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Bariatric surgery and the diseased kidney: a 5-year assessment of safety and postoperative renal outcomes

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Abstract

Background Obesity and its related medical conditions are well-established contributors to the development of chronic kidney disease (CKD). Metabolic and bariatric surgery (MBS), including procedures such as sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB), is a potential intervention for these individuals. However, the heightened risk of postoperative complications casts doubts on the suitability of MBS in this population. Our aim is to evaluate the long-term safety, anthropometric and renal outcomes of MBS in patients with CKD.

Methods A retrospective review of patients who underwent primary laparoscopic MBS with a BMI $\geq$ 35 kg/m^2 and a preoperative diagnosis of stage 2 to 5 CKD. Criteria for CKD diagnosis and staging were based on estimated glomerular filtration rate measurements in accordance with established guidelines. Anthropometric and renal outcomes were measured at 3-, 6-, 12-, 24- and 60-months postoperatively.

Results A total of 302 patients (177 SG, 125 RYGB) were included. RYGB was preferred for patients with stage 3 CKD, while SG was more common in stages 4 and 5. At 5-year follow-up, percentage of total weight loss was higher in the RYGB cohort compared to SG (25.1% vs. 18.6%, $p = 0.036$). Despite SG patients having more advanced CKD, the incidence of late complications was significantly higher following RYGB, with 11 incidents (8.8%), compared to the SG cohort with only 4 cases (2.3%) ($p = 0.014$). In those with preoperative CKD stage 3, 76 patients (43.2%) improved to stage 2, with another 9 patients (5.1%) improving further to stage 1. Of all patients, 63 (20.8%) eventually received a successful renal transplant.

Conclusions MBS is an effective strategy for sustained weight loss in patients with CKD with acceptable complications rates. RYGB leads to a higher percentage of overall weight loss, albeit with an elevated likelihood of late surgical complications. Future studies are needed to determine the safety of MBS in this demographic.

Keywords Metabolic and bariatric surgery · Roux-en-Y gastric bypass · Sleeve gastrectomy · Chronic kidney disease · Renal transplantation · Weight loss

Obesity stands as an alarming global health crisis, with its prevalence doubling over the past four decades [1]. Defined as a body mass index (BMI) of 30 kg/m^2 or higher [2], obesity is a complex and multifaceted disease process that has been associated with an increased risk of developing other systemic health conditions [3]. The burden of excess body fat on individual health is profound, leading to an increased risk of various systemic diseases including cardiovascular, metabolic, musculoskeletal, and cancer-related conditions [4]. Moreover, obesity is a well-established contributing factor to the development of chronic kidney disease (CKD), defined as an estimated glomerular filtration rate (eGFR) less than 90 mL/min/1.73m^2 for a duration of at least 3 months, with this disease now affecting approximately 1 in

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7 adults in the United States [5, 6]. Extensive research has identified that obesity alone, in addition to obesity-related medical conditions such as hypertension and diabetes mellitus, contribute to glomerular hyperfiltration, leading to the development of CKD in affected individuals [7–11].

Metabolic and bariatric surgery (MBS), including procedures such as sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB), has emerged as a safe and effective management option for patients with obesity [12–14]. These procedures have been extensively studied across various clinical settings, demonstrating their efficacy in significant weight reduction, improvement in weight-related medical conditions, and enhancement of overall quality of life [15–17]. However, the safety and efficacy of MBS in patients with CKD remains a subject of interest. It must be recognized that patients with CKD face a heightened risk of postoperative complications, which casts doubt on the suitability of MBS in this population [18, 19]. It is, therefore, crucial to consider an individualized assessment for these patients during preoperative counseling, considering factors such as the CKD stage, concurrent medical conditions, and the anticipated risk-to-benefit ratio following surgery.

Despite these challenges, MBS holds potential as a viable adjunctive therapeutic avenue for the management of CKD patients, offering promise as a reno-protective intervention that not only reduces the risk of developing CKD, but also helps in preserving renal function [10, 11, 20, 21]. There is also evidence suggesting that weight loss following MBS may decrease the likelihood of CKD progressing into end-stage renal disease (ESRD) [22]. Furthermore, these procedures have also been shown to reduce all-cause mortality among patients with co-existent obesity and CKD [23]. Considering these factors, the advantages of MBS in patients with CKD could surpass the associated risks. Our aim is to evaluate the long-term safety, complications and weight loss outcomes of both SG and RYGB in patients with CKD stages 2 to 5, ultimately shedding light on the importance of MBS as an intervention in this patient group. Additionally, postoperative renal outcomes were also monitored in terms of change in eGFR and access to renal transplantation in patients with advanced CKD.

Materials and methods

Study design and patient selection

An Institutional Review Board approved (Protocol number: 23-007477) retrospective review of prospectively maintained electronic health records between January 2008 and December 2020 was performed at a single tertiary academic institution of excellence. All patients over the age of 18 who underwent a primary, laparoscopic MBS with a BMI $\geq$ 35 kg/m^2 and a preoperative diagnosis of stage 2 to 5 CKD were included. Identification of patients with CKD was done through relevant lab values as well as International Classification of Diseases (ICD) codes. Patients with missing data, lack of follow-up, or those who underwent MBS as a secondary (revisional or conversion) procedure were excluded. Our primary objective was to evaluate the long-term safety and outcomes of SG and RYGB in this patient demographic. Additionally, as a secondary aim, we monitored the postoperative improvements in renal function and the possibility of renal transplantation at last follow-up, categorized by preoperative CKD staging.

Chronic kidney disease: diagnosis and staging

The selection of patients with CKD was meticulously conducted through a systematic approach and was screened and cross-checked between 2 individual abstractors. Patients were primarily identified through their visits to specialized multidisciplinary teams (MDT) that included expert nephrologists. The criteria employed for diagnosing CKD were in accordance with established clinical guidelines, including the Kidney Disease: Improving Global Outcomes (KDIGO) criteria, which consider a combination of eGFR, urinary albumin-to-creatinine ratio, and the presence of kidney damage markers for at least 3 months [24]. The preoperative classification of CKD was determined according to eGFR measurements (expressed in ml/min/1.73 m^2) and encompassed the following stages: stage 2 (eGFR 60-89), stage 3A (eGFR 45-59), stage 3B (eGFR 30-44), stage 4 (eGFR 15-29), and stage 5 (eGFR < 15). Stages 3A and 3B were combined for the sake of this analysis.

Renal function follow-up and transplantation assessment

Following surgery, patients were systematically monitored at their visits to expert providers for changes in renal function or the requirement for renal transplantation. Renal function improvement was monitored in a similar fashion to initial diagnosis using the KDIGO criteria. These indicators were measured at 3-, 6-, 12-, 24-, and 60-months postoperatively, allowing for a comprehensive evaluation of renal function trajectory over time.

The selection of postoperative candidacy for renal transplantation involved a rigorous and collaborative effort facilitated by an MDT discussion. This MDT comprised bariatric surgeons, nephrologists, transplant surgeons, and other specialists. The criteria for considering a patient as a candidate for renal transplantation initially pertained to significant weight loss and reduction in BMI. Once approved from this standpoint, these patients underwent the standard process for transplant workup, including an assessment of the worsening or stabilization of renal function postoperatively, alongside a consideration of the patient's overall health status, co-existent medical conditions, and contraindications or risks associated with surgery. The MDT also evaluated eligibility based on established transplant criteria, such as absence of active infection or malignancy, and the patient's psychological readiness, support systems, and adherence to strict medication regimens and follow-up.

Data collection

The data were extracted from electronic health records, audited by two independent reviewers, and cross-checked to maximize accuracy of collection. Patient demographics, characteristics, and medical conditions were first collected at baseline for all included patients. Anthropometric and renal outcome measurements were collected on the day of MBS procedure, as well as at 3-, 6-, 12-, 24- and 60-months postoperatively. Percentage of total weight loss (%TWL) was calculated using the formula [(preoperative weight—postoperative weight)/preoperative weight × 100]. Next, all information related to early (< 30 days) or late (≥ 30 days) postoperative complications were documented. All postoperative complications were then sorted into severity according to the Clavien-Dindo surgical classification system [25].

Statistical analysis

Data were analyzed using IBM SPSS statistics (version 27) and figures were generated using GraphPad Prism (version 10). Variables were first tested for normality of distribution using Shapiro–Wilk's tests, and visually using histograms and Q-Q plots. All data were normally distributed, and hence parametric tests were used accordingly. Continuous variables were compared using independent samples *t*-tests and were summarized as mean ± standard deviation (SD). Categorical variables were compared using a Pearson Chi-square, and post-hoc analyses using Bonferroni adjustments were performed as necessary to delineate intra-group differences. These results were summarized as frequencies (*n*) and percentages (%). All hypothesis testing was conducted with a 2-sided p-value < 0.05 strictly set for statistical significance. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline (Supplementary Material).

Results

Baseline characteristics

We analyzed a total of 302 patients across two different surgical procedure groups, SG ($n = 177$, 58.6%) and RYGB ($n = 125$, 41.4%), following the application of the specified inclusion and exclusion criteria (Fig. 1). The average total

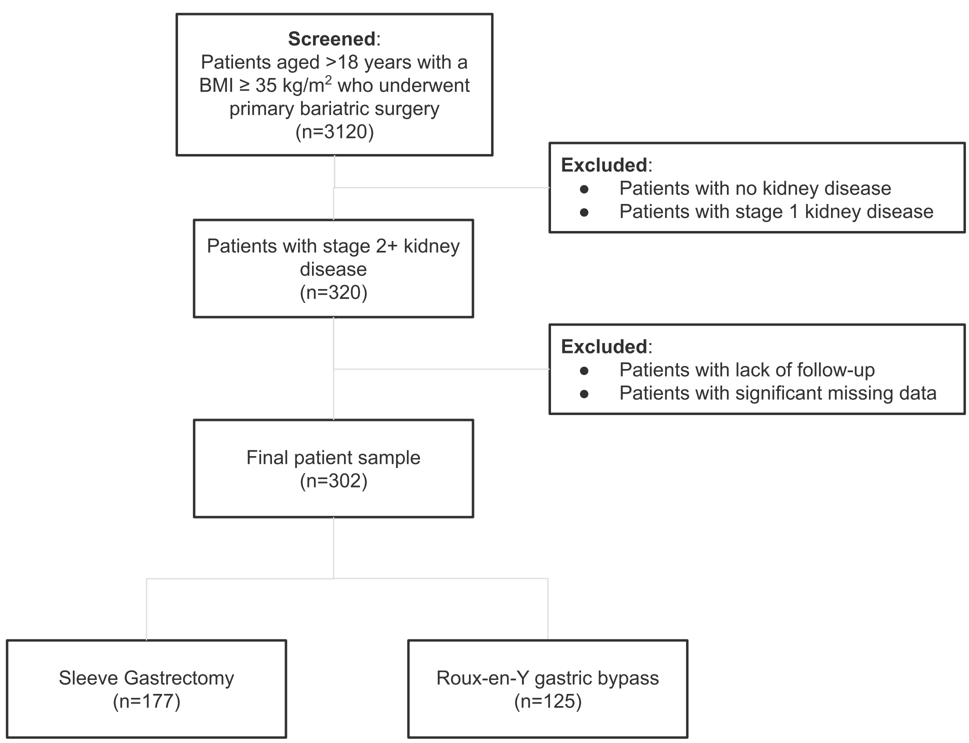

Fig. 1 Flowchart representing patient selection criteria

follow-up period was 4.5 ± 3.1 years. Baseline characteristics were largely comparable between the two cohorts, with no significant differences in sex, ethnicity, or preoperative BMI. RYGB patients were on average older compared to SG patients (59.4 ± 9.2 years vs. 54.4 ± 11.3 years, $p < 0.001$) (Table 1). There were no differences in preoperative medical conditions, including diabetes, hypertension, hyperlipidemia, and sleep apnea between groups. Notably, patients who received SG were significantly more likely to be dialysis-dependent preoperatively compared to RYGB patients (45.2% vs. 8%, $p < 0.001$).

Subgroup analysis and procedure selection

Figure 2 displays our patient cohort after stratification into different preoperative CKD stages including stage 2 ($n = 24$,

Table 1 Description of patient demographics, baseline characteristics and preoperative medical conditions

	SG (*N* = 177)	RYGB (*N* = 125)	*p*-value
Patient demographics			
Age—yrs	54.4 ± 11.3	59.4 ± 9.2	**< 0.001**[1]
Female—*n* (%)	96 (54.2)	75 (60)	0.347[2]
Ethnicity—*n* (%)			0.131[2]
White, non-hispanic	123 (98.4)	123 (98.4)	
Hispanic or latino	9 (5.1)	2 (1.6)	
BMI—kg/m^2	43.9 ± 7.3	45.5 ± 8.7	0.085[1]
Preoperative medical conditions			
Diabetes mellitus—*n* (%)	83 (46.9)	60 (48)	0.907[2]
Hypertension—*n* (%)	148 (83.6)	102 (81.6)	0.646[2]
Hyperlipidemia—*n* (%)	115 (65)	80 (64)	0.903[2]
Sleep apnea—*n* (%)	122 (68.9)	88 (70.4)	0.801[2]
Previous foregut surgery—*n* (%)	4 (2.3)	5 (4)	0.496[2]
History of myocardial infarction—*n* (%)	5 (2.8)	7 (5.6)	0.228[2]
Previous cardiac stent/surgery—*n* (%)	5 (2.8)	8 (6.4)	0.156[2]
Therapeutic anticoagulation—*n* (%)	22 (12.4)	20 (16)	0.402[2]
On dialysis—*n* (%)	80 (45.2)	10 (8)	**< 0.001**[2]

Continuous variables are presented as mean ± SD. Categorical variables are presented as number (percentage)

SG Sleeve gastrectomy, *RYGB* Roux-en-Y gastric bypass, *BMI* Body mass index

P-values illustrated in bold represent statistically significant values, $p < 0.05$

[1]Independent samples *t*-test

[2]Pearson Chi-squared

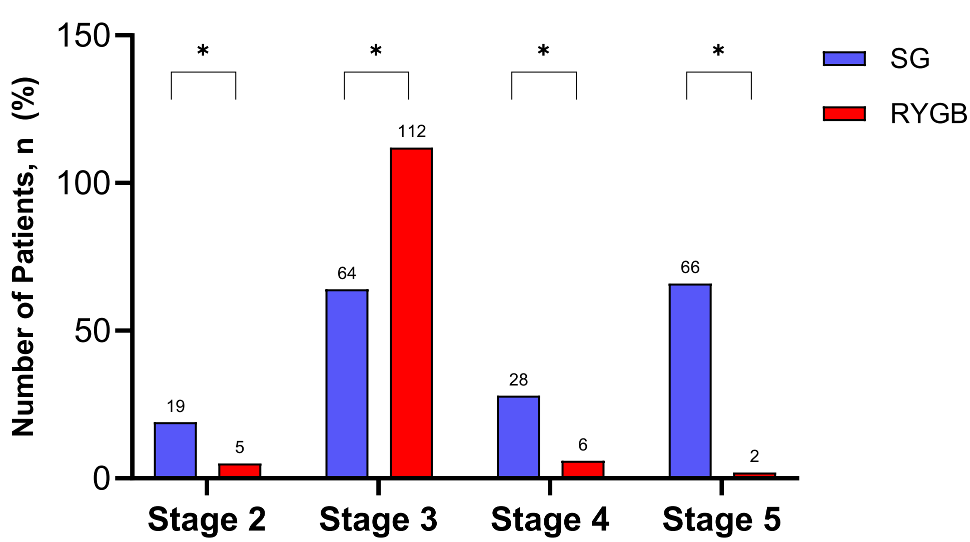

Fig. 2 Distribution of Patients Undergoing Sleeve Gastrectomy and Roux-en-Y Gastric Bypass Across Different Stages of Chronic Kidney Disease.*Represents a statistically significant difference, $p < 0.05$

7.9%), stage 3 ($n=176$, 58.3%), stage 4 ($n=34$, 11.3%), and stage 5 ($n=68$, 22.5%). Among patients with stage 3 CKD, there was a significant preference for RYGB, with 112 individuals (63.6%), in contrast to SG which was offered to 64 patients (36.4%) ($p<0.001$). On the other hand, the majority of patients with stage 4 CKD ($n=28/34$, 82.4%) and stage 5 CKD ($n=66/68$, 97.1%) received SG as the preferred surgical option ($p<0.001$).

Weight loss outcomes

Table 2 presents a comparison of BMI and %TWL between the two cohorts up to 5 years following surgery. Starting from the 6-month postoperative mark, the RYGB cohort consistently exhibited a higher %TWL in comparison to the SG cohort (22.2 ± 13.4% vs. 16.0 ± 10.8%, $p<0.001$). This trend was maintained through 12, 24, and 60 months postoperatively (Fig. 3). Ultimately, at the final follow-up, %TWL remained notably higher in the RYGB cohort in comparison to the SG cohort (25.1 ± 13.2% vs. 18.6 ± 16.8%, $p=0.036$).

Postoperative outcomes and complications

Despite the SG patients having more advanced kidney disease overall, the occurrence of acute complications was found to be statistically comparable between the SG ($n=11$, 6.2%) and RYGB ($n=6$, 4.8%) cohorts ($p=0.801$) (Table 3). However, the RYGB cohort exhibited a significantly higher rate of late complications, with 11 incidents (8.8%), compared to the SG cohort with only 4 cases (2.3%) ($p=0.014$). There were no notable differences in complication rates observed when considering different CKD stages within each group. Details of both early and late complications according to the Clavien-Dindo classification system are shown in Table 4. The complications observed in the RYGB cohort included 5 Grade IIIa complications including 3 cases of mild narrowing of anastomosis requiring

Table 2 Weight loss outcomes at 3-,6-,12-,24- and 60-months follow-up compared to baseline

	SG	RYGB	Mean difference (SG—RYGB)	*p*-value	95% Confidence interval	
					Lower	Upper
Baseline						
N	177	125				
BMI—kg/m^2	43.9 ± 7.3	45.5 ± 8.7	− 1.639	0.085[1]	− 3.505	0.225
3 months						
N	159	120				
BMI—kg/m^2	38.6 ± 7.0	39.1 ± 8.1	− 0.463	0.619[1]	− 2.294	1.367
%TWL	11.1 ± 10.1	13.5 ± 16.4	− 2.355	0.141[1]	− 5.493	0.782
6 months						
N	151	115				
BMI—kg/m^2	36.7 ± 6.9	35.1 ± 7.4	1.577	0.079[1]	− 0.186	3.341
%TWL	16.0 ± 10.8	22.2 ± 13.4	− 6.223	**< 0.001**[1]	− 9.228	− 3.218
12 months						
N	155	115				
BMI—kg/m^2	34.8 ± 7.6	32.5 ± 7.1	2.317	**0.011**[1]	0.538	4.097
%TWL	19.5 ± 13.2	27.9 ± 13.9	− 8.368	**< 0.001**[1]	− 11.663	− 5.074
24 months						
N	104	89				
BMI—kg/m^2	34.8 ± 8.5	32.1 ± 8.1	2.679	**0.027**[1]	0.314	5.042
%TWL	22.0 ± 13.9	28.8 ± 16.7	− 6.806	**0.003**[1]	− 11.216	− 2.396
60 months						
N	42	68				
BMI—kg/m^2	36.1 ± 8.0	34.7 ± 8.2	1.393	0.389[1]	− 1.802	4.588
%TWL	18.6 ± 16.8	25.1 ± 13.2	− 6.505	**0.036**[1]	− 12.571	− 0.439

Continuous variables are presented as mean ± SD

Comparisons are presented as mean difference with 95% confidence interval

SG Sleeve gastrectomy, *RYGB* Roux-en-Y gastric bypass, *TWL* Total weight loss, *BMI* Body mass index

p values illustrated in bold represent statistically significant values, $p<0.05$

[1]Independent samples *t*-test

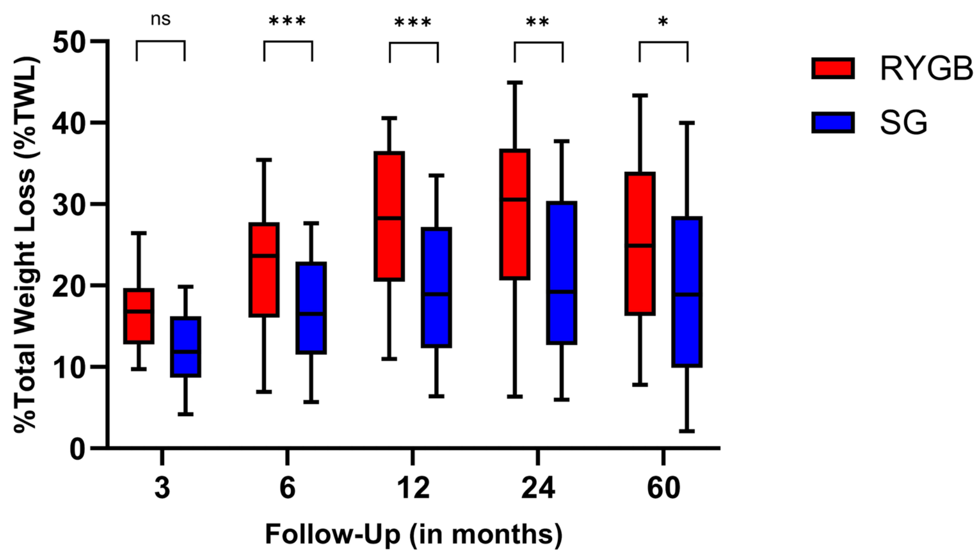

Fig. 3 Percentage of total weight loss over time in patients undergoing sleeve gastrectomy compared to Roux-en-Y Gastric Bypass. Statistically significant difference is represented by: *$p < 0.05$; **$p \leq 0.01$, ***$p \leq 0.001$

Table 3 Comparison of early (< 30 days) and late (≥ 30 days) complications across both procedures

	Early complications			Late complications		
CKD stage	SG *n* = 11 (6.2)	RYGB *n* = 6 (4.8)	*p* value	SG *n* = 4 (2.3)	RYGB *n* = 11 (8.8)	*p* value
Stage 2	1/19 (5.3)	0/5 (0)	0.801[1]	0/19 (0)	1/5 (20)	**0.014**[1]
Stage 3A/3B	3/64 (4.7)	6/112 (5.2)		2/64 (3.1)	10/112 (8.9)	
Stage 4	3/28 (10.7)	0/6 (0)		2/28 (7.1)	0/6 (0)	
Stage 5	4/66 (6.2)	0/2 (0)		0/66 (0)	0/2 (0)	

Categorical variables are presented as numbers (percentages)

p values illustrated in bold represent statistically significant values, $p < 0.05$

SG Sleeve gastrectomy, *RYGB* Roux-en-Y gastric bypass, *CKD* Chronic kidney disease

[1]Pearson Chi-squared with Bonferroni adjustment

endoscopic dilation and 2 marginal ulcer bleeds necessitating endoscopic intervention (Table 4). There was one mortality on the long-term following an RYGB procedure, with the reported cause being a severe marginal ulcer bleed (Grade V).

Renal function follow-up and transplantation

Figure 4 illustrates the renal outcomes after an average of 4.5 ± 3.1 years for patients undergoing MBS stratified by preoperative CKD staging. For those initially in CKD stage 2, the majority remained stable postoperatively, with 18 out of the 24 patients retaining their stage 2 status. In those with preoperative CKD stage 3, 76 patients (43.2%) improved to stage 2, with another 9 patients (5.1%) improving further to stage 1. On the other hand, renal function did not significantly improve in patients with stages 4, with 32.4% remaining in Stage 4 and another 23.5% worsening to stage 5, while 20.6% successfully received a transplant. Remarkably, in those with CKD stage 5, the data show a significant number of individuals who were postoperatively classified as candidates for transplantation, with 40 patients (58.8%) eventually receiving successful renal transplant within the study duration, with the majority of those who did not receive transplant remaining as stage 5 CKD (36.8%). Out of the 302 patients included, a total of 63 patients (20.8%) eventually received a successful renal transplant.

Discussion

This study provides a comprehensive insight into the long-term outcomes of two commonly performed MBS procedures, SG and RYGB, in patients with a preoperative diagnosis of CKD. We examined 302 patients across CKD stages 2 to 5 and found that while RYGB was more frequently chosen for patients with CKD stage 3, SG was predominantly selected for those with CKD stages 4 and 5. RYGB resulted in a notably higher %TWL and a greater reduction in BMI than SG at the 6-month mark, maintaining this advantage up to 5 years postoperatively. Nonetheless, when contextualized within the CKD population, both procedures demonstrated appreciable weight loss. While the perceived safety of both procedures was comparable on the short-term, RYGB was

Table 4 Detailed description of early and late postoperative complications following sleeve gastrectomy and Roux-en-Y gastric bypass classified according to the Clavien-Dindo grading system

	SG	RYGB
Early complications		
Grade I		
Wound dehiscence (dressing change)	0	2
Esophagitis (PPIs)	1	0
Colitis (managed conservatively)	1	0
Grade II		
Acute kidney injury (IV fluids)	2	2
DVT (Heparin drip)	0	1
Pneumonia (antibiotics)	1	0
Peri-gastric hematoma (IV platelets, observation)	1	0
Upper GI bleed, not specified (managed conservatively)	1	0
Grade IIIb		
Hematoma requiring surgical evacuation	1	0
Grade IVa		
Pneumonia, sepsis, respiratory failure (ICU admission)	1	1
Severe hypotension (ICU admission)	1	0
Gastric leak, sepsis (pigtail placement, antibiotics)	1	0
Late complications		
Grade I		
Dumping syndrome (dietary modifications)	0	1
Grade IIIa		
Dysphagia (upper GI studies, endoscopy)	2	0
Mild narrowing of anastomosis (endoscopic dilation)	0	3
Marginal ulcer bleed (endoscopy)	0	2
Grade IIIb		
Ventral hernia (surgical repair, mesh placement)	2	1
Small bowel volvulus (bowel resection)	0	1
Perforation of gastric pouch (omental patching)	0	1
Anastomotic stricture (surgical revision)	0	1
Grade V		
Marginal ulcer bleed, patient demise	0	1

SG sleeve gastrectomy, *RYGB* Roux-en-Y gastric bypass, *PPIs* proton pump inhibitors, *IV* intravenous, *DVT* deep venous thrombosis, *GI* gastrointestinal *ICU* intensive care unit

associated with a higher likelihood of late complications compared to SG. Further subgroup analysis indicated that the stage of CKD did not significantly influence complication rates in either procedure group.

The prevalence of obesity and its implications in the development and progression of kidney disease are well established. The excessive body fat associated with obesity increases the risk of developing systemic conditions such as hypertension, hyperlipidemia, and diabetes, all of which are known to contribute to renal disease [26]. Additionally, emerging research suggests that obesity in itself, independent of these medical conditions, can lead to alterations in kidney function [27]. These include factors directly affecting the kidneys, including hemodynamic changes triggered by the activation of the renin–angiotensin–aldosterone system (RAAS), neurohormonal shifts, and a persistent inflammatory state [27, 28]. Adipocytes can also release pro-inflammatory cytokines (IL-6 and TNF-a) resulting in further kidney damage.

MBS is an effective method for significant and sustained weight loss, which in turn has been shown to decrease the prevalence of kidney disease risk factors such as hypertension and insulin resistance. MBS is proven to have a satisfactory safety profile in a wide variety of clinical scenarios, such as severe obesity and heart disease, in addition to being comparable to many commonly performed operations in this regard [12, 13, 29]. However, there is a scarcity of data on the long-term effects of MBS in patients with CKD, especially concerning safety and potential complications. The impact of renal function on complication rates following MBS has been described using the National Surgical Quality Improvement Program (NSQIP) database, however, these studies are limited to 30-day outcomes [30]. A recent meta-analysis by Khajeh et al. has explored the results of MBS in individuals with advanced CKD stages, yet these discussions often focus solely on complications or provide limited insights into weight loss results, typically excluding long-term weight management outcomes and omitting further details on the range of CKD stages examined [31]. The study herein distinctively explores the use of SG and RYGB in patients with varying stages of CKD, including a notable number of dialysis-dependent patients, and reports on anthropometric outcomes, complications, and mortality rates over a period of up to 5 years post-surgery. Notably, our findings suggest favorable rates of renal transplantation and a slower progression of CKD in patients who underwent MBS. Similar research has shown a nearly twofold increase in the hazard of renal transplant rates at 5 years following MBS compared to non-surgical candidates [23]. Additionally, another study demonstrated that MBS was associated with a 58% lower risk of experiencing an eGFR decline of $\geq$ 30% and a 57% lower risk of doubling of serum creatinine or progressing to ESRD [32].

Our study highlights the differential preference for MBS procedures based on the stage of preoperative CKD, revealing a strategic aspect of surgical planning. Specifically, patients with stage 3 CKD were more likely to undergo RYGB, while SG was favored among patients with more advanced CKD, particularly those undergoing dialysis. This pattern suggests a nuanced assessment of each procedure's risk-to-benefit ratio by dedicated multidisciplinary bariatric teams. The combination of the restrictive and malabsorptive nature of the RYGB procedure contributes to the significantly higher weight loss when compared to SG, a finding

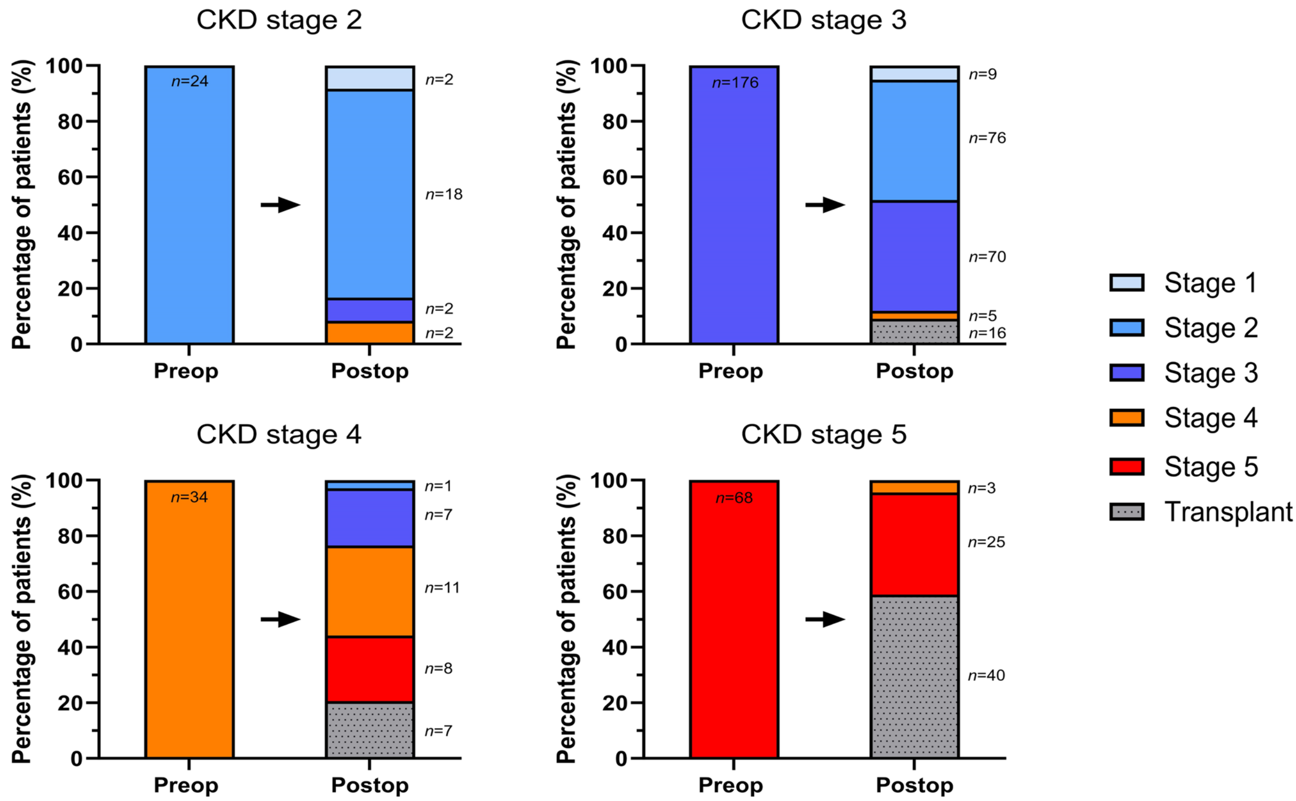

Fig. 4 Description of postoperative renal outcomes in patients undergoing MBS Stratified by preoperative CKD staging

that was echoed in our analysis [33]. However, it is worth mentioning that a greater proportion of patients undergoing SG were classified as CKD stages 4 and 5, which has been associated with inferior weight loss when compared to earlier CKD stages [34]. While these factors could have influenced the selection of RYGB for patients with stage 3 CKD, other factors were at play when considering patients with later stages of CKD for MBS. The observable preference for SG in patients with CKD stages 4 and 5 is likely due in part to the perceived simplicity of this procedure. Laparoscopic SG has been shown to have shorter operative times and lower rates of short- and long-term complications compared to RYGB [35, 36]. Additionally, a substantial number of patients in the SG group were on dialysis at the time of surgery. This group underwent SG as a strategic decision by the MDT and bariatric program, anticipating future needs for renal transplantation [37]. The consideration of post-transplantation needs, such as the long-term use of immunosuppressive medications and concerns over potential complications like staple line leaks or marginal ulceration in RYGB, might further justify the preference for SG in dialysis patients and those contemplating transplantation [38]. Additionally, the increased risk of kidney stones and oxalate nephropathy, some notable concerns with procedures that involve bypassing the duodenum such as RYGB, should be carefully weighed against the potential for aggravating renal conditions, especially in those with more advanced CKD [39]. These multifaceted considerations underscore the necessity for a holistic approach to procedure selection. Patients present with a constellation of health conditions—ranging from CKD and diabetes to gastroesophageal reflux—which different MBS procedures may address to varying degrees of efficacy. This tailored approach to procedural selection in the CKD population is indicative of the evolving understanding of MBS and its versatility.

The safety of MBS procedures in patients with CKD is a critical consideration, given the increased potential for perioperative and postoperative complications in this population [31]. Our results indicated statistically comparable rates of early postoperative complications between SG and RYGB, which aligns with a propensity-score matched analysis of both procedures in individuals without CKD [40]. A detailed examination of these complications, categorized by the Clavien-Dindo classification, reveals that they are predominantly non-severe and can be managed medically without the need for further surgical intervention, providing additional evidence of MBS's comparable short-term safety in patients with CKD [25]. The higher observed incidence of late complications in the RYGB group, while significant, should be weighed against the broader context of overall benefit, and underscores the need for a vigilant follow-up, as is the case in the non-CKD population. However, the majority of complications in the RYGB cohort were Clavien-Dindo grade IIIA or IIIB, and required intervention or reoperation, as opposed to early complications. These findings again resonate with broader literature, and reinforce the rationale for avoiding these procedures in patients with more advanced CKD stages [41].

This study, despite its strengths, is subject to several limitations. First, its retrospective design inherently carries the risk of selection bias and limitations associated with historical data accuracy, as it relies on pre-existing medical records. Second, the exclusion of patients with missing data and no follow-up and could lead to further bias, potentially skewing the results towards more favorable outcomes. Third, while not the primary goal of this study, grouping CKD stages 3A and 3B for analysis may have obscured subtle differences in outcomes pertinent to these specific stages. Fourthly, although preoperative renal status was identified through serum creatinine tests, calculated eGFR measurements, and ICD codes, there is a potential for some cases to have been missed due to incomplete data. Finally, the evaluation of CKD progression following weight loss often relies on creatinine-based equations, which may not always provide accurate insights. As weight loss following MBS typically leads to a reduction in muscle mass, creatinine levels may decrease, ostensibly improving the eGFR using these equations. Additionally, adjustments in the formula for CKD that account for body surface area (BSA) are necessary, as weight loss results in a reduced BSA, potentially leading to an apparent improvement in eGFR that may not accurately reflect true renal function improvements.

Conclusion

MBS remains an effective strategy for sustained weight loss in patients with CKD and displays an acceptable complication rate. The findings indicate that RYGB leads to a higher percentage of overall weight loss, albeit with an elevated likelihood of late surgical complications, in comparison to SG for patients dealing with concurrent obesity and CKD. The observed practice pattern, where patients with more severe CKD undergo SG and those with less severe disease undergo RYGB, aligns with current clinical considerations. SG is preferred for advanced CKD due to its lower risk of complications, while RYGB might be chosen for its greater weight loss, metabolic benefits and preferable outcomes in those with reflux esophagitis. Several factors, including pre-existing comorbidities, nutritional risks, CKD severity, and patient preferences, should be considered when recommending the MBS procedure. Additionally, a substantial number of patients showed improvements in kidney function over the course of the study, with a particular group successfully progressing to candidacy for kidney transplants and undergoing the procedure. With the increasing prevalence of obesity and CKD in the United States, more studies are needed determining the safety of MBS in this demographic of patients.

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Data availability Dr. Ghanem is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and accuracy of data analysis. The datasets generated and/or analyzed during the current study are not publicly available due to the need to protect patient privacy and confidentiality in accordance with ethical standards and regulatory requirements, but are available from the corresponding author upon reasonable request.

Declarations

Disclosures Ghanem is a consultant for Olympus, Regeneron and Medtronic. All other authors (Abi Mosleh, Sample, Belluzzi, Bartosiak, Bettancourt, Buttar, Kukla and Diwan) have no conflict of interest or financial ties to disclose. These disclosures have no effect on the results of this study.

Ethical approval This study was conducted in strict adherence to the principles outlined in the Declaration of Helsinki for ethical research involving human subjects.

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