrence	NR	No	NR	NR	Mean hernia defect size 2.6 cm (1.3–4.2)	Yes	4 patients with self-limited seroma, 1 recurrence at 14 months	12 months	

Table 7 (continued)

Author, year [ref]	Complications between MBS and hernia repair	Complications hernia repair	Early mortality	Late mortality	Long-term complications	Weight loss prior to hernia repair (kg)	Bridge to surgery yes/no	Time between hernia consultation and ultimate repair (months)	Time between MBS and hernia repair (months)	Type of hernia	Hernia repair with mesh (yes/no)	Outcomes of hernia repair	Mean follow-up after VHR (months)	
Morrell, David J et al. [143]	$n = 2$ (SBO, 1 conservative, 1 surgery)	NR	0	0	NR	Mean BMI loss 20.7 ± 12.3%	Yes	22.6 ± 12.5	13.5 ± 11.7 months	494.9 ± 221.2 cm^3	NR	No recurrence	20.9 ± 16.5	LSG in patients with complex AWH successfully
Vitiello A. et al. [165]	NR	2 recurrences in delayed group, 1 trocar site hematoma in synchronous group, and 1 in delayed group	NR	NR	2 recurrences	NR	Mixed	NR	NR	Periumbilical hernia	Yes onlay mesh open in delayed group	2 recurrences	19.8 ± 5.6	

[74, 75]. Both supported MBS in the elderly with a careful selection of patients.

According to the literature, although there was only one RCT, we could state that MBS is a safe and effective treatment of the elderly in carefully selected cases. In this patient population, attention must be paid to patient selection and procedure selection, considering the chance of comorbidity resolution and post-operative follow-up compliance.

Recommendation

- *MBS has been performed successfully in increasingly older patients, including patients ≥70 years of age. In septuagenarians, compared with a younger population, MBS is associated with slightly higher rates of postoperative complications but still provides substantial benefits of weight loss and co-morbid disease remission.*
- *Frailty, cognitive capacity, smoking status, and end-organ function have an important role in the indications for MBS.*
- *There is no evidence to support an age limit for older patients seeking MBS, but a careful patient selection that includes a frailty assessment is recommended.*

Level of Evidence 2a
Grade of recommendation B

5. MBS for the pediatrics and adolescents [76–117]
PRISMA Appendix 5 [PubMed, Cochrane, Embase]
Systematic Review Table 5

Forty-two papers have been retrieved for qualitative analysis [76–117]. One RCT [76] and 14 comparative papers [83, 88, 90, 93, 94, 96–98, 101, 104–107, 115] were found.

Seven studies about MBS versus lifestyle modifications [76, 88, 90, 94, 97, 105, 115] were evaluated. The surgical approach was more effective and durable than lifestyle modification regarding excess weight loss (%EWL), total weight loss (%TWL), and comorbidity resolutions.

Ten papers used the teen-LABS database [92–101], comparing different laparoscopic MBS procedures (AGB, RYGB, SG) to assess many aspects of MBS in pediatric and adolescent patients. All papers demonstrated an acceptable lasting %EWL with a good resolution of obesity-related complications.

Sixteen papers evaluated the efficacy of RYGB in adolescent patients [78, 85, 92, 95, 97–99, 101, 103, 105, 107, 108, 113, 115–117]; only six of them were comparative [97, 98, 101, 105, 107, 115]. All studies concluded that RYGB achieved good weight loss, improvement, and/or resolution of comorbidities in the pediatric and adolescent population with an acceptable complication rate.

A matched-control study evaluated the outcomes of MBS in Prader Willi syndrome (PWS) compared with a non-PWS group of patients and concluded that the SG is a well-tolerated, effective treatment option for PWS patients with obesity. In both groups, the weight loss and the resolution of the comorbidities were similar [96].

Alqathani et al., in a retrospective study with 10 years of follow-up, suggested that MBS would not negatively impact pubertal development or linear growth, and therefore, a specific Tanner stage and bone age should not be considered a requirement for surgery [96].

According to a literature review, the AGB seems to be a safer procedure. However, it achieved a lower weight loss, which was less durable than the RYGB or the SG.

Recommendation

- *MBS does not negatively impact pubertal development or linear growth.*
- *MBS is safe in the population younger than 18 years and produces durable weight loss and improvement in comorbid conditions.*

Level of Evidence 1b
Grade of recommendation A

Bridge to other Treatments

6. MBS prior to joint arthroplasty [120–141]
PRISMA Appendix 6 [PubMed, Cochrane, Embase]
Systematic Review Table 6 (some studies not in favor)
Delphi Table 15

Twenty-two articles were chosen to be included in the present review.

Several studies have shown that patients with severe obesity (BMI ≥40 kg/m^2) were at increased risk of major and minor complications after joint surgery. The American Association for Hip and Knee Surgeons (AAHKS) provided a consensus opinion recommending delaying elective surgery when the BMI exceeds 40 kg/m^2, and in 2023, adherence to these recommendations was evaluated [142]. Pre-operative health optimization programs, including weight loss with MBS before joint surgery, have been implemented to reduce postoperative complications.

However, the current literature is unclear whether persons undergoing MBS have a lower risk of postoperative complications and need for revisions after joint surgery when compared to people with obesity who have not had MBS. This systematic review (Table 6) demonstrated that only one RCT was available. Additional results were obtained from cohort studies. Some studies have demonstrated the benefits of preoperative MBS, while others have highlighted the risks of prior MBS. In addition, it seems that MBS should be performed within 2 years before joint arthroplasty to decrease the negative impact of metabolic bone disease. Furthermore,

Table 8 MBS prior to organ transplantation

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Type of surgery	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidity resolution	Post-transplant survival
J. Wesley Alexander, Hope Goodman [166]	Retrospective		32 pts with CRF–GBP without KT	GBP		48 (BMI of first group GBP without KT)		68% EBMIL	51% T2DM	92% at 1 year
J. Wesley Alexander, Hope Goodman			9 pts GBP + KT (after)	GBP						92% at 1 year
J. Wesley Alexander, Hope Goodman			10 pts KT + GBP (later)	GBP	13 years			70.5% EBMIL		92% at 1 year
Modanlou, Muthyala, Xiao et al. [167]	Retrospective		72 before listing 188 total	GBP, VBG, restrictive procedures, BPD-DS	36.6 M (18.6, 55.7)	38.1 ± 12.4	35.1 ± 6.2	60.6 (41.5, 72.4)		
Modanlou, Muthyala, Xiao et al.	Retrospective		72 were performed pre-listing,, 29 on waitlist 188 total	GBP, VBG, restrictive procedures, BPD-DS	22.6 M (11.1, 47.2)	40.1 ± 9.2	35.1 ± 10.8	60.2 (0, 68.2)		
Modanlou, Muthyala, Xiao et al.	Retrospective		87 after transplant 188 total	GBP, VBG, restrictive procedures, BPD-DS	12 M	46.6 ± 4.6	40.2 ± 7.8	30.8 (8.7, 48.3)		
Mohammad H. Jamal, Ricard Corcelles, Christopher R. Daigle et al. [168]	Retrospective		21	18 GBP/2 SG/1 AGB	27.6 M	47.1 ± 5.5	35.3 ± 8.4	60.5% ± 35.4% (%EWL)	18% T2DM remission (2/11)	
Anthony B. Mozer, John R. Pender, William H. H. Chapman et al. [169]	Retrospective		138	33.8% ($n = 47$) AGB, 48.9% (n=68) GBP, and 16.5% (n=23) LSG		45.5±8.1				
C. M. Freeman, E. S. Woodle, J. Shi et al. [170]	Prospective		52	SG	220 ± 152 days	43.0 ± 5.4	36.4 ± 5.4	29.8 ± 18.7%	37.8% (18) hypertension resolution, 30% T2DM resolution	

Table 8 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Type of surgery	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidity resolution	Post-transplant survival
Shadi Al-Bahri, Tannous K. Fakhry, John Paul Gonzalvo et al. [171]	Retrospective		16	12 GBP, 3 AGB, 1 SG	2.8 years median (1–10 years)	48 ± 8	31 ± 7	62 ± 24 (EBWL)		
Gheith, Al-Otaibi, Halim et al. [172]	Retrospective		22 after KT	Unspecified procedure	6 M	38.49 ± 9.1	34.34 ± 7.6			
Y. Kim, A. D. Jung, V. K. Dhar et al. [173]	Retrospective		20	SG before KT		41.5 ± 4.4	32.3 ± 3.1 (BMI at time of KT)		HTN 85% resolution rate; T2DM 42% resolution rate	100%
Ian A. Thomas, Jeffrey J. Gaynor, Tameka Joseph [174]	Retrospective		31	GBP	72 M post-KT	43.5 ± 0.7	28.1 ± 0.8	72.8% ± 3.0%	38.7% HTN resolution; 42% T2DM resolution	DGF was experienced by 21.4% (3/14) of RYGB (similar to control group); complication rate 35.7% (5/14) of RYGB patients vs 42.1% (control group 8/19). Death 0% vs 16 ± 8%
Cohen JB, Lim MA, Tewksbury CM et al. [175]	Retrospective		43 pre-KT BS	GBP 27/63%, SG 5/12%, AGB 5/12%, unspecified 1/2%	43 M (interquartile range 20–89)	43 (38–48)	32 (28–36)	69%/22% 2-year FU		1/ 43 died/mortality 2.3%
Cohen JB, Lim MA, Tewksbury CM et al.	Retrospective		21 post-KT BS	GBP 6/28%, SG 10/48%, AGB 4/19%, VBG 1/5%	130 M (interquartile range 74–194)	41 (39–44)	34 (33–37)	71%/59% 2-year FU		0
Renana Yemini, Eviatar Nesher, Idan Carmeli et al. [176]	Retrospective		24 pre-KT	LSG 17/GBP 7	47 months (range 0.5–5 years)	41 kg/m^2 (range 35–51)	28 kg/m^2 (range 19–36)	66%/29%	T2DM 44%; dyslipidemia 22%; HTN 45%	

Table 8 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Type of surgery	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidity resolution	Post-transplant survival
Renana Yemini, Eviatar Nesher, Janos Winkler et al. [177]			34 after transplant	19 SG; 15 GBP; 26 KT, 1 KT + LT, 2 KT + PT, 4 LT, 1 HT		41 (range 35–48) kg/m^2		%EWL 72% (1 year); 84% (3 years)	8/30 HTN complete remission (27%); 67% improvement; 4/21 T2DM complete remission (19%); 67% improvement	
Philippe Bouchard, Jean Tchervenkov, Sebastian Demyttenaere et al. [178]	Retrospective		32	LSG	14 months (± 41)	42.3 (± 5.2) kg/m^2		56% at 1 year	T2DM remission 31%	
Jordana B. Cohen, Colleen M. Tewksbury, Samuel Torres Landa et al. [179]	Retrospective		925 with end-stage kidney disease (ESKD)	775/84% SG, 150/16% GBP		44.7 (40.7–49.6) IQR				
			323,034 without chronic kidney disease (CKD)	229,537/71% SG; 93,497/29% GBP		43.9 (39.9–49.5) IQR				
			1694 with CKD	1146/68% SG; 548/32% GBP		45.3 (40.4–50.9) IQR				
Hilla Schindel BSc, Janos Winkler MD, Renana Yemini MD et al. [180]	Retrospective case–control		30 after KT	19/63% SG; 10/33% GBP, 1/3.3% BPD-DS	2.5 ± 1.3	41.3±3.7	29.5±4.7	71.6 ± 28.7%	The total number of obesity-related comorbidities (T2D, HTN, dyslipidemia, etc.) and number of prescribed medications decreased in the bariatric surgery group (−0.7 and −2, respectively) and increased in the control group (+0.3 and +1.1, respectively) ($P < .001$).	
Al-Faraaz Kassam, Ahmad Mirza, Young Kim et al. [181]	Prospective		243; 198 with ESRD/45 with CKD	SG	2.3±1.5 years	44.0±6.3 kg/m^2 (range 35.0–69.7 kg/m^2)	36.7±6.6 kg/m^2 (range 20.8–61.7 kg/m^2)	38.2±20.3%	39% HTN resolution. 54% T2DM resolution	

Table 8 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Type of surgery	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidity resolution	Post-transplant survival
Kyle H. Sheetz, Kenneth J. Woodside, Vahakn B. Shahinian [182]	Retrospective		Surgical trends 2006–2008 *N*=275 (10), 2009–2013 *N*=1094 (41), 2014–2016 *N*=1329 (49)	The use of SG increased significantly from 1% in 2006 to 84% in 2016 (10% per year increase; *P*=.001). AGB declined precipitously 1% of patients by 2016 (4% per year decrease; *P*=.004). GBP also declined from 58% in 2006 to 13% in 2016 (4% per year decrease; *P*=.02)						
Małgorzata Dobrzycka, Monika Proczko-Stepaniak, Łukasz Kaska et al. [183]	Retrospective		20 with ESKD	9 OAGB, 9 GBP, 2 SG	1 year	38.7		90% EBMIL vs 68% of non ESKD group (*P* n.s.)		
Loubna Outmani, Hendrikus J. A. N. Kimenai, Joke I. Roodnat et al. [184]	Retrospective		23 before KT	11 SG, 9 GBP, 3 AGB	1.2 years	42.3 (41.3–47.8) IQR;	33.8 (31.6–34.1) BMI at time of KT	54 (45–64) 1 year; 67 (31–76) 2 years	8.7% T2DM remission	
Basem G. Soliman, Nabil Tariq, Yi Ying Law et al. [185]	Retrospective		38	24 GBP, 14 SG		44.5 (33.4; 57.0)	35.3±3.8	51.56 ± 32.24 (−56.27; 87.76) 24 M		
Elaine Ku, Charles E. McCulloch, Garrett R. Roll et al. [186]	Retrospective		503 prior to KT	38.6% GBP, 37.8% SG; 23.7% AGB			33.3 ± 4.8			

Table 8 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Type of surgery	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidity resolution	Post-transplant survival
Roxaneh Zaminpeyma, Matias Claus, Steven Paraskevas et al. [187]	Retrospective		32	SG	53 (58) months	42.3 (5.2) kg/m^2	34.0 (5.1) kg/m^2	% TWL 21 (13.3)		
Mark C. Takata, Guilherme M. Campos, and Ruxandra Ciovica [188]	Retrospective		7 on 15	GBP	15.4 M (range 3–24)	50		EWL 61 (range 41-75)	33% T2DM resolution rate	
Matthew Y.C. Lin, M. Mehdi Tavakol, Ankit Sarin et al. [189]	Retrospective		6 on 26	SG		48.3 kg/m^2 (range 38–60.4 kg/m^2)		%EWL 50 (1 year); 66% (2 year)	7/13 54% T2DM resolution	

Author, year [ref]	Mortality	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery	Conclusions
J. Wesley Alexander, Hope Goodman [166]	0	0	0		5 experienced stabilization/resolution of CRF (9.8%). Mortality between 112 and 2869 days 10% (causes not related to surgery)			Weight loss after GBP also seems to stabilize or improve renal disease in some patients, suggesting additional benefits for GBP early in CRF. Early GBP may also allow preemptive transplantation
J. Wesley Alexander, Hope Goodman	0	0	0		9 pts successfully transplanted			
J. Wesley Alexander, Hope Goodman	0	0	0					
Modanlou, Muthyala, Xiao et al. [167]	0							
Modanlou, Muthyala, Xiao et al.	3.5%							Given the known contributions of obesity to excess morbidity and mortality in this population, BS warrants prospective study as a strategy for improving outcomes before and after kidney transplantation
Modanlou, Muthyala, Xiao et al.	3.5%							

Table 8 (continued)

Author, year [ref]	Mortality	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery	Conclusions
Mohammad H. Jamal, Ricard Corcelles, Christopher R. Daigle et al. [168]	1/4.8% (GBP group, death unrelated to BS)		14%	19%			16 patients (76%) had lost sufficient weight and were placed on the transplant list, and 2 patients (9.5%) underwent kidney transplantation; 1 patient who had a LAGB was denied because of failure of weight loss, and 2 patients were denied because of their high cardiopulmonary risk	Chronic renal failure requiring dialysis should not be considered a contraindication to bariatric surgery. Our experience with this patient population has shown excellent medium-term weight loss and an acceptable (albeit increased) risk/benefit ratio
Anthony B. Mozer, John R. Pender, William H. H. Chapman et al. [169]	0.7% (1)		5.8%					Bariatric surgery in selected patients with DDRF is safe with a low rate of 30-day morbidity and mortality
C. M. Freeman, E. S. Woodle, J. Shi et al. [170]	37.8% (18) hypertension resolution, 30% T2DM resolution		1.9% (1)			55.8% of patients were eligible for waitlisting or living donor transplant, 6 (11.5%) were successfully transplanted	1-year mortality 3.8% comparing with 7% of overall waitlist mortality	LSG is a safe and effective means for addressing obesity in kidney transplant candidates in the context of a multidisciplinary approach

Table 8 (continued)

Author, year [ref]	Mortality	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery	Conclusions
Shadi Al-Bahri, Tannous K. Fakhry, John Paul Gonzalvo et al. [171]	0	0		0	2 deaths (12.5%) unrelated to surgery	Four patients 25% underwent renal transplantation 2.5–5 years post-BS. No rejection; 5 listed (31%): 5 not listed (31%); 2 lost in FU		Bariatric surgery is effective in patients with ESRD and improves access to renal transplantation. Bariatric surgery offers a safe approach to weight loss and improvement in comorbidities in the majority of patients. Referrals of transplant candidates with obesity for bariatric surgery should be considered early in the course of ESRD
Gheith, Al-Otaibi, Halim et al. [172]							Graft function 95% vs 88% in obese non-BS group (44 pts). Survival rate 100% vs 95%. Statin therapy 47% vs 71%. New-onset T2DM 13.6% vs 31.8%. Mean tacrolimus dose lower in the non-bariatric group with significantly lower targeted level (P = .02). No significant differences in the dose or targeted cyclosporine levels	Bariatric surgeries are feasible, safe procedures for selected obese renal transplant recipients
Y. Kim, A. D. Jung, V. K. Dhar et al. [173]	0	0	0	0	15% readmission 30 days; 40% readmission 1st year		5% Hemodialysis 24 h after SG, survival rate 100%, 10% graft loss at 1 year. All values inferior compared to control group	Post-operative complications frequently experienced among obese recipients, such as DGF, NODAT, and obesity-associated conditions, are favorably impacted by surgical weight loss

Table 8 (continued)

Author, year [ref]	Mortality	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery	Conclusions
Ian A. Thomas, Jeffrey J. Gaynor, Tameka Joseph [174]	0		25.8% (2 severe—6.4%)—outcomes BS related			80.6% (25/31) of patients had been waitlisted for a transplant, and 14 of 31 (45%) patients received a kidney transplant at the center	Outcomes 72 M median post-KT	
Cohen JB, Lim MA, Tewksbury CM et al. [175]	1/ 43 died/mortality 2.3%						Increased risk of acute rejection at 1 year (aOR 1.19, 95% CI 1.07–1.33) and a decreased risk of delayed graft function (aOR .53, 95% CI .42–.68), all-cause allograft failure (aHR .31, 95% CI .29–.33), and mortality (aHR .57, 95% CI .53–.61)	
Cohen JB, Lim MA, Tewksbury CM et al.				3/21 14%			Was associated with a decreased risk of all-cause allograft failure (aHR .85, 95% CI .85–.86) and mortality (aHR .80, 95% CI .79–.82)	Bariatric surgery appears to be a safe and reasonable approach to weight loss, both before and after transplantation. The issues should be discussed in detail with all obese transplant candidates when they are seen for transplant evaluation. Having a kidney transplant should not be a contraindication to bariatric surgery; however, because of the possibility of kidney-related complications, close monitoring of allograft function and calcineurin-inhibitor levels is recommended. Pretransplant bariatric surgery does not seem to significantly delay access to transplantation based on the results of the present study and should be considered for this group of patients
Renana Yemini, Eviatar Nesher, Idan Carmeli et al. [176]	2/8%					16/24 (67%) successfully transplanted. Average time form BS 1.5 years	50% re-admission rate in 1st year FU. 2/16 (12.5%) acute tubular necrosis requiring dialysis. One acute rejection (1/16-6.2%)	While the surgical risk is probably higher than that of the regular bariatric surgery population, we believe that the net advantages of the resulting weight reduction before kidney transplantation provide a convincing argument in favor of bariatric surgery for morbidly obese patients who require kidney transplantation

Table 8 (continued)

Author, year [ref]	Mortality	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery	Conclusions
Renana Yemini, Eviatar Nesher, Janos Winkler et al. [177]	1/3%							
Philippe Bouchard, Jean Tchervenkov, Sebastian Demyttenaere et al. [178]				3%		KT in 14 (44%) patients at a median of 8 (12) months after SG; 20 (63%) listed for KT	2/14 (14%) acute rejections. No graft loss	The acceptable safety and efficacy of SG in this high-risk population makes it an optimal choice as a bridging procedure. Furthermore, SG may allow for kidney transplantation in patients who may otherwise not be considered transplant candidates at some institutions due to their weight and body habitus
Jordana B. Cohen, Colleen M. Tewksbury, Samuel Torres Landa et al. [179]	13 (1.4%)			Reoperation 45 (4.9%); intervention 45 (4.9%); readmission 113 (12.2%); acute kidney injury 0				Patients with CKD and ESKD experience higher relative risk of post-bariatric surgery complications compared to patients without CKD. Although patients with ESKD have higher mortality risk compared to patients without CKD, this is comparable to the expected increased mortality rates in the non-surgical ESKD population, and substantially lower than postoperative ESKD mortality rates previously reported in other non-emergent surgeries. Our results reinforce that CKD and ESKD should not be contraindications to undergoing bariatric surgery

Table 8 (continued)

Author, year [ref]	Mortality	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery	Conclusions
	Mortality 322/0.1%; patients with CKD had no significant difference in 30-day mortality compared to patients without CKD (adjusted OR [aOR] 1.26, 95% CI 0.59–2.72); however, patients with ESKD had a significantly increased 30-day mortality risk (aOR 8.65, 95% CI 4.78–15.68) compared to patients without CKD		Patients with both CKD and ESKD had a significantly increased risk of 30-day reoperation (CKD aOR 1.72, 95% CI 1.33–2.22; ESKD aOR 2.73, 95% CI 2.01–3.72), intervention (CKD aOR 2.49, 95% CI 2.02–3.07; ESKD aOR 2.28, 95% CI 1.67–3.10), and readmission (CKD aOR 1.78, 95% CI 1.51–2.08; ESKD aOR 2.23, 95% CI 1.82–2.74)	Reoperation 5389 (1.7%); intervention 6266 (1.9%); readmission 15,677 (4.9%); acute kidney injury 552 (0.2%)	There was no effect modification of the association between CKD status and age ≥60 years, hypertension, and type of bariatric surgery ($P > .05$)			
	7/0.4%			Reoperation 64 (3.8%); intervention 102 (6%); readmission 182 (10.7%); acute kidney injury 63 (3.7%)				

Table 8 (continued)

Author, year [ref]	Mortality	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery	Conclusions
Hilla Schindel BSc, Janos Winkler MD, Renana Yemini MD et al. [180]	2/6.7% vs 16.7% in control group	2/6.7% vs 16.7% in control group	2/6.7% vs 16.7% in control group			4.6±3.1 years between BS and KT	CKD classification improved in 30% of the bariatric surgery group (9 patients) and in 12% of the control group (6 patients) (P = .083). The eGFR increased in the bariatric surgery group (+13.4) and decreased in the control group (−3.9) (P < .001)	The results of this analysis of kidney recipients demonstrated an improvement in renal function among the patients in the bariatric surgery group, while the patients in the control group had worsening of their renal function
Al-Faraaz Kassam, Ahmad Mirza, Young Kim et al. [181]	0			1.2% readmission rate		71 achieved a BMI ≤40 kg/m^2 and were waitlisted for KT, with 45 (63.4%) of these patients receiving KT and 10 (14.1%) remaining on the waitlist	Mortality rate among waitlisted patients after SG was 1.8 deaths per 100 patient-years, compared to 7.3 deaths per 100 patient-years on the waitlist and 5.5 nationally	SG has significant, sustainable effects on weight loss and medical comorbidities in this high-risk population and improves transplant candidacy safely and effectively, without increasing patient morbidity and mortality while on dialysis. It may also decrease the time from initial referral to KT
Kyle H. Sheetz, Kenneth J. Woodside, Vahakn B. Shahinian [182]			Readmission rate 8.6% vs 5.4% (pts without ESKD)	3.4% vs 3.6%(pts without ESKD)			GBP was associated with more complications, longer hospital stays, and more readmissions for all patients	This study suggests that laparoscopic sleeve gastrectomy has replaced Roux-en-Y gastric bypass as the most common bariatric surgical procedure in patients with ESKD. The data also demonstrate a favorable complication profile in patients with sleeve gastrectomy

Table 8 (continued)

Author, year [ref]	Mortality	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery	Conclusions
Małgorzata Dobrzycka, Monika Proczko-Stepaniak, Łukasz Kaska et al. [183]			1/20 5% (leak after OAGB 1st day p.o. reoperated)					Morbidly obese kidney transplantation candidates benefit from bariatric surgery and can be eagerly included in bariatric surgery weight loss programs. Bariatric surgery allows efficient pretransplantation weight loss results, and the procedures in ESKD patients seem as safe as previously published
Loubna Outmani, Hendrikus J. A. N. Kimenai, Joke I. Roodnat et al. [184]	0			39% Grade IIIa; 4.3% grade IIIb; 4.3% grade IV, 0 grade V	Weight gain 1 year post-transplantation was comparable among both groups, 2 kg (−5.5 to 8.5) in the TO and 0.8 kg (−10.1 to 5.5) in the BSG	Time between BS and KT 6.87 years (5.37–9.35)	5-Year survival rate 80% vs 81% of TO group. Graft failure 26. vs 37.6% of TO group	Patients who became eligible for KTx after BS after initial rejection due to obesity have similar results of KTx as matched kidney transplant patient with obesity class II and III who were eligible while being obese. Kidney transplantation after BS does not negatively affect the outcome of KTx compared with transplanting patients with obesity class II or higher
Basem G. Soliman, Nabil Tariq, Yi Ying Law et al. [185]	0	0	Readmission 2/5.3%; reoperation 2/5.3%; bleeding 2/5.3%			8/21% transplanted; 18/47% waitlisted	No reported peri-operative morbidity or mortality, no delayed graft function, or allograft failure over follow-up period of 1–23 months	Bariatric surgery has significant, sustainable effects on weight loss and improves transplant candidacy effectively and can successfully move patients through the care pathway to transplantation

Table 8 (continued)

Author, year [ref]	Mortality	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery	Conclusions
Elaine Ku, Charles E. McCulloch, Garrett R. Roll et al. [186]							34% re-admission vs 30% of non-BS pts; 10.5% of graft failure (*N* = 53) vs 14.6% in non-BS. No association between BS and risk of death; odds of acute rejection within the first year after KT tended to be higher (OR 1.14; 95% CI 0.87–1.48) among BS not statistically significant. There was no statistically significant association between a history of bariatric surgery and risk of graft failure. There was a tendency toward higher risk of death in those with a history of bariatric surgery compared with those without, although this finding also did not achieve statistical significance	

Table 8 (continued)

Author, year [ref]	Mortality	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery	Conclusions
Roxaneh Zaminpeyma, Matias Claus, Steven Paraskevas et al. [187]						27 (84%) listed for transplantation and 23 (72%) patients successfully transplanted	0% mortality, 0% SSI, readmission 90-day 4/17%; reintervention 3/13%, reoperation 2/9%; acute graft rejection 2/8.7%; chronic graft rejection 3/13%; return to dialysis 1/4.3%	
Mark C. Takata, Guilherme M. Campos, and Ruxandra Ciovica [188]	0	0	0	0		13 patients for whom follow-up data of 3 months were available reached our institution's BMI limits for transplantation and were undergoing their pretransplant evaluation		
Matthew Y.C. Lin, M. Mehdi Tavakol, Ankit Sarin et al. [189]	7/13 54% T2DM resolution	1/17%	0	0		1 pts successfully transplanted; another combined KT+LT		LSG in patients with end-organ dysfunction awaiting transplant is well tolerated, is technically feasible, provides excellent weight loss, and improves candidacy for transplantation

Table 9 MBS for BMI ≥60 kg/m²

Author, year	Study design	Population (comparator)	Age (comparator)	Initial BMI (comparator)	Presence of weight-related comorbidities (comparator)	Intervention (comparator)	Length of hospital stay (comparator)
Howell 2021 [192]	Retrospective cohort study	208 people with BMI ≥60 kg/m² (super super obese SSO)	43	65.9 ± 6.0	(Obstructive sleep apnea) OSA 153 (73.6%), (hypertension) HTN 123 (59.1%), (gastroesophageal reflux disease) GERD 90 (43.3%), (type 2 diabetes) T2DM 62 (29.8%)	97 Roux-en-Y gastric bypasses RYGB (46%), 88 laparoscopic sleeve gastrectomies SG (42%), 23 adjustable gastric bands LAGB (11%)	2.3 ± 0.9
Banks 2021 [193]	Prospective cohort study	21 SSO (super super obese) people treated with two-stage procedure (21 SSO people treated with single-stage procedure). Overall 42	45 (44)	66.1 ± 4 (63.7 ± 3.9)	HTN 10 (47.6%) (9 (42.8%)), T2DM 3 (14%) (3 (14%)), cardiovascular disease 3 (14%) (0), OSA 4 (19%) (8 (38%))	21 two-staged procedure (intragastric balloon for 6 months + sleeve gastrectomy) (21 single stage: 5 RYGB, 16 sleeve gastrectomy)	After definitive procedure 3.3 ± 1.9 (2.2 ± 0.6) *P*=.005
Nasser 2021 [194]	Retrospective cohort study	2505 LRYGB. (3510 LSG). Overall 6015 SSO	43.4 ± 11.3 (42.8 ± 11.3)	66.6 ± 6.2 (66.7 ± 6.6)	HTN 1580 (63.1%), (2131 (60.7%)) (dyslipidemia) DL 1137 (45.4%), (1349 (38.4%)) T2DM 1037 (41.4%), (1215 (34.6%)), GERD 1180 (47.1%) (1483 (42.3%)), OSA 1657 (66.2%) (2206 (62.9%))	2505 LRYGB. (3510 LSG)	NR
Mahmoud 2021 [195]	Prospective cohort study	52 SSO people. Overall 664 morbidly obese (MO) people	39.4 ± 11.6	>60 for 52 patients	NR	NR	NR
Dupree 2018 [196]	Retrospective cohort study	381 Obese, 225 superobese, 109 super super obese. Overall 715	40.7	67.4	T2DM 41 (37.6%), HTN 68 (62.3%), DL 10 (9.1%), OSA 31 (28.4%), GERD 20 (18.3%)	86 SG, 21 RYGB	NR
Samuel 2020 [197]	Retrospective cohort study	168 Obese, 182 super obese, 23 super super obese. Overall 353	40.9	65.03	T2DM 9 (39.1%), HTN 7 (30.4%), DL 6 (26%), OSA 2 (8.6%), GERD 4 (17.3%)	4 LAGB, 6 SG, 13 RYGB	NR

Table 9 (continued)

Author, year	Study design	Population (comparator)	Age (comparator)	Initial BMI (comparator)	Presence of weight-related comorbidities (comparator)	Intervention (comparator)	Length of hospital stay (comparator)
Stephens 2008 [198]	Retrospective cohort study	291 SSO. (3401 obese or super obese)	41	67 (46)	HTN 88 (30.2%) (1192), T2DM 52 (17.8%) (623), DL 24 (8.2%) (645), OSA 81 (27.8%) (500)	Vertical banded gastroplasty–Roux-en-Y gastric bypass VBG-RYGB 130 (1073), RYGB 116 (1356), laparoscopic adjustable gastric banding LAGB 45 (972)	3 (2)
Romero-Velez 2020 [199]	Retrospective database analysis	2322 people with BMI >70 (161,091 obese BMI < 70)	40.18 ± 10.489 (44.68 ± 11.73)	76.55 ± 8.772 (45.55 ± 7.298)	HTN 58,5% (50.6%) P= .01, T2DM 29.4% (27.7%), OSA 34.1% (16.3%) P=.001	954 SG, 1368 RYGB (68,271 SG, 92,820 RYGB)	2.66 ± 2.66 (2.18 ± 2.231) P=.0001
Schwartz 2013 [200]	Prospective cohort study	20 SSO	37.5	63	HTN 13 (65%), OSA 4 (35%), T2DM 7 (20%)	RYGB	6 days
Gonzalez-Heredia 2016 [201]	Retrospective cohort study	12 RYGB (68 SG). Overall 89 SSO	44.4 (38.1)	64.2 (64.9)	HTN 9 (75%) (38 (49.4%)), T2DM 6 (50%) (24 (31.2%)), DL 2 (16.7%) (23 (29.9%)), OSA 8 (66.7%) 34 (44.2%)	RYGB (SG)	3 (3.7)
Ochner 2013 [202]	Retrospective cohort study	BMI 35–39.9: n=232; BMI 40–49.9: n=1166; BMI 50–59.9: n=429; BMI ≥60: n=166	NR	NR	NR	Not relevant for the study	NR
Arapis 2019 [203]	Retrospective cohort study	210 SSO: 91 SG (119 RYGB)	44.9 ± 11.4 (39.7 ± 9.9) P=.0032	68.2 ± 7.1 (65.1 ± 4.3) P=.0003	T2DM 27 (29.6%) (38 (31.9%)), HTN 39 (42.8%) (50 (42.1%)), OSA 65 (68%) (75 (61.4%)), GERD 20 (21%) (38 (31.1%))	SG (RYGB)	7 (12) P=.003
Serrano 2016 [204]	Retrospective cohort study	135 SSO: 93 RYGB (42 LSG)	33.1 ± 11.5 (38.2 ± 11.3)	66.3 ± 5.4 (68.4 ± 7.9)	T2DM 26 (28.0%) (9 (21.4%)), DL 28 (32.2%) (10 (23.8%)), GERD 17 (18.3%) (10 (23.8%)), HTN 60 (64.5%) (20 (50.0)), OSA 43 (46.2%) (27 (64.3%))	RYGB (SG)	3.02 ± 2.8 (3.40 ± 2.7)

Table 9 (continued)

Author, year	Study design	Population (comparator)	Age (comparator)	Initial BMI (comparator)	Presence of weight-related comorbidities (comparator)	Intervention (comparator)	Length of hospital stay (comparator)
Mehaffey 2015 [205]	Retrospective database analysis	328 SSO (1681 non-SSO). Overall 2009.	41.10 ± 9.92 (42.88 ± 9.98)	67.0 ± 6.53 (50.9 ± 9.21)	GERD 28.66% (31.11%), OSA 45.73% (28.47%), HTN 60.67% (55.30%), T2DM 31.10% (32.80%)	RYGB on SSO (RYGB on non-SSO)	3.20 ± 3.27 (2.48 ± 2.02) *P*=.0341
Nasser 2019 [206]	Retrospective database analysis	18,861 SSO (65,565 SO, 272,195 MO). Overall 356,621	41.3 ± 11.1 (SO 42.7 ± 11.8; (MO 45.2 ± 11.9)	66.7 ± 7.44 (SO 53.9 ± 2.75; MO 42.4 ± 3.87)	GERD: 5265 (27.9%) (MO: 85,696 (31.5%); SO: 19,052 (29.1%)). HTN: 10,909 (57.8%) (MO: 128,184 (47.1%); SO: 34,228 (52.2%)). DL: 3775 (20.0%) (MO: 67,448 (24.8%); SO: 14,115 (21.5%)). T2DM: 5481 (29.1%) (MO: 69,697 (25.6%); SO: 18,241 (27.8%)). OSA: 10,460 (55.5%) (MO: 96,745 (35.5%); SO: 30,440 (46.4%)). *P*<.001	LSG: 12,725 (67.5%) (MO: 198,656 (73.0%); SO: 44,078 (67.2%)) RYGB: 6136 (32.5%) (MO: 73,539 (27.0%); SO: 21,487 (32.8%))	LSG: 1.79 ± 2.28 (MO: 1.57 ± 1.28; SO: 1.62 ± 1.19). RYGB: 2.27 ± 2.47 (MO: 1.97 ± 1.66; SO: 2.06 ± 2.47). *P*<.001
Thereaux 2015 [207]	Prospective cohort study	30 SSO (60 MO)	42.0±12.4 (41.8±11.5)	64.1±4.1 (46.3±5.6)	HTN: 76.7% (53.3%) T2DM: 40% (40%) OSA: 76.7% (56.7%) DL: 30% (45%)	RYGB	NR
Peraglie 2008 [208]	Retrospective cohort study	16 SSO	40	62.4	NR	One anastomosis gastric bypass (OAGB)	NR
Madhok 2016 [209]	Retrospective cohort study	19 SSO OAGB (56 SSO SG). Overall 75 SSO	45 (51)	67 (65)	T2DM: 6 (17); HTN: 8 (28); OSA: 3(12)	OAGB (LSG)	2 (2)
Gegner 2008 [210]	Retrospective cohort study	63 SSO	43	68	NR	LSG	5
Taylor 2006 [211]	Retrospective cohort study	60 SSO (444 MO)	40 (37)	≥60 (<60)	HTN: 3 (5%) (20 (4.5%)); T2DM: 15 (25%)(58 (13%)); OSA: 5 (8.3%) (26 (5.8%))	Open RYGB	5.1 (4.8)

Table 9 (continued)

Author, year	Study design	Population (comparator)	Age (comparator)	Initial BMI (comparator)	Presence of weight-related comorbidities (comparator)	Intervention (comparator)	Length of hospital stay (comparator)
Wilkinson 2019 [212]	Retrospective database analysis	5723 SSO (24,940 SO)	41.65 ± 11.22 (42.63 ± 11.88)	63.67 ± 2.7 (53.91 ± 2.75)	GERD: 1597 (27.9%) (7380 (29.6%)); HTN: 3230 (56.4) (12,893 (51.7%)); DL: 1159 (20.3%) (5309 (21.3%)); T2DM: 1687 (29.5%) (6856 (27.5%)); OSA: 3184 (55.6%) (11,620 (46.6%))	RYGB and LSG	NR
Abeles 2009 [213]	Retrospective cohort study	95 SSO (1311 MO)	42.8 ± 11.8 (42.6 ± 11.2)	64.9 ± 5.3 (45.8 ± 5.7)	NR	RYGB	3.1 ± 1.6 (3.1 ±2.9)
Parmar 2017 [214]	Retrospective cohort study	19 SSO OAGB, 47 SSO RYGB	45 (47)	67 (64.4)	T2DM: 7 (36.8%) (22 (46.8%)); HTN: 8 (42.1%) (24 (51.1%))	OAGB (RYGB)	2 (2)
Artuso 2004 [215]	Retrospective cohort study	21 SSO (61 SO)	42±10 (43±9)	≥60 (<60)	NR	RYGB	6.6±6 (5.3±3) *P*<.05
Ece 2018 [216]	Retrospective cohort study	28 SSO (52 SO, 83 MO)	42.5 ± 10.4 (SO: 40.1 ± 11.2; MO: 39.2 ± 14.6)	64.1 ± 3.0 (SO: 55.3 ± 2.7; MO: 44.8 ± 2.4)	T2DM: 15 (53.5%) (SO: 22 (42.3%); MO: 33 (39.7%)); HTN: 19 (67.8%) (SO: 23 (44.2%); MO: 32 (38.5%)); DL: 11 (39.2%) (SO: 17 (32.6%); MO: 25 (30.1%)). *P*<.05	SG	NR
Sachenz-Santos 2006 [217]	Prospective cohort study	70 SSO (184 SO, 483 MO)	42.2±10.8 (SO: 42.1±11.5; 40±2.6)	66 (SO: 54, MO: 44) Extrapolated from figures	HTN: 32.9% (SO: 34.8%; MO: 29%); OSA: 64.3% (SO: 33.1%; MO: 18.7%); T2DM: 30.4% (SO: 30.9%; MO: 16.9%); DL: 45.7% (SO: 38.7%; MO: 30.5%) *P* < .05 except for HTN	RYGB	6.3±4.7 (SO: 5.8 ±7.5; MO: 4.6±2.6)

Table 9 (continued)

Author, year	Study design	Population (comparator)	Age (comparator)	Initial BMI (comparator)	Presence of weight-related comorbidities (comparator)	Intervention (comparator)	Length of hospital stay (comparator)
Schmitz 2022 [218]	Retrospective cohort study	243 SSO. 93 SG, 150 OAGB	39.1 OAGB, 41.5 SG	65.2 (SG: 66.91; OAGB: 64.14)	OSA: SG: 69 (74.2%); OAGB: 113 (75.3%); T2DM: SG: 42 (45.7%); OAGB: 51 (34.0%); HTN: SG: 69 (74.2%); OAGB: 98 (65.3%)	OAGB (SG)	OAGB: 3.4 (SG: 4.5)
Moon 2016 [219]	Retrospective cohort study	230 SSO (661 SO, 1555 MO)	40.1±10.3 (SO: 42.1±10.8; MO: 42.3±11.0)	66.2±6.6 (SO: 54.1±2.7; MO: 44.6±7.7)	Number of comorbidities: 1.4±1.2 (SO: 1.5±1.2; MO: 1.5±1.2)	RYGB	NR
Farkas 2005 [220]	Prospective cohort study	46 SSO (167 MO)	40 (37)	67 (48)	T2DM: 10 (22%) (31 (19%)); HTN: 22 (48%) (52 (31%)); OSA: 9 (20%) (15 (9%))	RYGB	NR
Gould 2006 [221]	Retrospective cohort study	28 SSO (260 MO)	43.8 (45.2)	62.0 ± 2.3 (48.3 ± 5.4)	HTN:18 (64%) (139 (54%)); T2DM: 8 (29%) (60 (23%)); DL: 6 (21%) (86 (33%)); OSA: 11 (39%) (83 (32%))	RYGB	2.3 (2.2)
Kushnir 2010 [222]	Retrospective cohort study	21 SSO (147 MO)	46.7 (44)	68.6 (45.1)	Mean number of comorbidities: 4 (4)	RYGB	NR
Oliak 2002 [223]	Retrospective cohort study	39 SSO (261 MO)	41 (41)	66 (48)	HTN: 10 (26%) (101 (39%)); T2DM: 4 (10%) (43 (16%)); OSA: 11 (28%) (57 (22%)); DL: 3 (8%) (30 (11%))	RYGB	NR
Fielding 2003 [224]	Retrospective cohort study	76 SSO	39	69 ± 6.2	HTN: 16 (21%); T2DM: 4 (5.2%); OSA: 6 (7.9%)	LAGB	3
Hering 2022 [225]	Retrospective cohort study	26 SSO with balloon (52 SSO without balloon)	48.24 ± 10.2 (47.87 ± 10.1)	69.26 (64.07) $P<.01$	T2DM: 15 (57.7%) (21 (41.2%)); HTN: 25 (96.2%) (49 (94.2%))	10 Balloon + RYGB (17); 16 balloon + sleeve (35)	7.15 ± (7.67 ± 2.72)
Wang 2014 [226]	Retrospective cohort study	26 SSO	32.1	65.8	DL 25 (96.2%); OSA 14 (53.8%); T2DM 11 (42.3%); HTN 6 (23.1%); GERD 4 (15.4%)	RYGB	8.9

Table 9 (continued)

Author, year	Study design	Population (comparator)	Age (comparator)	Initial BMI (comparator)	Presence of weight-related comorbidities (comparator)	Intervention (comparator)	Length of hospital stay (comparator)
Singhal 2022 [227]	Multicenter observational cohort study	155 SSO (905 SO; 6024 MO)	39.3 ± 11.7 (SO: 41.2 ± 12.5; MO: 40.3 ± 11.8)	>60	*P* < .001 for all comorbidities among people with BMI >60. T2DM: 48 (31%); HTN: 77 (49.7%); OSA 51 (32.9%); DL: 42 (27.1%)	LSG 111 (71.6%); OAGB 23 (14.8%); RYGB 12 (7.7%); others 9 5.8%)	NR
Myers 2006 [228]	Retrospective cohort study	53	39.7	66	OSA 64%; HTN 42%; GERD 28%; DL: 23%; T2DM 19%	LAGB	2.7
Tichansky 2005 [229]	Retrospective cohort study	45 SSO (640 MO)	41.6 ± 10.1	65.6 ± 5.3 (47.8 ± 5.2)	HTN 66.7% (49.7) *P*=.03; OSA 44.4% (27.5) *P*=.03; T2DM 26.7%; GERD 55.6%	RYGB	6.4
Zerrweck 2012 [230]	Retrospective case–control	23 SSO balloon + RYGB (37 SSO RYGB)	44±10.8 (44.9±10.6)	65±3.8 (66.6±6.7)	T2DM: 8 (34%) (10 (27%)); HTN: 17 (73%) (22 (59%)); OSA: 8 (34%) (16 (43%))	Intragastric balloon prior to RYGB (RYGB alone)	5.4±2.4 (7.3±6.6)
Catheline 2012 [231]	Prospective cohort study	30	35	66	OSA 17 (58%); HTN 15 (50%); T2DM 13 (42%); DL 13 (42%)	LSG	7.5
Torchia 2009 [232]	Prospective cohort study	95	38.5±13.5	62.5±4.2	HTN: 44 (49.3%); T2DM: 11 (12.6%); OSA: 35 (39.4%); DL: 22 (29.4%)	LAGB	NR
Date 2013 [233]	Retrospective cohort study	28 SSO (23 MO)	44 (48)	67 (42)	T2DM: 15 (18); OSA: 14 (7); HTN: 16 (18); DL: 6 (13)	RYGB	NR
Di Betta 2008 [234]	Retrospective cohort study	32	37±9.3	70.1±5.3	T2DM 9 (28.1%); HTN 12 (37.5%); DL 17 (53.1%); OSA 9 (28.2%)	Duodenal switch associated with transitory vertical gastroplasty (DS-TVG)	12
Spyropoulos 2007 [235]	Retrospective cohort study	26	40.8 ± 8.1	65.3 ± 9.8	OSA 21 (81%); T2DM 18 (69%); HTN 7 (27%). Mean comorbidities per patient: 4.33±1.12	Intragastric balloon BIB	2

Table 9 (continued)

Author, year	Study design	Population (comparator)	Age (comparator)	Initial BMI (comparator)	Presence of weight-related comorbidities (comparator)	Intervention (comparator)	Length of hospital stay (comparator)
Gottig 2009 [236]	Retrospective cohort study	109	39.1±8.4	68.8±8.9	HTN 74 (67.8%); T2DM 53 (48.6%); OSA 39 (35.7%)	Intragastric balloon BIB	NR
Shuhabier 2004 [237]	Retrospective cohort study	25 SSO (25 SO)	38 (38.7)	78 (55)	OSA: 16 (18); HTN: 11 (12); GERD: 3 (3) T2DM: 6 (7)	Open RYGB	4.56 (3.04)
Fazylov 2005 [238]	Retrospective cohort study	102 SSO (283 SO)	38.75 (39.35)	68.45 (51)	HTN 55% (44.25%); T2DM 22.5% (24.3%); OSA 80.3% (49.8%); DL 29.4% (35.3%)	Open duodenal switch	NR

Author, year	Follow-up duration	Weight loss achieved (comparator)	Comorbidity resolution (comparator)	Early complications requiring reoperation (comparator requiring reoperation)	Long-term complications	Summary of findings	Additional notes
Howell 2021 [192]	30 days	NR	NR	11 complications (5.2%). 1 anastomotic leak (0.48%). No mortality. Complications occurred in 14.8% of conversion/revision cases and only 3.9% in primary cases (P = .0395)	NR	Bariatric surgery is feasible in patients with SSO (super super obesity). Revision procedures may increase risk of operative complications	
Banks 2021 [193]	12 months after definitive procedure	BMI 48.4 ± 1.9 (43.5 ± 2) P=.057; %EWL 45 (41.5) P=.47. %EBMIL 43 (51.3) ΔBMI 17.7	NR	7. 1 port site hernia (1)	NR	Routine use of an intra-gastric balloon in super-super obese patients is not required and may be associated with poorer peri-operative outcomes and delayed weight loss	

Table 9 (continued)

Author, year	Follow-up duration	Weight loss achieved (comparator)	Comorbidity resolution (comparator)	Early complications requiring reoperation (comparator requiring reoperation)	Long-term complications	Summary of findings	Additional notes
Nasser 2021 [194]	12 months	%EWL 55.5 ± 14.2 (47.5 ± 14.3) $P<.01$	T2DM 74.1% (58.2%) $P<.01$, HTN 52.9% (48.3%) $P=.10$, DL 62.7% (53.3%) $P=.01$, OSA 52.3% (43.5%) $P<.01$, RGE 78.4% (68.9%) $P=.04$	Any complications 14.5% (6.8%) $P<.01$, leak or perforation 1.0% (0.3%) $P<.01$, bowel obstruction 2.9% (0.4%) $P<.01$, bleeding 2.4% (1.1%) $P<.01$, surgical site infection 5.7% (1.4%) $P<.01$, rate of reoperation 2.8% (1.2%) $P<.01$	NR	LRYGB was associated with better weight loss and medication discontinuation 1 year following surgery at the expense of an increase in perioperative complications and resource utilization compared to LSG	
Mahmoud 2021 [195]	NR	NR	NR	NR	NR	Neither super obesity nor super super obesity is associated with difficult intubation or difficult mask ventilation. High STOP-Bang and Mallampati scores are the independent factors of possible difficult intubation in patients undergoing bariatric surgery	

Table 9 (continued)

Author, year	Follow-up duration	Weight loss achieved (comparator)	Comorbidity resolution (comparator)	Early complications requiring reoperation (comparator requiring reoperation)	Long-term complications	Summary of findings	Additional notes
Dupree 2018 [196]	30 days	NR	NR	2 major complications among super super obese. 1 leak 1 death	NR	BMI was significantly lower in patients with complications, ($P < .05$), whereas patients' age was significantly higher ($P < .05$) in complication cohort. BMI showed an inverse correlation to the patients' age at surgery ($P < .05$). Conclusion: Super super obesity should not be considered as a limiting factor for bariatric surgery outcome	
Samuel 2020 [197]	24 months	BMI 50.8. %EBMIL 35.54; ΔBMI 14.23	NR	0	NR	The mid-term results for weight loss and resolution of obesity-related comorbidities are best achieved in super-obese patients undergoing LRYGB, without any significant increase in complications with this procedure as compared with LAGB and LSG	

Table 9 (continued)

Author, year	Follow-up duration	Weight loss achieved (comparator)	Comorbidity resolution (comparator)	Early complications requiring reoperation (comparator requiring reoperation)	Long-term complications	Summary of findings	Additional notes
Stephens 2008 [198]	30 days	NR	NR	1 death (4 deaths) no significance	NR	Super-super obese patients required longer total operating room times, a longer hospital length of stay, and were more likely to be discharged to chronic care facilities than were patients with a BMI 60 kg/m^2; however, the in-hospital mortality was similar for both groups	Longer operating time for SSO. SSO people more likely to be discharged to chronic facilities
Romero-Velez 2020 [199]	30 days	NR	NR	9 Mortality 0.4% (0.1%) *P*=.0001, 25 sepsis 1.1% (0.4%) *P*=.001, 15 septic shock 0.6% (0.2%) *P*=.0001, 67 reoperation 2.9% (2%) *P*=.003	NR	BMI >70 is associated with higher morbidity and mortality, still relatively low	
Schwartz 2013 [200]	12 months	BMI 42.9, %EBMIL 52.89; ΔBMI 20.1	HTN 69%, T2DM 75%, OSA 43%	2 minor complications (10%), 1 death (5%)	NR	LGBP appears feasible and effective for SSO, both in terms of weight loss and improvement of comorbidities. Rate of complications is considered low	
Gonzalez-Heredia 2016 [201]	24 months	%EWL 68.5 (45.8) *P*=.014	NR	0 (2) no deaths	NR	SG and RYGB appear to be viable procedures for SSO patients. RYGB provides a significantly higher %EWL and %WL at 12 and 24 months compared to SG	

Table 9 (continued)

Author, year	Follow-up duration	Weight loss achieved (comparator)	Comorbidity resolution (comparator)	Early complications requiring reoperation (comparator requiring reoperation)	Long-term complications	Summary of findings	Additional notes
Ochner 2013 [202]	36 months	%EWL (extrapolated): BMI 35–39.9: 88%; BMI 40–49.9: 65%; BMI 50–59.9: 46%; BMI ≥60: 38%. *P*<.0005	NR	NR	NR	A dosage effect of preoperative BMI was apparent, with heavier individuals showing lower percentages of initial and excess weight loss, regardless of BMI above or below 60 kg/m^2	
Arapis 2019 [203]	60 months	BMI 46.07 (42.15), %EBMIL 51.22 (57.23); ΔBMI 22.13 (22.95) *P* not significant	Extrapolated: T2DM 32% (68%), HTN 38% (22%), GERD 82% (52%) *P*=.05	6 (6.6%) (14(11.7%), 1(5). 1 death (1). *P*=.02	26% of patients of the RYGB group. gallstone formation (6.7%), marginal ulcers (5.8%), internal hernias (5.4%), and anastomotic strictures (3.3%). The SG group had a 16.1% complication rate (*P* = .04). The most common was newly acquired GERD syndrome (7.6%)	SG as a primary procedure for SSO patients remains effective even though RYGB achieves better midterm-outcomes. RYGB associated with higher complications rate, both short and long term	
Serrano 2016 [204]	12 months	BMI 43.6 ± 5.4 (46.9 ± 6.8), %EBMIL 54.96 (49.53); ΔBMI 22.7 (21.5)	NR	RYGB: 15.1% of patients. Occlusion (5.4%), wound infection (4.3%), leak (2.2%), stricture (2.2%), bleeding (1.1%) and pulmonary embolism (2.2%). 1 death. SG: 4.8% of patients. Occlusion (2.4%) and pulmonary embolism (2.4%)	NR	Bariatric surgery is feasible in the SSO patients with comparable EWL outcomes and postoperative complications to historical non-SSO patients. Higher complication rate among RYGB patients	

Table 9 (continued)

Author, year	Follow-up duration	Weight loss achieved (comparator)	Comorbidity resolution (comparator)	Early complications requiring reoperation (comparator requiring reoperation)	Long-term complications	Summary of findings	Additional notes
Mehaffey 2015 [205]	48 months	%EBMIL 61.6 (69.36) P=.018	NR	11.4% (7.97%). 7.93% (7.72%). Mortality 0.61% (0.4%)	NR	RYGB is a safe operation for super-super obese patients with BMI >60 kg/m^2 in experienced centers. SSO patients still have significant reduction in excess BMI despite being less than non-SSO patients undergoing RYGB	
Nasser 2019 [206]	30 days	NR	NR	LSG: 582 (4.57%) (MO: 5060 (2.55%); SO: 1482 (3.36%)). RYGB: 532 (8.67%) (MO: 4,355 (5.92%); SO: 1419 (6.60%)). Mortality: 23 (.18%) (MO: 82 (.04%); SO: 35 (.08%))	NR	SO and SSO patients are at increased risk of 30-day morbidity and mortality compared with MO patients. Despite this elevated perioperative risk, the overall risk of these procedures remains low and acceptable especially as bariatric surgery is the durable treatment option for obesity	
Thereaux 2015 [207]	60 months	BMI: 46.6±8.6 (BMI: 32.6±5.9); %EBMIL 44.7 (64.3); ΔBMI 17.5 (13.7)	HTN: 56.5% (65.6%) T2DM: 83.3% (75.0%) OSA: 60.9% (82.4%) DL: 66.7% (70.4%)	Major adverse events 0% (7.1%)	NR	RYGB is associated with similar and beneficial long-term effects for SSO as for non SSO patients with regard to percentage of weight loss, diabetes and hypertension risks at 5 years	
Peraglie 2008 [208]	24 months	%EWL 65	NR	No complications	NR	OAGB seems safe and effective among SSO people	

Table 9 (continued)

Author, year	Follow-up duration	Weight loss achieved (comparator)	Comorbidity resolution (comparator)	Early complications requiring reoperation (comparator requiring reoperation)	Long-term complications	Summary of findings	Additional notes
Madhok 2016 [209]	24 months	%EWL 66 (38)	T2DM 66% (52%) HTN 12.5% (14.2%) OSA 66% (58%)	0 (3)	2 (5)	OAGB yields superior weight loss in comparison with SG in obese patients with BMI ≥60 kg/m2 without an increase in early complication rate	
Gegner 2008 [210]	12 months	BMI 50%EBMIL41.8; ΔBMI 18	NR	4 (5.8%)	NR	SG represents an excellent procedure for SSO to achieve good weight loss	
Taylor 2006 [211]	30 months	NR	NR	2 (3.33%) (38 (7.65%)) (2 deaths in the control group)	Anemia 7 (11.7%) (37 (8.3%))	Super-super-obese patients should not be excluded from RYGBP because of a perceived increased risk based upon BMI	
Wilkinson 2019 [212]	30 days	NR	NR	Unplanned ICU admission: 63 (1.1%) (185 (0.7%)) P=.006; re-admission: 276 (4.8%) (1038 (4.2%)) P=.03; mortality: 10 (0.2%) (33 (0.1%)) P=.44. Among SSO patients who underwent RYGB experienced more complications compared to those who underwent LSG: Re-admission 116 (6.4) 160 (4.1) <.0005 Intervention 53 (2.9) 47 (1.2) <.0005 Re-operation 41 (2.3) 33 (0.8) <.0005		Patients with SSO undergoing LRYGB or LSG have an increased risk of post-operative 30-day complications compared to patients with SO. For patients with SSO, LSG may be the preferred procedure of choice to counter the increased peri-operative risk associated with multiple pre-operative co-morbidities affording a lower 30-day post-operative complication profile compared to LRYGB	

Table 9 (continued)

Author, year	Follow-up duration	Weight loss achieved (comparator)	Comorbidity resolution (comparator)	Early complications requiring reoperation (comparator requiring reoperation)	Long-term complications	Summary of findings	Additional notes
Abeles 2009 [213]	30 days	NR	NR	Overall complications: 13 (13.7%) (167 (12.7%)) P= .8; Death: 0 (3 (0.2)) P=.08	NR	RYGB is safe for SSO. Overall, there were no increased risks of intraoperative complications or postoperative morbidity or mortality as compared with MO patients	
Parmar 2017 [214]	24 months	%EWL 70.4 (54.7–87) (57.1 (16–104)) P=.01	T2DM 3/7 (42.9%) (13/22 (59.1%)) P=.45 Resolution of hypertension 2/8 (25.0%) 11/24 (45.8%) P=.30	1 (0)	6 (2)	OAGB/MGB yields superior weight loss at 18- and 24-month follow-ups in comparison with the gold standard RYGB in patients with BMI ≥60 kg/m^2	
Artuso 2004 [215]	12 months	%EWL 47 (61) P<.05	NR	1 minor, 2 major, 1 death (6 minor, 1 major)	NR	BMI >60 kg/m^2 have a higher risk of major complications after LRYGBP than patients with BMI <60. BMI >60 has acceptable morbidity and should not be considered contraindicated to laparoscopic RYGB	
Ece 2018 [216]	41 months	BMI 45.0 ± 2.8 (SO: 37.0 ± 1.9; MO: 31.7 ± 2.1). %EBMIL 48.8. ΔBMI 19.0 ± 3.1 (SO: 18.2 ± 2.8; MO: 13.0 ± 2.7). P<.012	T2DM: 11 (73.3%) (SO: 19 (79.1%); MO: 27 (81.8%)); HTN: 14 (73.6%) (SO: 20 (80.0%); MO: 25 (78.1%)); DL: 9 (81.8%) (SO: 15 (83.3%); MO: 20 (87.0%))	5 (17.8%) (SO: 7 (13.4%); MO: 9 (10.8%))	NR	LSG is a safe standalone bariatric surgical procedure to use for the resolution of comorbidities in MO, SO, and SSO patients	

Table 9 (continued)

Author, year	Follow-up duration	Weight loss achieved (comparator)	Comorbidity resolution (comparator)	Early complications requiring reoperation (comparator requiring reoperation)	Long-term complications	Summary of findings	Additional notes
Sachenz-Santos 2006 [217]	60 months	BMI 36 (SO: 30, MO: 29) Extrapolated from figures, %EBMIL 46.8. ΔBMI 30	96% (MO: 88%)	Leak: 3.2% (SO: 4.7%; MO: 3.7%); reoperation: 0 (SO: 4.1%; MO: 2.2%); mortality: 1.6% (SO: 1.4%; MO: 0) P =.005	Incisional hernia among laparotomic RYGB 18.8% (SO: 12.2%; MO: 8.3%)	RYGBP achieved significant durable weight loss and effectively treated co-morbid conditions in SO and SSO patients with acceptable post-operative morbidity and slightly greater mortality than in MO patients	
Schmitz 2022 [218]	36 months	%BMIL: OAGB: 27.4 (SG: 22).	OSA: SG:24%; OAGB: 50%; T2DM: SG: 30%; OAGB: 22%; HTN: SG:22% ; OAGB: 50%	Clavien-Dindo >3: 2.7% (11.8%)	Insufficient weight loss/weight regain: OAGB: 14 (33.3%) (SG: 28 (66.7%)) $P<$ .001; Ulcer: OAGB: 11 (7.3%) (SG: 1 (1%)) P=.033	OAGB can be considered a safe and effective option in the treatment of SSO patients and can possibly even be considered superior to LSG in these patients	
Moon 2016 [219]	21.6 months	%EBMIL 59.1 (SO: 65.9; MO: 80.9)	Number of comorbidities: 1.1	Readmission rate: 11.7% (SO: 9.2%; MO: 10.7%) P=.07. Reoperation rate: 6.1% (SO: 5%; MO:7.3%) P<0.04. Mortality rate: 0.4% (SO: 0.2%; MO: 0.1%) P=0.56	NR	Readmission and reoperation rates were similar in BMI 40–50, 50–60, and ≥60 kg/m^2 group. Super-obese and super-super obese patients are not at greater risk for surgical complications when compared to those with lower BMIs	
Farkas 2005 [220]	24 months	%EWL 57 ± 7 (67 ± 18)	NR	Major complications: 5 (9); minor complications: 4 (10)	NR	LRYGBP can be performed safely and effectively in super-super-obese patients (BMI >60). Although these patients have less %EWL than lighter patients, they still end up with a good result	

Table 9 (continued)

Author, year	Follow-up duration	Weight loss achieved (comparator)	Comorbidity resolution (comparator)	Early complications requiring reoperation (comparator requiring reoperation)	Long-term complications	Summary of findings	Additional notes
Gould 2006 [221]	24 months	%EWL 60.8 ± 10.1 (70.9 ± 15.4)	T2DM: 100% (80%); HTN: 63% 89%); DL: 80% (92%); OSA 91% (92%)	1 (3.6%) leak; 1 (3.6%) wound infection	8 (28%) anastomotic stenosis (24 (9.2%)) P<.01; 3 (10.7%) marginal ulcers	Laparoscopic Roux-en-Y gastric bypass can be accomplished safely even in extremely obese patients. Although excess weight loss in the super super obese is diminished postoperatively when compared with less obese patients, health is improved and quality of life is good regardless of a patient's preoperative BMI	
Kushnir 2010 [222]	30 days	NR	NR	Major complications: 0 (2(1.4%)); minor complications: 1 (4.8%) (18 (11.8%))	NR	Patients with BMI ≥60 kg/m^2 do not have a higher postoperative morbidity compared with other patients undergoing laparoscopic Roux-en-Y gastric bypass	
Oliak 2002 [223]	30 days	NR	NR	Major complications: 4 (10%) (17 (6%)); 2 deaths (5%). Minor complications: 8 (21%) (34 (13%))	NR	Laparoscopic RYGBP is feasible for patients with BMI ≥60. Our data suggest that these patients are at a higher risk for GI leak, postoperative infection, and death	
Fielding 2003 [224]	60 months	BMI 35.09 ± 5.37 %EBMIL 77.27; ΔBMI 34	HTN: 9 (56%); T2DM: 4 (100%); OSA: 4 (66.6%)	2 minor (2.63%)	NR	Laparoscopic adjustable gastric banding is a valid surgical approach for mega obese patients	

Table 9 (continued)

Author, year	Follow-up duration	Weight loss achieved (comparator)	Comorbidity resolution (comparator)	Early complications requiring reoperation (comparator requiring reoperation)	Long-term complications	Summary of findings	Additional notes
Hering 2022 [225]	24 months	BMI 51.15 ± 6.99 (42.25 ± 6.62) %EBMIL 40.9; ΔBMI 18 (%EMBIL 56.4; ΔBMI 22)	NR	1 (3.8%) (1 (1.9%)	NR	No differences among complications, lower %EBMIL and ΔBMI in the balloon + surgery group	
Wang 2014 [226]	30 months	BMI 35.5±4.1 %EBMIL 74.2; ΔBMI 30.3	DL 20 (80%); OSA 8 (57%); T2DM 8 (72%); HTN 4 (66%); GERD 0 (100%)	2 minor (7.7%)	6 minor (23%)	LRYGB is feasible for Chinese super-obese patients, with significant short-term results	
Singhal 2022 [227]	30 days	NR	NR	12 (7.7%) P not significant. 3 deaths (1.9%) (SO: 0.1%; MO: 0.1%). P=0.001	NR	The 30-day mortality rate was significantly higher in patients with BMI >60 kg/m^2. There was, however, no significant difference in complications rates in different BMI groups	
Myers 2006 [228]	18 months	BMI 47.3 %EBMIL 45.6; ΔBMI 18.7	NR	One band removal for chronic obstruction (1.9%), one band revision for slip (1.9%), and one nonfatal pulmonary embolism (1.9%)	NR	LAGB is an appropriate surgical option for treatment of massive super-obesity. The procedure can be performed with minimal morbidity and mortality and leads to promising medium-term weight loss	
Tichansky 2005 [229]	12 months	%EWL 58 ± 13 (70 ± 16)	NR	Marginal ulcer 2 (4.4%) (25 (3.9%)); stomal stenosis 3 (6.7%) (18 (2.8%)); SBO requiring operation 3 (6.7%) (12(1.9%)) 0.07. Anastomotic leak 1 (2.2%) (26 (4.1%)); internal hernia 1 (2.2%) (5 (0.8))	NR	The complication and mortality rates are not increased in super-super obese patients who undergo RYGB, with acceptable weight loss	

Table 9 (continued)

Author, year	Follow-up duration	Weight loss achieved (comparator)	Comorbidity resolution (comparator)	Early complications requiring reoperation (comparator requiring reoperation)	Long-term complications	Summary of findings	Additional notes
Zerrweck 2012 [230]	12 months	%EBMIL 52.4±17.3 (50.3±12.7)	NR	2 (8%) (4 (11%)	NR	IGB prior to LGBP in super-super obese patients significantly reduced excess BMI. It was associated with a shorter operative time and a lower overall risk of significant adverse outcomes	
Catheline 2012 [231]	24 months	BMI 45 %EBMIL 51.2 ΔBMI 21	NR	4 (14%): two subphrenic hematoma, one leak, one pulmonary embolism	2 (7%) port site hernia, 6 (20%) reintervention for insufficient weight loss	Laparoscopic sleeve gastrectomy is a safe and efficient procedure for treating super super obesity. In the case of insufficient weight loss, a second-stage operation like resleeve gastrectomy or gastric bypass can be proposed	
Torchia 2009 [232]	48 months	BMI 28.9; %EBMIL 89.6 ΔBMI 33.6	HTN: 86%; T2DM: 90.9%; OSA: 100%; DL: 54.5%	2 minor	0	LAGB can be considered an appropriate bariatric surgical option in super-super obese patients, both for low morbidity rate and weight loss	
Date 2013 [233]	12 months	BMI 45 %EBMIL 52.3 ΔBMI 22 (28 %EBMIL 82.35 ΔBMI 14)	86% (79%)	2 (2)	NR	Higher %EBMIL but lower ΔBMI for MO compared to SSO	

Table 9 (continued)

Author, year	Follow-up duration	Weight loss achieved (comparator)	Comorbidity resolution (comparator)	Early complications requiring reoperation (comparator requiring reoperation)	Long-term complications	Summary of findings	Additional notes
Di Betta 2008 [234]	48 months	BMI 37.5±7.5 %EBMIL 72.3 ΔBMI 32.6	Improvement 100%	Major: Gastrointestinal bleeding 1 (3.1%) Abdominal rupture after laparotomy 1 (3.1%) Acute pancreatitis 1 (3.1%) Pulmonary embolism 2 (6.2%) Minor: Urinary infection 1 (3.1%) Wound infection 2 (6.2%) Pneumonia 1 (3.1%)	NR	In persons with BMI >60 DSTVG should be considered as a valid surgical option with two-staged laparoscopic procedures	
Spyropoulos 2007 [235]	6 months	BMI 54.3 ± 9.9 %EBMIL 27.29 ΔBMI 11	OSA 89%; T2DM 81.5%; HTN 85.7%	1 vomiting treated with medical therapy for 5 days	0	BIB placement can be considered an effective first-stage treatment of high-risk mega-obese patients in need of surgical intervention	
Gottig 2009 [236]	6 months	%EBMIL 19.7±10.2 ΔBMI 8.7±5.1		3 minor	0	The study shows safety and efficacy of intragastric balloon in extremely obese patients particularly as a first step before a definitive anti-obesity operation	
Shuhabier 2004 [237]	30 days	NR	NR	Intensive care unit ICU days: 17 (0); days on ventilator: 7 (0). $P<.05$	NR	Gastric bypass in mega-obese persons can be performed safely. A longer LOS, need for ICU stay and mechanical ventilation should be anticipated	

Table 9 (continued)

Author, year	Follow-up duration	Weight loss achieved (comparator)	Comorbidity resolution (comparator)	Early complications requiring reoperation (comparator requiring reoperation)	Long-term complications	Summary of findings	Additional notes
Fazylov 2005 [238]	30 days	NR	NR	Mortality: 8 (7.8%) vs 0 in SO group, P <0.01; among male patients (7/8) 16.7% vs 0. Other complication similar between SSO and SO	Incisional hernia and small bowel obstruction similar between two groups	SSO patients (males especially) experience significantly higher mortality compared with SO patients	

given the setting of these studies, there is the possibility of bias due to the selection of patients.

In an RCT on 82 patients with obesity and osteoarthritis, 39 were randomized to AGB 12 months prior to total knee arthroplasty (TKA), and 41 patients were randomized to receive the usual nonoperative weight management prior to TKA. In a median follow-up of 2 years after TKA, 14.6% of patients in the MBS group incurred the primary outcome of composite complications, compared with 36.6% in the control group (difference 22.0%, $P = .02$). The incident TKA decreased by 29.3% in the MBS group because of symptom improvement following weight loss, compared with only 4.9% in the control group [133].

MBS can be performed safely before joint arthroplasty. However, further data are needed with specifically designed trials to clarify the causal role of MBS on the outcomes of subsequent joint arthroplasties.

Considering the conflicting data obtained from the literature, the IFSO and ASMBS decided to conduct a Delphi analysis on the topic of joint arthroplasty in patients with obesity (Table 15). This included the role of MBS as a bridge to joint arthroplasty and the proper time to arthroplasty after MBS.

During the two rounds of the Delphi analysis, the 49 experts reached a consensus on 5 statements concluding that MBS is indicated in patients with class II and III obesity (BMI of ≥ 35 kg/m^2) even with no other medical conditions and in all age groups following a comprehensive multidisciplinary team assessment. In this survey, consensus was reached in four statements. First, MBS can be considered a bridge to joint arthroplasty in patients with a BMI ≥ 30 kg/m^2. Second, MBS can decrease the operating time, risk of readmission, and short-term complications of subsequent joint arthroplasty in patients with a BMI ≥ 30 kg/m^2. Third, MBS can decrease the need for joint arthroplasty in patients with BMI ≥ 30 kg/m^2. Fourth, the experts also reached a consensus that joint arthroplasty in patients with a BMI ≥ 30 kg/m^2 should be done 6 months to 1 year after MBS, depending on the severity of the joint disease, if there is weight loss stabilization and if the patient has good muscle mass and nutritional status.

Recommendation

- *Obesity is associated with poor outcomes after total joint arthroplasty. Orthopedic surgical societies discourage hip and knee replacement in patients with BMI ≥40 kg/m^2, mainly due to the increased risk of readmission and surgical complications, such as wound infection and deep vein thrombosis.*
- *Before total knee and hip arthroplasty, MBS has decreased operative time, hospital LOS, and early post-operative complications.*
- *According to experts, MBS can be considered a bridge to joint arthroplasty in patients with BMI ≥ 30 kg/m^2.*

Table 10 MBS in patients with liver cirrhosis

PMID	Author, year [ref]	Publication	Evidence	Number of patients	Intervention	Length of stay	Mean follow-up (months)	Weight (kg)	BMI basal	Weight (kg) follow-up	BMI follow-up	EWL/TWL %	Comorbidity resolution
33900587	Kaul A et al. [239]	*Obes Surg*. 2020	Level 3	22 Cirrhosis	SG 20, RYGB 2	4/8	27 (6–51)	129 ± 24.7	48.8 ± 7.5	86.4 ± 14.8	33.1 ± 5.5	62.4 ± 15.8 (EBMIL)	Amelioration DM2
30109667	Hanipah ZN et al. [240]	*Obes Surg*. 2018	Level 3	13 (cirrhosis + portal hypertension)	SG 10, RYGB 3	3 (2–4)	24/00	137 (111–156)	48	97.1 (71.7–132.9)	36.7 (28.3–43.8)	49/25	100% diabetes, 100% dyslipidemia, 50% hypertension
31853866	Younus H et al. [241]	*Obes Surg*. 2020	Level 2	26 Cirrhosis	GB 1, SG 7, RYGB 17, open RYGB 1,	5	54 (24–132)	126	46	NR	NR	NR	NR
32808168	Quezada N et al. [242]	*Obes Surg*. 2020	Level 2	16 Cirrhosis (including 3 with portal hypertension)	SG 11, RYGB 5	3 ± 1	24/00	NR	39 ± 6.8	NR	NR	84.9%/28%	Hypertension 14%, DM2 50%, dyslipidemia 85%
27881858	Singh T et al. [243]	*Int J Obes (Lond)*. 2017	Level 2	99 (fibrosis stage 3 and 4)	GB5, SG 19, RYGB 75	4	12/00	NR	46.4 ± 9.6	NR	33.5 ± 7.7	NR	NR
32152677	Salman MA et al. [244]	*Surg Endosc*. 2021	Level 2	71 (NASH-related cirrhosis)	SG 71	NR	30/00	122.5 ± 14.5	44.1 ± 4.3	95.1	NR	NR	DM 50%, hypertension 61.5%, dyslipidemia 70.6%
32285332	Mumtaz K et al. [245]	*Obes Surg*. 2020	Level 2	3086 compensated cirrhosis, 103 decompensated cirrhosis	RYGB 2367, SG 719; RYGB 78, SG 25	1.7 (1.2–2.6) and 3.4 (2.0–7.6)	NR	NR	NR	NR	NR	NR	NR
33156104	Are VS et al. [246]	*Am J Gastroenterol*. 2020	Level 2	9802 (cirrhosis), 9356 CC, 446 DC	46% restrictive procedure	3.4 ± 10.5%	NR	NR	NR	NR	NR	NR	NR
34351576	Miller A et al. [247]	*Updates Surg*. 2021	Level 2	3032	RYGB 1864, SG 1168	3.4 RYGB vs 3 SG	NR	NR	NR	NR	NR	NR	NR
30794300	Klebanoff MJ et al. [248]	*JAMA Netw Open*. 2019	Level 2	161	SG, RYGB	NR	NR	NR	NR	NR	NR	NR	NR

Table 10 (continued)

PMID	Author, year [ref]	Publication	Evidence	Number of patients	Intervention	Length of stay	Mean follow-up (months)	Weight (kg)	BMI basal	Weight (kg) follow-up	BMI follow-up	EWL/TWL %	Comorbidity resolution
23201210	Shimizu H et al. [249]	*Surg Obes Relat Dis*. 2013	Level 3	23	RYGB 14, SG 8, GB 1	4.3 ± 2.7	37 ± 11.1	137 ± 32.6	48.2 ± 8.6	124.8 ± 33.7	45 ± 7.7	67.7 ± 24.8	Lipid profile improvement in majority of pt, 86.7 improved glucose control in dm2, clinical improvement dyslipidemia 66.7 and hypertension 68.7
14980033	Dallal RM et al. [250]	*Obes Surg*. 2004	Level 3	30 Cirrhosis	27 RYGB, 3 SG	4 ± 4	16/00	NR	52.6 ± 8.3	NR	NR	63±15	NR
34129090	Mittal T et al. [251]	*Surg Endosc*. 2022	Level 3	15 Portal hypertension	SG	2.73 ± 0.59	12/00	117.53 ± 19.97	43.7 ± 5.79	86.05 ± 14.4	31.16 ± 3.82	26.5 ± 5.42 TWL	Diabetes resolution 80%, hypertension resolution 72.72%
30397876	Minambres I et al. [252]	*Obes Surg*. 2019	Level 3	41	SG 28, GB 11, BPD 2	NR	38 ± 20	NR	45 ± 8.3	NR	NR	21.16± 15.32 TWL	DM2 remission 53.6%,
32925171	Vuppalanchi R et al. [253]	*Ann Surg*. 2022 (full text missing)	Level 3	106		3.7 ± 4						29.1 ± 10.9	

PMID	Author, year [ref]	Intra-operative complications	Peri-operative complications	Post-operative complications	Earzly mortality	Late mortality	Long-term complications	Child–Pugh	Diagnosis of cirrhosis	Liver outcome	TIPS	Transplantation list
33900587	Kaul A et al. [239]	0	0	$n = 1$ postoperative liver decompensation, $n = 1$ postoperative flank echymoses (both after SG)	0	1 (after 6 months)	0	A	Transient elastography, intraoperative and percutaneous biopsy	$n = 3$ worsening on transient elastography	0	0

Table 10 (continued)

PMID	Author, year [ref]	Intra-operative complications	Peri-operative complications	Post-operative complications	Earzly mortality	Late mortality	Long-term complications	Child–Pugh	Diagnosis of cirrhosis	Liver outcome	TIPS	Transplantation list	
30109667	Hanipah ZN et al. [240]	0	0	Infection (1), intra-abdominal hematoma (1), sub-cutaneous hematoma (1)	0	1 (8 months)	GERD 1, dysphagia 1, cholecystitis 1	NR	Endoscopy, imaging studies, routine intra-operative liver biopsy, mean MELD prior to MBS 9 (7–17)	MELD post-operative 10 (7–13), no changes in the liver function	6 (4 prior, 2 after MBS)	4—but nobody transplanted	
31853866	Younus H et al. [241]	0	(10/26)	$n = 3$ CD > III (12%)	0	0	0	A	Intra-operative biopsies	MELD score from 7 to 6	NR	NR	
32808168	Quezada N et al. [242]	0	(5/16)	$n = 2$; CD > III (12%)	0	1 (traffic accident)	$n = 1$ hepato-carcinoma at 6 years—LT	A	Intra-operative biopsies	MELD pre 7.38± 1, 2-year FU: 8.63 ± 3 ($P = .52$)	NR	NR	
27881858	Singh T et al. [243]	0	(13/99)	17 (17.2%)	0	0	36.4%	A	Intraoperative biopsies	MELD pre 7 (6–7) to post 6 (6–7)	0	0	
32152677	Salman MA et al. [244]	0	(9/71)	Bleeding 4, leakage 2, ascites 1, HE 1, ARDS 1	0	0	0	A	Wedge biopsy	Fibrosis score at 30 months: F2 26.8%, F3 40.8%, F4 32.4%	NR	NR	
32285332	Mumtaz K et al. [245]	NR	NR	NR	20 (0.6%) with CC, 20 (19.4%) with DC	NR	NR	NR	NR	NR	NR	NR	Higher mortality in DC, undergoing RYGB, low-volume centers (<50 BS)

Table 10 (continued)

PMID	Author, year [ref]	Intra-operative complications	Peri-operative complications	Post-operative complications	Earzly mortality	Late mortality	Long-term complications	Child–Pugh	Diagnosis of cirrhosis	Liver outcome	TIPS	Transplantation list	
33156104	Are VS et al. [246]	NR	2% (1.4 CC, 14.1 DC)	Bleeding 2.9%, sepsis 1.8%, urinary tract infection 1.9%, acute kidney injury 4.5%	9356: 0.8% in CC and 446 22.1% in DC	NR	NR	NR	NR	NR	NR	NR	Higher inpatient mortality in nonrestrictive surgery and low-volume centers (<50 BS/year)
34351576	Miller A et al. [247]	NR	See post-operative	Ascites 1.7 vs 1, variceal bleeding <1 vs 1.1, encephalopathy 0.6 vs < 1	21 (1.1%) RYGB vs <10 SG	42 (2.2%) RYGB vs <10 SG	Ascites 3.5 vs 1.4, variceal bleeding <1 vs 1.1, encephalopathy 2.3 vs <1		NR	NR	NR	NR	RYGB increased healthcare utilization in CC
30794300	Klebanoff MJ et al. [248]	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	BS highly cost-effective in patients with NASH and compensated cirrhosis, with SG being the most cost-effective option across all weight classes

Table 10 (continued)

PMID	Author, year [ref]	Intra-operative complications	Peri-operative complications	Post-operative complications	Earzly mortality	Late mortality	Long-term complications	Child–Pugh	Diagnosis of cirrhosis	Liver outcome	TIPS	Transplantation list
23201210	Shimizu H et al. [249]	NR	RYGB changed in SG in 3 pt	8 (34.8%): 1 gastrojejunal leak, 2 anastomotic strictures, 1 infected hematoma, 1 leak, 1 stricture, 1 pneumonia, 1 bleeding	0	1 (9 months)	NR	A (22), B (1)	21 Liver biopsy during surgery	Follow-up biopsies in 3 patients: marked improvement in the degree of fatty change and inflammation, others not evaluated	2 prior	NR
14980033	Dallal RM et al. [250]	Greater average blood loss 290 ml (vs 115 ml in general)	RYGB changed in SG in 3 pt	10/30 4 acute tubular necrosis, 1 anastomotic leak, 2 transfusions, 1 prolonged ileus, 2 intubation	0	1	9/30 1 Prolonged nausea and malnutrition, 3 abdominal pain, 1 protein malnutrition, 1 renal calculi, 2 marginal ulcer, 1 acute cholecystitis		Intra-operatively in 90%	No liver-related complications	NR	NR
34129090	Mittal T et al. [251]	0	0	0	0	0	3 with GERDA		Endoscopy with dilated esophageal varices	NR	NR	NR

Table 10 (continued)

PMID	Author, year [ref]	Intra-operative complications	Peri-operative complications	Post-operative complications	Earzly mortality	Late mortality	Long-term complications	Child–Pugh	Diagnosis of cirrhosis	Liver outcome	TIPS	Transplantation list
30397876	Minambres I et al. [252]	NR	7/41 patients fistula, hemoperitoneum, upper GI bleeding in ulcers, portal thrombosis, wound infection, 2 ascites decompensation	2 liver decompensation, 3 late liver decompensation	0	0	6 patients HCC post-surgically	A 40, B 1	Biopsy during surgery, 17 prior to surgery	MELD 7.2 ± 1.9, 7.8± 2.2 1 year, 8.4±3.1 3 years, 9.8 ± 4.6 5 years	NR	1 of 41
32925171	Vuppalanchi R et al. [253]				0	3		97%	46% prior to surgery			

Level of Evidence 2b

Grade of recommendation B

7. MBS and abdominal wall hernia repair [143–165]

PRISMA Appendix [PubMed, Cochrane, Embase]

Systematic Review Table 7

Twenty-three studies were included [143–165]. Five studies were extracted from national registers, including the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) [144, 151], the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) [159], and the French hospital discharge summaries database system [154]. The other 18 studies were single-cohort retrospective studies. The studies were heterogeneous regarding timing and technique. Timing is mainly divided into ventral hernia repair (VHR) before MBS (symptomatic, low- or high-grade intestinal obstruction), concomitant VHR, and VHR after MBS. Some authors presented treatment algorithms regarding timing in their studies [147, 158, 161]. Of the 23 studies, 18 studies included a concomitant VHR and 5 studies a staged procedure [143, 147, 155, 162, 163]. Ventral hernias included epigastric, incisional, umbilical, paraumbilical, and Spigelian hernias, and one study reported the multistep approach in complex hernias with loss of domain [162]. Studies included primary and recurrent incisional hernia repair. VHR included open and laparoscopic techniques, with and without mesh. MBS included AGB, SG, and open and laparoscopic RYGB.

The studies analyzed postoperative morbidity and mortality, long-term complications, and recurrence rates. Abdominal wall hematoma, seroma, and surgical site infections were the most reported complications associated with all types of VHR. Small bowel obstructions (SBOs) and mesh dehiscence were reported in some studies, with the highest incidence of SBO at 37.5% in one study with deferred treatment [153].

Early mortality was reported in four register studies that analyzed concomitant VHR and was reported to be 0.3% [144], <1% [151], 0.2% [157], and 0.1% [159].

The literature presents a large amount of heterogeneous data regarding VHR in patients with obesity, and only five studies evaluated a staged approach. Due to the higher risk of reoperation for recurrence, VHR would be avoided in bariatric patients before MBS.

Recommendation

- *Obesity is a risk factor for the development of ventral hernias.*
- *In persons with obesity and an abdominal wall hernia, MBS-induced weight loss is suggested before ventral hernia repair in order to reduce the rate of postoperative complications.*

Level of Evidence 2b

Table 11 MBS in patients with heart failure

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidity resolution	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery
Blumer 2020 [254]	Retrospective	5	5216 (2636 RYGB, 2272 SG, 308 LAGB)	NA	Range from <35 to >60	NA	NA	NA	NA	Myocardial infarction 9% vs 0.1%; AF 28.7% vs 1.9%; pneumonia 12.7% vs 0.82%; respiratory failure 16.8% vs 1%; AKI 27.9% vs 1.9%	NA	NA	788,195 BS vs 5216 BS with HF	Higher in-hospital mortality than BS without HF (10.3 vs 0.4)
Sun, 2022 [255]	Retrospective	5	318 SG (72%), 110 RYGB (25%), 15 others (14%)	NA	72% BI >40	NA	NA	NA	None	None	10/433 worsening of HF	NA	433 with hypertrophic cardiomyopathy	Safe surgery with few post-operative complications
Balakuraman, 2022 [256]	Retrospective	5	10 SG, 5 RYGB	2	50	38.3	35.77 TWL	NA	NA	NA	NA	NA	NA	12/15 had recovery for LVEF
Mentias, 2022 [257]	Retrospective propensity score match	5	94,885 BS vs 94,885 matched cohort	4 years	44.7	NA	NA	NA	NA	NA	NA	NA	NA	54% lower risk of new onset HF; lower rate of readmission for HF
Val, 2020 [258]	Retrospective	5	23 SG, 3 RYGB	12 mm	42.8	31.7	35 lb	NA	None	2 DVT, 4 AKI, 3 SSI	NA	1 death 48 dd	12 LVAD inserted	Complication rates remain in an acceptable range

Table 11 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidity resolution	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery
Alsabrook, 2006 [259]	Retrospective	5	32 RYGB	2 yy	56.5	38.9	48 kg	15/16 DM, 17/23 HTN, 20/23 OSAS	None	May-32	1 death	NA	32 CHF	Acceptable morbidity and mortality
Vest, 2016 [260]	Retrospective	5	8 LAGB (19%), 23 RYGB (55%), 11 SG (26%)	12 mm	48.2	35.5	22.6%	NA	None	HF/pulmonary edema 10%, MI 2% AKI 2%, ICU 5%, readmission 12%	NA	NA	42 LSVD	Improvement of LVEF; acceptable morbidity
Naslund, 2021 [261]	Retrospective	5	465 RYGB, 44 SG	4.6 yy	40.6	28	29% TWL	51% DM, 24.7% HTN 66.1% OSAS	NA	8.4%, serious 3.8%	NA	1 death 0.2%	53 HF	Lower risk of new-onset HF and MI
Doumouras, 2021 [262]	Retrospective propensity score match	5	1319 BS (79.5% RYGB, 20.5% SG) vs 1319 non-BS	NA	NA	NA	NA	NA	NA	NA	NA	Overall 7.7% and 0.15% mortality	274 HF	Bariatric surgery was associated with a significant lower incidence of MACE in patients with CVD and severe obesity. These observed results apply to both patients with IHD and HF

Table 11 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidity resolution	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery
Aminian 2021 [263]	Retrospective observational matched	5	1362 RYGB; 693 SG	5 yy	45.3	NA	NA	NA	NA	NA	NA	NA	204 HF	Lower incidence of MACE; reduction in incidence of HF
Lundberg, 2022 [264]	Retrospective population-based cohort	5	27,882 RYGB	10 yy	NA	NA	NA	NA	NA	NA	NA	NA		Lower risk of developing HF than non-operated obese match, higher risk than controls (but slightly)
Yuan, 2021 [265]	Retrospective	5	308 RYGB	1 y	>35	NA	NA	NA	NA	NA	NA	NA	1 HF	Lower rates of developing MACE
Ng, 2022 [266]	Retrospective	5	22 SG	18 mm	43.3	31.5	26.8% TWL	NA	NA	NA	NA	NA	22 LVAD positioned before SG	2 LVAD explanted, 10 HT, 5 listed for HT
Benotti, 2017 [267]	Retrospective longitudinal cohort	5	1724 RYGB and 1724 matched control	8 yy	46.5	NA	NA	70% DM	NA	NA	NA	NA	79 HF	Reduced risk of relapse
Hoskuldsdottir, 2021 [268]	Cohort study retrospective	5	5321 RYGB and 5321 matched	4.5 yy	42	32	NA	NA	NA	NA	NA	NA	142 HF	Lower rates of rehospitalization for HF and reduction in mortality

Table 11 (continued)

Author, year [ref]	Study design	Quality assessment	Number of patients (intervention)	Mean follow-up (months)	BMI basal	BMI follow-up	EWL/TWL	Comorbidity resolution	Intra-operative complications	Peri-operative complications	Post-operative complications	Long-term complications	Bridge to surgery	Outcomes of secondary surgery
Yang, 2020 [269]	Retrospective	5	18 LAGB, 2SG, 1 BPD	1 y	46.2	38	43.8 % EWL	NA	NA	NA	4 Clavien–Dindo 1, 3 CD 2, 2CD 3b	1 Infected band	3 Heart transplant	1 had successful HT, 2 were removed from HT list because of increased LVEF; 76,2% had an increase of at least 10% of LVEF
Strzelczyk, 2021 [270]	Retrospective	5	65	1 y	43.7	30	31.2 %EWL	NA	NA	NA	NA	NA	NA	Left atrial function increased after BS, with overall cardiac improvement
Stenberg, 2022 [271]	Observational matched cohort database	6	974 RYGB and 191 SG with HD vs 4870 RYGB and 955 SG without HD	2 yy	NA	NA	28.7 %TWL	NA	2.80%	9.40%	NA	0.70%	NA	Same complication rate in HD obese patients. Higher but acceptable cardiovascular complication rate for HF 1.2% vs 0.2%

Table 12 Multidisciplinary care

Practical Recommendations of the Obesity Management Task Force of the European Association for the Study of Obesity for the Post-Bariatric Surgery Medical Management [272]	Busetto L, Dicker D, Azran C, Batterham RL, Farpour-Lambert N, Fried M, Hjelmesæth J, Kinzl J, Leitner DR, Makaronidis JM, Schindler K, Toplak H, Yumuk V	*Obes Facts*	Metabolic/obesity surgery is today the most effective long-term therapy for the management of patients with severe obesity, and its use is recommended by the relevant guidelines of the management of obesity in adults. Bariatric surgery is in general safe and effective, but it can cause new clinical problems and is associated with specific diagnostic, preventive, and therapeutic needs. For clinicians, the acquisition of special knowledge and skills is required in order to deliver appropriate and effective care to the post-bariatric patient. In the present recommendations, the basic notions needed to provide first-level adequate medical care to post-bariatric patients are summarized. Basic information about nutrition, management of co-morbidities, pregnancy, psychological issues as well as weight regain prevention and management is derived from current evidences and existing guidelines. A short list of clinical practical recommendations is included for each item. It remains clear that referral to a bariatric multidisciplinary center, preferably the one performing the original procedure, should be considered in case of more complex clinical situations	Eng	2017	MEDLINE

Table 12 (continued)

Optimizing Bariatric Surgery Multidisciplinary Follow-up: A Focus on Patient-Centered Care [273]	Aarts MA, Sivapalan N, Nikzad SE, Serodio K, Sockalingam S, Conn LG	*Obes Surg*	Background: Failure to follow-up post-bariatric surgery has been associated with higher postoperative complications, lower percentage weight loss, and poorer nutrition Objective: This study aimed to understand the patient follow-up experience in order to optimize follow-up care within a comprehensive bariatric surgery program Methods: Qualitative telephone interviews were conducted in patients who underwent surgery through a publicly funded multidisciplinary bariatric surgery program in 2011, in Ontario, Canada. Inductive thematic analysis was used Results: Of the 46 patients interviewed, 76.1% were female, mean age was 50, and 10 were lost to follow-up within 1 year post-surgery. Therapeutic continuity was the most important element of follow-up care identified by patients and was most frequently established with the dietician, as this team member was highly sought and accessible. Patients who attended regularly (1) appreciated the specialized care, (2) favored ongoing monitoring and support, (3) were committed to the program, and (4) felt their family doctor had insufficient experience/knowledge to manage their follow-up care. Of the 36 people who attended the clinic regularly, 8 were not planning to return after 2 years due to (1) perceived diminishing usefulness, (2) system issues, (3) confidence that their family physician could continue their care, or (4) higher priority personal/health issues. Patients lost to follow-up stated similar barriers Conclusion: Patients believe the follow-up post-bariatric surgery is essential in providing the support required to maintain their diet and health. More personalized care focusing on continuity and relationships catering to individual patient needs balanced with local healthcare resources may redefine and reduce attrition rates	Eng	2017	MEDLINE

Table 12 (continued)

Panel report: best practices for the surgical treatment of obesity [274]	Gould J, Ellsmere J, Fanelli R, Hutter M, Jones S, Pratt J, Schauer P, Schirmer B, Schwaitzberg S, Jones DB	*Transplantation*	The multidisciplinary bariatric patient care team and the bariatric program accreditation process are key factors in best outcomes. The multidisciplinary WLS team should include trained surgeon(s), a WLS program coordinator, nutritionist, primary care physician, medical subspecialists, and the operating room team. Optimal perioperative care of the WLS patient involves the use of multiple medical disciplines and the multidisciplinary team. For this reason, WLS should be focused at centers where these resources are readily available. The multidisciplinary WLS team is an important component of any bariatric surgery program for a variety of reasons. First of all, bariatric surgery patients have needs that are very different from patients undergoing other types of surgery. Education and behavior modification are important for WLS to succeed. These complex needs, coupled with an extremely low tolerance for poor outcomes (public scrutiny), the essentially elective nature of these operations, and a lack of sympathy for and bias against obesity, create an environment where multidisciplinary programs and accreditation of these programs is essential. There are currently two systems of accreditation for WLS programs not run by individual insurance companies. The American College of Surgeons Bariatric Surgery Centers Network and the Surgical Review Corporation Bariatric Surgery Center of Excellence Program (affiliated with the American Society of Metabolic and Bariatric Surgery) are similar in many ways [22, 23]. Both programs require specific resources (facilities and specialized equipment), and evaluate key personnel, the bariatric surgeon(s), the patient selection process, and patient education as well as outcomes and follow-up. There are some minor differences in terms of the data collection process, fees, and the fact that the ACS only accredits centers where the Surgical Review Corporation accredits both surgeons and centers. As outcomes data from these accredited centers have accumulated over the years, it has become apparent that the morbidity and mortality rates for these centers are lower than expected based on published data [24]. Future steps in the accreditation process include developing a risk-adjusted system where outcomes can replace surgical volume as a surrogate for excellence. It is likely that the future of bariatric surgery accreditation and reimbursement will take into account these outcomes	Eng	2011	MEDLINE

Table 12 (continued)

The application of laparoscopic bariatric surgery for treatment of severe obesity in adolescents using a multidisciplinary adolescent bariatric program [275]	Warman JL	*Crit Care Nurs Q*	The evolution of laparoscopic surgery has made bariatric surgery acceptable for weight loss; however, much controversy exists about its appropriateness for adolescents. Despite the controversial issues, the growing epidemic in adolescent obesity has resulted in rising numbers of applications for bariatric surgery. There are few bariatric surgical programs designed for adolescents. Pediatric settings face high start-up costs and poor reimbursement and lack established bariatric surgeons. Even so, bariatric surgery is increasingly being performed on adolescents in alarming numbers. To avoid adverse physical and psychosocial outcomes, the application of the principles of growth and development is essential. The program should be established as a multidisciplinary approach to management of adolescents and should be in institutions capable of meeting the guidelines for surgical treatment outlined by the American Society of Bariatric Surgery. To prevent postoperative complication, a multidisciplinary team of experienced medical and surgical specialists is needed for optimal preoperative decision making and postoperative management and long-term follow-up. Laparoscopic Roux-en-Y gastric bypass is a safe procedure and an effective means to treat obesity-related morbidity in the adolescent. Results have been excellent and justify a clinical trial to confirm the safety and efficacy of bariatric surgery in the adolescent population	Eng	2013	MEDLINE
Collazo-Clavell ML, Clark MM, McAlpine DE, et al. Assessment and preparation of patients for bariatric surgery. *Mayo Clin Proc*. 2006;81:S11–7.39. 2012report2/downloads/BS_full-report.pdf [276]	Collazo-Clavell ML, Clark MM, McAlpine DE, et al.			Eng		

Table 12 (continued)

Proposal for a multidisciplinary approach to the patient with morbid obesity: the St. Franciscus Hospital morbid obesity program [277]	Elte JW, Castro Cabezas M, Vrijland WW, Ruseler CH, Groen M, Mannaerts GH	*Eur J Intern Med*	Morbid obesity is a serious disease as it is accompanied by substantial comorbidity and mortality. The prevalence is increasing to an alarming extent, in Europe as well as in the USA. In the past few decades, bariatric surgery has developed and gained importance. It currently represents the only long-lasting therapy for this group of patients, resulting in an efficient reduction in body weight and obesity-related medical conditions, mostly cardiovascular in nature. The importance of a standardized protocol, the use of selection criteria, and a multidisciplinary approach have been stressed but not yet described in detail. Therefore, in this article, the multidisciplinary approach and the treatment protocol that have been applied in our hospital for more than 20 years are set out in a detailed manner. The application of a strict protocol may help to select and follow up motivated patients and to organize multidisciplinary research activities	Eng	2008

Table 12 (continued)

Apovian CM, Cummings S, Anderson W, et al. Best practice updates for multidisciplinary care in weight loss surgery. *Obesity*. 2009;17:871–89. https://doi.org/10.1038/oby.2008.58 [278] Best practice updates for multidisciplinary care in weight loss surgery	Apovian CM, Cummings S, Anderson W, Borud L, Boyer K, Day K, Hatchigian E, Hodges B, Patti ME, Pettus M, Perna F, Rooks D, Saltzman E, Skoropowski J, Tantillo MB, Thomason P	*Obesity (Silver Spring)*	The objective of this study is to update evidence-based best practice guidelines for multidisciplinary care of weight loss surgery (WLS) patients. We performed systematic search of English-language literature on WLS, patient selection, and medical, multidisciplinary, and nutritional care published between April 2004 and May 2007 in MEDLINE and the Cochrane Library. Key words were used to narrow the search for a selective review of abstracts, retrieval of full articles, and grading of evidence according to systems used in established evidence-based models. A total of 150 papers were retrieved from the literature search and 112 were reviewed in detail. We made evidence-based best practice recommendations from the most recent literature on multidisciplinary care of WLS patients. New recommendations were developed in the areas of patient selection, medical evaluation, and treatment. Regular updates of evidence-based recommendations for best practices in multidisciplinary care are required to address changes in patient demographics and levels of obesity. Key factors in patient safety include comprehensive preoperative medical evaluation, patient education, appropriate perioperative care, and long-term follow-up	Eng	2009	MEDLINE	Santry HP, Chin MH, Cagney KA, Alverdy JC, Lauderdale DS. The use of multidisciplinary teams to evaluate bariatric surgery patients: results from a national survey in the USA. *Obes Surg* 2006;16:59–66. [PubMed: 16417760] 8. Giusti V, De Lucia A, Di Vetta V, et al. Impact of preoperative teaching on surgical option of patients qualifying for bariatric surgery. *Obes Surg* 2004;14:1241–1246. [PubMed: 15527642] 9. Cunningham E. What is the registered dietitian's role in the preoperative assessment of a client contemplating bariatric surgery? *J Am Diet Assoc* 2006;106:163. [PubMed: 16390679]

Table 12 (continued)

Clinical practice guidelines of the European Association for Endoscopic Surgery (EAES) on bariatric surgery: update 2020 endorsed by IFSO-EC, EASO and ESPCOP [279]	Di Lorenzo N, Antoniou SA, Batterham RL, Busetto L, Godoroja D, Iossa A, Carrano FM, Agresta F, Alarçon I, Azran C, Bouvy N, Balaguè Ponz C, Buza M, Copaescu C, De Luca M, Dicker D, Di Vincenzo A, Felsenreich DM, Francis NK, Fried M, Gonzalo Prats B, Goitein D, Halford JCG, Herlesova J, Kalogridaki M, Ket H, Morales-Conde S, Piatto G, Prager G, Pruijssers S, Pucci A, Rayman S, Romano E, Sanchez-Cordero S, Vilallonga R, Silecchia G	*Surg Endoscop*	Preoperative dietitian consultation should be considered for patients undergoing bariatric surgery Strong recommendation Justification A meta-analysis reporting 3 RCTs was found on this topic [40]. Analyses were re-performed due to error in the primary meta-analysis (calculation of WMD instead of standardized MD, SMD). The overall quality of evidence was very low for weight loss and low for postoperative complications due to risk of bias across RCTs, inconsistency (conceptual and statistical heterogeneity due to variety of preoperative interventions for weight loss, and heterogeneity in the duration of follow-up) and indirectness (follow-up duration for weight loss insufficient for generalizability of findings). Postoperative weight loss was more pronounced in the preoperative diet consultation group (SMD 0.4, 95% CI 0.03 to 0.78 higher). No difference in the odds of postoperative complications was found (risk ratio, RR, 0.80, 95% CI 0.22 to 2.86), although interval estimates were wide. Confidence in the evidence was generally low (Supplementary Table S3); however, the panel favored a strong recommendation after consulting with the patient representative who expressed a strong preference for a holistic approach of the bariatric patient with continuous preoperative and postoperative consultation. The panel considered this practice feasible, requiring moderate human and financial resources, and being acceptable to stakeholders. There was no evidence of any risk for the intervention according to the panel's judgement	Eng	2020	Paper for justification Antoniou SA, Anastasiadou A, Antoniou GA, Granderath F-A, Kafatos A (2017) Preoperative nutritional counseling versus standard care prior to bariatric surgery: effects on postoperative weight loss. *Eur Surg Acta Chir Aust*. https://doi.org/10.1007/ s10353-016-0459-4
van Hout GC, Vreeswijk CM, van Heck GL. Bariatric surgery and bariatric psychology: evolution of the Dutch approach. *Obes Surg*. 2008 Mar;18(3):321-5. https://doi.org/10.1007/s11695-007-9271-3. Epub 2008 Jan 17. PMID: 18202896. [280]				0		

Table 12 (continued)

It's Time for Multidisciplinary Obesity Management Centers Comment Obesity (Silver Spring). 2019 Apr;27(4):534. https://doi.org/10.1002/oby.22450. COMMENTARY [281]	Walter J Pories 1, Louis J Aronne 2	US problems
Predictors of attrition in a multidisciplinary adult weight management clinic. Gill RS, Karmali S, Hadi G, Al-Adra DP, Shi X, Birch DW Can J Surg. 2012 Aug;55(4):239-43. https://doi.org/10.1503/cjs.035710. PMID: 22617538; PMCID: PMC3404143 [282]		Background: Worldwide, more than 1.7 billion individuals may be classified as overweight and are in need of appropriate medical and surgical treatments. The primary goal of a comprehensive weight management program is to produce sustainable weight loss. However, for such a program to be effective, the patient must complete it. We analyzed attrition rates and predictors of attrition within a publicly funded, multidisciplinary adult weight management program Methods: We retrospectively reviewed charts from an urban multidisciplinary adult weight management clinic program database. Patients received medical or surgical treatment with appropriate follow-up. We collected information on demographics and comorbidities. Patients in the surgical clinics received either laparoscopic gastric band insertion or gastric bypass. We conducted univariate analysis and multivariate analyses on predictors of attrition Results: A total of 1205 patients were treated in the weight management program: 887 in the medical clinic and 318 with surgery and follow-up in a surgical clinic. Overall, 516 patients left the program or were lost to follow-up (attrition rate 42.8%). The attrition rate was 53.9% in the medical clinic and 11.9% in the surgical clinic. Multivariate analyses identified participation in the medical clinic, younger patient age, and lower body mass index as predictors of attrition Conclusion: We found lower attrition rates among surgically than medically treated patients in a multidisciplinary weight management clinic. Further research is needed to understand those variables that lead to improved attrition rates

Table 12 (continued)

Andalib A, Bouchard P, Bougie A, Loiselle SE, Demyttenaere S, Court O. Variability in bariatric surgical care among various centers: a survey of all bariatric surgeons in the Province of Quebec, Canada. *Obes Surg*. 2018 Aug;28(8):2327-2332. https://doi.org/10.1007/s11695-018-3157-4. PMID: 29492752. [283]	
Aboueid S, Jasinska M, Bourgeault I, Giroux I. Current weight management approaches used by primary care providers in six multidisciplinary healthcare settings in Ontario. *Can J Nurs Res*. 2018 Dec;50(4):169-178. https://doi.org/10.1177/0844562118769229. Epub 2018 Apr 17. PMID: 29665702. [284]	Canada situation

Table 13 Revisional surgery

First author (year)	Study design	Quality assessment (NOS)	Number of patients	BMI	Reason for conversion/revision	Conversion/revision	Laparoscopic/robotic/open	Intervention	Operative time (min)	Length of stay (days)	Weight loss	Complication Clavien–Dindo 1–2	Complications Clavien–Dindo 3–4	Complications Clavien–Dindo 5 (surgical related mortality)	Nutritional complications	Follow-up (months)	Other outcomes
Vahibe (2023) [285]	Retrospective	Fair quality	53	Not available	Malnutrition	Revision	Laparoscopic	Different types	Not available	Not available	Not available	45.2%	Not available	3.8%	5.7%	24	Improvement of nutritional complications
Vanetta (2022) [286]	Retrospective	Good quality	20,387	39.5–47.2	Weight regain, GERD, complications	Conversion	Laparoscopic/robotic	Different types (especially from AGB and SG)	103–196.9	1.3–2.9	Not available	3.8%	9%	0.2%	Not available	30 days	
Major (2022) [287]	Retrospective	Fair quality	799	48	Weight regain, complications	Conversion	Laparoscopic	Different types (especially from AGB and VGB to RYGB and OAGB)	Not available	3.5	33.4% WL; 14 Δ BMI	9.52%	4.76%	0%	4.76%	22.7	43% Remission from TD2M; 31% remission from hypertension
Xie (2022) [288]	Retrospective	Good quality	221	45.6	Weight regain, GERD, complications	Conversion	Laparoscopic/robotic	Different types (especially from AGB and SG)	149.2	2	17.3% WL	7.7%	3.1%	0.4%	0.9%	24	
Hernandexz (2021) [289]	Retrospective	Fair quality	54	41.7	Weight regain, GERD, complications	Revision	Laparoscopic	Revisional RYGB, AGB, SG	Not available	4.1	Not available	Not available	0.9% early and 1.8% late	0%	Not available	Not available	

Table 13 (continued)

First author (year)	Study design	Quality assessment (NOS)	Number of patients	BMI	Reason for conversion/revision	Conversion/revision	Laparoscopic/robotic/open	Intervention	Operative time (min)	Length of stay (days)	Weight loss	Complication Clavien–Dindo 1–2	Complications Clavien–Dindo 3–4	Complications Clavien–Dindo 5 (surgical related mortality)	Nutritional complications	Follow-up (months)	Other outcomes
Gero (2021) [290]	Retrospective	Good quality	3143	35.2	Weight regain, GERD, complications	Revision/conversion	Laparoscopic	Different types	93	not available	17.7% WL	Not available	23.8%	0.06%	Not available	12	Secondary BS is safe, although postoperative morbidity exceeds the established benchmarks for primary BS
Dreifuss (2021) [291]	Retrospective	Good quality	76	45.7	Weight regain, GERD, complications	Revision/conversion	Robotic	Different types (especially from AGB and SG to RYGB)	182	2.1	22.4% WL	Not available	3.9% early and 5.2% late	1%	Not available	24	
King (2020) [292]	Retrospective	Good quality	167	37–39.5	Complications, weight regain	Revision	laparoscopic/robotic	Revisional RYGB, AGB, SG	Not available	5.2–5.8%	Not available	5.2–5.8%	1.9–5.2%	0%	Not available	30 days	Comparable results between laparoscopic and robotic revisional surgery

Table 13 (continued)

First author (year)	Study design	Quality assessment (NOS)	Number of patients	BMI	Reason for conversion/revision	Conversion/revision	Laparoscopic/robotic/open	Intervention	Operative time (min)	Length of stay (days)	Weight loss	Complication Clavien–Dindo 1–2	Complications Clavien–Dindo 3–4	Complications Clavien–Dindo 5 (surgical related mortality)	Nutritional complications	Follow-up (months)	Other outcomes
Cheema (2021) [293]	Retrospective	Fair quality	266	39.8–45	Weight regain, GERD, complications	Revision/conversion	Laparoscopic	Revisional RYGB, conversion from AGB and SG	Not available	2	10–30% WL	Not available	2.6%	0%	Not available	24 months	Improvement of HbA1c and CV risk
El Chaar (2021) [294]	Retrospective	Good quality	440	42.4	Not available	Revision	Laparoscopic/robotic	Revisional RYGB, revisional SG	145.5	Not available	Not available	Not available	3%	0%	Not available	30 days	
Mora Oliver (2020) [295]	Retrospective	Fair quality	112	41.9	Weight regain	Conversion	Laparoscopic	Different types (especially from AGB, VBG, and SG to OAGB)	135.8	4.9	27.5% WL	3%	2.7%	0%	Not available	20.8	Improvement of TD2M and HTN
Keren (2019) [296]	Retrospective	Good quality	266	41.3	Weight regain (90%), complications	Revision/conversion	Laparoscopic/open	Different types (especially from AGB and SG)	Not available	3.2	30.5% WL	4.8%	2.4	2%	Not available	12	
Acevedo (2020) [297]	Retrospective	Good quality	2288	40.9	Not available	Revision/conversion	Laparoscopic/robotic	Revisional RYGB, revisional SG	125.4	2.2	Not available	Not available	3.2%	0.2%	Not available	30 days	

Table 13 (continued)

First author (year)	Study design	Quality assessment (NOS)	Number of patients	BMI	Reason for conversion/revision	Conversion/revision	Laparoscopic/robotic/open	Intervention	Operative time (min)	Length of stay (days)	Weight loss	Complication Clavien–Dindo 1–2	Complications Clavien–Dindo 3–4	Complications Clavien–Dindo 5 (surgical related mortality)	Nutritional complications	Follow-up (months)	Other outcomes
Clapp (2019) [298]	Retrospective	Good quality	37,916	41.6	Not available	Revision/conversion	Laparoscopic/robotic	Revisional RYGB, conversion from AGB and SG	103–167	1.7-2.3	10 Δ BMI	Not available	Not available	0.1%	Not available	12	
Aleassa (2019) [299]	Retrospective	Fair quality	81	41.2–47.2	Weight regain, complications	Revision/conversion	Laparoscopic	Revisional RYGB, conversion of VBG, AGB, and SG to RYGB	Not available	Not available	20.5% WL	Not available	Not available	Not available	Not available	22	23.1–35% Remission from TD2M
Qiu (2018) [300]	Retrospective	Good quality	84	38-42	Weight regain, complications	Revision/conversion	Laparoscopic	Revisional RYGB, conversion of VBG, AGB, and SG to RYGB	133–175	2	7.7–30.2% WL	8.3%	6%	0%	Not available	12	
Gray (2018) [301]	Retrospective	Good quality	84	39–45	Weight regain, complications	Revision/conversion	Laparoscopic/robotic	Revisional RYGB, conversion from AGB and SG	177–238	3.7–5.8	Not available	Not available	5.9%	0%	Not available	12	
Souto (2018) [302]	Retrospective	Fair quality	67	36.9	Malnutrition, weight regain	Revision/conversion	Laparoscopic	Revisional JIB, revisional BPD-DF	Not available	Not available	28.7–77% EWL	Not available	11.9%	11.9%	9.2%	Over 29 years	

Table 13 (continued)

First author (year)	Study design	Quality assessment (NOS)	Number of patients	BMI	Reason for conversion/revision	Conversion/revision	Laparoscopic/robotic/open	Intervention	Operative time (min)	Length of stay (days)	Weight loss	Complication Clavien–Dindo 1–2	Complications Clavien–Dindo 3–4	Complications Clavien–Dindo 5 (surgical related mortality)	Nutritional complications	Follow-up (months)	Other outcomes
Fulton (2017) [303]	Retrospective	Fair quality	117	44.7	Weight regain, malnutrition	Revision/conversion	Laparoscopic/open	Revisional RYGB, conversion from AGB and SG	168	4	61.2% EWL	Not available	10.8%	0%	Not available	12	
Daigle (2016) [304]	Retrospective	Fair quality	121	47.5	Weight regain	Revision/conversion	Laparoscopic	Revisional RYGB, conversion from AGB, SG, and VSG	Not available	6	59.4% EWL	17%	3.3%	0%	Not available	40	Revisional bariatric surgery is capable of treating both inadequate weight loss and refractory metabolic disease
Shimizu (2013) [305]	Retrospective	Fair quality	154	44	Weight regain, complications	Revision/conversion	Laparoscopic/open	Different types	268–280	5.4–9.5	37.6% EWL	10.3%	12.9%	0.6%	Not available	12	
Kuesters (2011) [306]	Retrospective	Fair quality	100	28–62	Weight regain, complications	Revision/conversion	Laparoscopic/open	Different types	Not available	Not available	56% EWL	Not available	Not available	0%	Not available	12	
Fronza (2010) [307]	Retrospective	Fair quality	63	38–41	weight regain, malnutrition	Revision/conversion	Laparoscopic/open	Different types	Not available	Not available	>50% EWL	19%	11%	0%	Not available	12	

Table 13 (continued)

First author (year)	Study design	Quality assessment (NOS)	Number of patients	BMI	Reason for conversion/revision	Conversion/revision	Laparoscopic/robotic/open	Intervention	Operative time (min)	Length of stay (days)	Weight loss	Complication Clavien–Dindo 1–2	Complications Clavien–Dindo 3–4	Complications Clavien–Dindo 5 (surgical related mortality)	Nutritional complications	Follow-up (months)	Other outcomes
Spyropoulos (2010) [308]	Retrospective	Fair quality	56	46.9	Weight regain, malnutrition	Revision/conversion	Open	Revisional RYGB, revisional BPD-DS	210	16.5	68.9% EWL	20.8%	13.1%	0%	3.6%	102	
Lim (2009) [309]	Retrospective	Fair quality	75	46.3	Weight regain, malnutrition	Revision/conversion	Laparoscopic/open	Revisional RYGB, conversion from AGB and SG	152–231	2–5.8	47.8% EWL	17.3%	4.0%	0%	Not available	6	
Nesset (2009) [310]	Retrospective	Fair quality	218	42	Weight regain, complication, malnutrition	Revision/conversion	Open/laparoscopic	Revisional RYGB, revisional JIB, revisional VBG	298	9	13 Δ BMI	Not available	26%	0.9%	Not available	84	
			67,408													35	

Table 14 Grade of recommendation and level of evidence

Grade of recommendation	Level of evidence	Type of study
A	1a	Systematic review of [homogeneous] randomized controlled trials
A	1b	Individual randomized controlled trials [with narrow confidence intervals]
B	2a	Systematic review of [homogeneous] cohort studies of “exposed” and “unexposed” subjects
B	2b	Individual cohort study/low-quality randomized control studies
B	3a	Systematic review of [homogeneous] case–control studies
B	3b	Individual case–control studies
C	4	Case series, low-quality cohort, or case–control studies
D	5	Expert opinions based on non-systematic reviews of results or mechanistic studies

Evidence-Based Medicine, Stony Brook University Libraries, 14 March 2023

Table 15 IFSO/ASMBS delphi results on MBS in individuals need joint arthroplasty

1. MBS can be considered a bridge to joint arthroplasty in patients with a Body Mass Index of ≥ 30 kg/m^2	84.7% Agree	-	CONSENSUS (AGREE)
2. MBS can decrease the operating time, risk of readmission, and short-term complications of subsequent joint arthroplasty in individuals with a Body Mass Index of ≥ 30 kg/m2	82.9% Agree	-	CONSENSUS (AGREE)
3. MBS can decrease the need for Joint arthroplasty in patients with a Body Mass Index of ≥ 30 kg/m2.	84.7% Agree	-	CONSENSUS (AGREE)
4. Joint arthroplasty in patients with a Body Mass Index of ≥ 30 kg/m2 should be done 6 months to 1 year after MBS depending on the severity of their arthritis or if their weight loss stabilizes and they have sufficient muscle mass and good nutritional status.	50.0% Agree	88.3% Agree	CONSENSUS (AGREE)

Grade of recommendation B

8. MBS prior to organ transplantation [166–189]

PRISMA Appendix 8 [PubMed, Cochrane, Embase]

Systematic Review Table 8

Generally, extremely high or low BMI is considered a contraindication to solid organ transplantation (SOT) due to poor outcomes. Class III obesity may prevent access to transplantation since it is considered a relative contraindication and poses specific technical challenges during surgery [190, 191]. MBS, despite worldwide recognition as the most effective treatment for obesity, may be overlooked as an option in patients with severe end-stage organ disease. Nonetheless, MBS has been described in patients with end-stage organ disease to improve their candidacy for transplantation.

A systematic review of 2241 papers identified 24 thoroughly analyzed studies. The studies included different SOT summarized as heart/lung, kidney, and liver.

The literature search considered several variables, such as surgical procedures, disease status, patient age, and follow-up time. In many studies, specific data points such as weight loss, operative time, and complication rates were missing. In addition, there were differences between patients and studies, including different transplant timing and surgical techniques.

Recommendation

- *Obesity is associated with end-stage organ disease and may limit access to transplantation. Obesity is also a relative contraindication for solid organ transplantation and poses unique technical challenges during surgery.*
- *Published data supports considering patients with end-stage renal disease and obesity grade 3 being able to be listed for kidney transplant after MBS.*
- *MBS is shown to be safe and effective as a bridge to liver transplantation in selected patients who would otherwise be ineligible.*
- *MBS can also improve heart transplants outcomes.*
- *Limited data suggest that MBS could improve eligibility for lung transplantation.*
- *MBS can be performed post-SOT or concomitantly to reduce complication rates and mortality.*

Level of Evidence 2b
Grade of recommendation B

MBS in the High-Risk Patients

9.MBS for BMI ≥60 kg/m^2 [192–238]

PRISMA Appendix 9 [PubMed, Cochrane, Embase]

Systematic Review Table 9

Forty-seven papers have been retrieved for qualitative analysis [192–238].

Twelve studies were focused on the safety and feasibility of MBS among patients with severe obesity at 30 days of follow-up after surgery with no reported data on weight loss or obesity-related comorbidities. Thirty-five studies analyzed MBS's safety, feasibility, and medium to long-term results in patients with obesity and BMI ≥60 kg/m^2.

Concerning weight loss, the mean initial BMI was ≥66.64 kg/m^2 (SD ± 3.05). After a mean follow-up of 28 months, the mean %EBMIL was 51.5 (SD ± 16) with a mean ΔBMI of 21.64 kg/m^2 (SD ± 7.16). Improvement or resolution of the obesity-related complications were reported in 17 studies, including patients with BMI ≥60 kg/m^2. The mean percentage of improvement/resolution of T2DM was 67.35% (SD ± 24.79). The mean percentage of improvement/resolution of HTN was 54.01% (SD ± .93). The mean percentage of improvement/resolution of obstructive sleep apnea (OSA) was 63.61% (SD ± 21.51), while the mean percentage of improvement/resolution of dyslipidemia was 70.95% (SD ± 10.31).

Early complications (within 30 days from surgery) were reported in 45 studies.

The overall mean percentage of early complications was 7.57% (SD ± 6.28), and the mean percentage of early complications requiring reoperation was 4.9% (SD ± 3.48). The overall mean mortality was 1.61% (SD ± 2.29).

Long-term complications were reported in 13 studies. The mean percentage of long-term complications was 13.56% (SD ± 10.93).

Recommendation

- *MBS is safe and effective in patients with BMI ≥60 kg/m^2.*
- *Evidence suggests a higher rate of perioperative complications after MBS in patients with BMI ≥60 kg/m^2.*
- *According to the literature, MBS appears safe in patients with initial BMI ≥70 kg/m^2.*

Level of Evidence 2a
Grade of recommendation B

10 MBS in patients with liver cirrhosis [239–253]

PRISMA Appendix 10 [PubMed, Cochrane, Embase]

Systematic Review Table 10

Fifteen studies were included in this systematic review. Some studies differed between compensated and decompensated liver cirrhosis.

The early mortality was reported as 0.6 and 0.8% in the Metabolic Dysfunction-associated Liver Disease (MAFDL) or compensated liver cirrhosis, and 19.4 and 22.1% in decompensated liver cirrhosis. Mumatz et al. and Are et al. [245, 246] underlined the higher mortality of patients in low-volume centers (<50/year). Miller et al. analyzed 3032 patients undergoing SG (n = 1168) and RYGB (n = 1864) with compensated liver cirrhosis and reported early mortality in 21 (1.1%) of patients after RYGB and 10 patients after SG (<1%). Late mortality occurred in 42 patients after RYGB (2.2%) and under 10 patients after SG (<0.8%) [247].

Based on the current systematic review, patients with MAFLD or compensated liver cirrhosis have acceptable perioperative morbidity and mortality. However, patients with obesity and decompensated liver cirrhosis are at much higher risk for perioperative complications and perioperative mortality following MBS. Those patients should only be considered for surgery on a selective basis after a comprehensive risk assessment and only in high-volume centers. The risk of postoperative liver decompensation is low but should not be underestimated. Weight loss and remission of comorbidities are similar to the general bariatric surgical population. Careful patient selection and consideration of the choice of surgical procedure are important to ensure the best outcomes.

Recommendation

- Obesity is a significant risk factor for MAFLD and liver cirrhosis.
- MBS has been associated with histologic improvement of MAFLD and regression of liver fibrosis.
- MBS is associated with a risk reduction of progression of MAFLD to liver cirrhosis.
- MBS in patients with "decompensated" cirrhosis is associated with high perioperative mortality.
- Careful patient selection and consideration of the choice of surgical procedure are important to ensure the best outcomes.

Level of Evidence 2b
Grade of recommendation B

11. MBS in patients with heart failure [254–271]
PRISMA Appendix 11 [PubMed, Cochrane, Embase]
Systematic Review Table 11

Thirty-one full-text articles were assessed for eligibility. Eighteen studies are included in the qualitative synthesis [254–271].

MBS is associated with a lower risk of major adverse cardiovascular events (MACE), including myocardial infarction, ischemic heart disease, or heart failure (HF) in patients with severe obesity [255–257].

The overall risk for early (less than 30 days) and late (30 days or more) complications was similar for patients with cardiovascular disease and the matched group that did not have cardiovascular disease [258–262]. Some studies reported an increased risk for early cardiovascular complications as well as a higher 90-day mortality rate (still within an acceptable range) for patients with heart disease, such as HF [263–266].

Current data suggest that MBS can be a useful adjunct to treatment in patients with obesity and HF before heart transplantation or placement of a left ventricular assistance device (LVAD) [266–268]. Patients who underwent MBS were observed to have improvement in cardiac function [269, 270]. This had several beneficial effects, such as a reduction in re-hospitalization for HF, and improvement in their left ventricular ejection fraction (LVEF). MBS could increase the patient's likelihood of receiving a heart transplant. On the other hand, some patients had enough improvement in their cardiac function to no longer require a heart transplant [269, 270].

Recommendation

- *MBS in patients with obesity and HF is associated with improvement of LVEF, improvement of functional capacity, and higher chances for receiving heart transplantation.*
- *In patients with obesity and HF, MBS has low morbidity and mortality and can be a useful adjunct before heart transplantation or placement of LVAD.*

Level of Evidence 2b
Grade of recommendation B

Patient Evaluation

12. Multidisciplinary care [272–284]
PRISMA Appendix 12 [PubMed, Cochrane, Embase]
Systematic Review Table 12

The search screened 95 papers, but only 6 were thoroughly analyzed. There were guidelines or consensus statements, including those from the European Association for the Study of Obesity (EASO) and the European Association for Endoscopic Surgery (EAES) [272, 279]. Standardized pre-operative multidisciplinary evaluations have been reported to reduce major complications and reoperation rates.

The studies of this systematic review support the protective role of the multidisciplinary team (MDT) to ensure patient safety.

Registered experts in nutrition in MBS can assist in the management of post-operative patients who may experience issues such as food intolerances, malabsorption, micronutrient deficiencies, dumping syndrome, hypoglycemia, and RWG. Licensed mental health providers with specialty knowledge and experience in MBS behavioral health are necessary to assess patients for psychopathology and determine the candidate's ability to cope with the adversity of surgery, the changing body image, and the lifestyle changes required after MBS.

Based on the EAES guidelines, scheduled multidisciplinary post-operative follow-up should be provided to every patient undergoing MBS [279].

Recommendation

- MDT has an important role in MBS patients' pre- and post-operative management.

Level of Evidence 2c
Grade of recommendation B

Revisional Surgery

13. Revisional MBS [285–310]
PRISMA Appendix 13 [PubMed, Cochrane, Embase]
Systematic Review Table 13

Twenty-six studies were selected for this systematic review. All studies were retrospective with a good/fair quality.

Recent articles report conversion from AGB and SG and revision of RYGB and OAGB. Revisional MBS is currently performed laparoscopically and robotically, with a growing trend toward a robotic approach. Operative time and LOS of revisional surgery were reduced with time and experience, which could be comparable to those reported in the literature for primary surgery.

All revisional and conversional interventions lead to additional weight loss. Clavien–Dindo complications 3–4 ranged from 0.9 to 26%. Mortality was lower than 1% for conversions from restrictive procedures, and up to 11.9% was reported after revisional stapling procedures. Revisional surgery appeared to induce further remission from T2DM and HTN.

Recommendation

- *Indication for revisional surgery after MBS varies among patients but may include insufficient weight loss, weight regain, insufficient remission of comorbidities, and management of complications (e.g., gastroesophageal reflux).*
- *Due to its complexity, revisional MBS may be associated with higher rates of perioperative complications. However, revisional MBS induces satisfactory metabolic outcomes with acceptable complications and mortality rates.*

Level of Evidence 2b
Grade of recommendation B

Discussion (see Criteria Table 16)

The indications for MBS have not changed since the NIH proposed them in 1991. In other words, the indications have not kept up with the evolution of surgical technique from open laparotomy to minimally invasive, the changing procedure types, the improved safety of MBS, and the emerging evidence on numerous health benefits of weight loss.

IFSO and ASMBS joined forces to tackle this major problem, and the new MBS guidelines were published in October 2022. Updated guidelines based on current literature and data are vital as access to this life-saving surgery is still very low despite the available evidence—in most countries, access to MBS is less than 2% of eligible candidates.

This study systematically reviewed the best literature available for the outcomes of MBS for various populations with differing demographics and obesity-related complications. Eleven of the 13 criteria were supported by the literature. Where there was a lack of evidence, a Delphi process was employed to achieve expert consensus. *PRISMA Prospect* summarized the findings.

From these data, MBS impacted positively a range of populations and settings. The majority of examined populations had Grade B recommendations for the indications of surgery. Expert opinion (Grade D) was only relied upon to strengthen the evidence for the role of MBS in a few unique circumstances. This includes patients with a BMI of 35–40 kg/m^2 who have no comorbidities, patients with a concurrent need for arthroplasty, and the role of the multidisciplinary team. Particularly in the pediatric and adolescent populations, the strength of the available data supported a Grade A recommendation. Improved access to surgery in adolescents was one of the two major new emphases of the new IFSO/ASMBS guidelines.

This systematic review highlights the need for well-designed RCTs or large prospective cohort studies to enable better-informed decision-making for clinicians and patients. Clinicians working in the field innately understand the benefit of multidisciplinary teamwork. However, it has yet to be proven in high-quality studies.

Just as the NIH indications from 1991 became outdated as surgical techniques, with a better understanding of the pathophysiology of obesity and improved perioperative safety, these current guidelines should be regularly revisited when new evidence emerges to inform treatment decisions.

List of Delphi consensus Experts

First Name	Last Name	Country
Edo	Aaarts	Netherland
Ahmad	Aly	Australia
Ali	Aminian	USA
Luigi	Angrisani	Italy
Ahmad Abdallah	Bashir	Jordan
Estuardo	Behrens	Guatemala
Helmuth Thorlakur	Billy	USA
Sonja	Chiappetta	Italy
Jean-Marc	Chevallier	France
Ricardo Vitor	Cohen	Brazil
Maurizio	De Luca	Italy
Pierre Y	Garneau	Canada
Khaled Aly	Gawdat	Egypt
Ashraf	Haddad	Jordan
Jacques M	Himpens	Belgium
Farah Anwari	Husain	USA
Angelo	Iossa	Italy
Mohammad	ermansaravi	Iran
Shanu Nikhil	Kothari	USA
Lilian	Kow	Australia
Marina	Kurian	USA
Teresa LeAnn	LaMasters	USA
Silvia	Leite Faria	Brazil
Ken Wing King	Loi	Australia
Kamal K	Mahawar	UK
Corrigan Lee	McBride	USA
Giovanni	Merola	Italy
Monali	Misra	USA
Abdelrahman Ali	Nimeri	USA
Joe	Northup	USA
Mary	O'Kane	UK
Pavlos	Papasavas	USA
Richard M	Peterson	USA
Giacomo	Piatto	Italy
Luis	Poggi	Peru
Jaime	Ponce	USA
Gerhard	Prager	Austria
Janey Sue Andrews	Pratt	USA
Almino Cardoso	Ramos	Brazil
Ann M	Rogers	USA
Paulina	Salminen	Finland
Nathaniel James	Sann	USA
John David	Scott	USA
Scott Alan	Shikora	USA
Michel	Suter	Switzerland
Salvatore	Tolone	Italy
Antonio	Vitiello	Italy
Cunchuan	Wang	China

Table 16 Summary of recommendations with their grade and level of evidence

Criteria	PRISMA and DELPHI	Appendix/ Table	Level of evidence	Grade of recommendation	Recommendation	References
MBS for BMI 30–34.9 kg/m^2	PRISMA	1	2a	B	MBS is recommended for patients with BMI 30–34.9 kg/m^2 with T2DM and/or other obesity-associated medical problems	[7–35]
MBS for BMI 35–40 kg/m^2 without obesity-associated comorbidities	PRISMA Insufficient data DELPHI	2	5	D	MBS is recommended regardless of the presence, absence, or severity of obesity-associated medical problems	–
BMI thresholds in the Asian population	PRISMA	3	2a	B	Access to MBS should not be denied solely based on the BMI	[36–54]
MBS in the older population	PRISMA	4	2a	B	There is no evidence to support an age limit	[55–72]
MBS for pediatric and adolescents	PRISMA	5	1b	A	MBS is safe in the population younger than 18 years, produces durable weight loss, and improves obesity-associated medical problems	[76–117]
MBS prior to joint arthroplasty	PRISMA Conflicting data DELPHI	6	2b	B	MBS can be considered a bridge to joint arthroplasty in patients with BMI ≥30 kg/m^2	[120–141]
MBS and abdominal wall hernia repair	PRISMA	7	2b	B	In patients with severe obesity and an abdominal wall hernia, MBS-induced weight loss is suggested before hernia repair	[143–165]
MBS prior to organ transplantation	PRISMA	8	2b	B	Published data supports considering patients in need of SOT first to undergo MBS to improve their eligibility for transplantation	[166–189]
MBS for BMI ≥60 kg/m^2	PRISMA	9	2a	B	MBS is safe and effective in patients with BMI ≥60 kg/m^2	[192–238]
MBS in patients with liver cirrhosis	PRISMA	10	2b	B	MBS is associated with a reduction of progression of MAFDL to cirrhosis	[239–253]
MBS in patients with heart failure	PRISMA	11	2b	B	MBS can be a useful treatment adjunct in patients with obesity and heart failure	[254–271]
Multidisciplinary care	PRISMA	12	2c	B	Despite the low evidence level, MDT is at present the unmodifiable core of pre- and post-operative obesity management	[272–284]
Revisional surgery	PRISMA	13	2b	B	Revisional MBS induces satisfactory metabolic outcomes with acceptable rates of complications and mortality	[285–310]

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Data Availability The data that support the findings of this study are available on request from the corresponding author.

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