Obesity Surgery (2020) 30:4494–4504
https://doi.org/10.1007/s11695-020-04841-5

ORIGINAL CONTRIBUTIONS

The Short-Term Renal Effects of Bariatric Surgery: A Comparative Study Between Sleeve Gastrectomy and One Anastomosis Gastric Bypass Operations Among Egyptian Patients With Severe Obesity

Amir I. Bassiony[1] · **Alaa Sabry**[1] · **Osama Shiha**[2] · **Ahmed ElGeidie**[3] · **Mohammed K. Nassar**[1]

Received: 24 May 2020 / Revised: 30 June 2020 / Accepted: 6 July 2020 / Published online: 23 July 2020

Abstract

Purpose Obesity is a major health problem with many renal sequelae. Bariatric surgery (BS) has become the treatment of choice for severe obesity. This study was conducted to assess the short-term renal effects of BS and to compare such effects between two distinct forms of BS.

Materials and Methods A single-center non-randomized prospective observational study was conducted on 57 patients with severe obesity. Two distinct forms of BS have been performed; laparoscopic sleeve gastrectomy (LSG) and laparoscopic one anastomosis gastric bypass (OAGB). Anthropometric measurements, 24-h urinary creatinine clearance (CL_{Cr}), protein and oxalate excretion, and abdominal fat tissue analysis by computerized tomography were performed prior to surgery and 6 months later.

Results LSG and OAGB were performed in 47 and 10 participants, respectively. BS resulted in pronounced reduction of body mass index (− 27.1% ± 7.11), with no substantial weight loss discrepancy between LSG and OAGB. The median percent change in 24-h urinary CL_{Cr} and protein and oxalate excretion were − 35.7, − 42.2, and − 5.8, respectively. The median (IQR) percent change of urinary oxalate excretion was − 11.1 (− 22.6, − 1.4) and 113.08 (82.5, 179.7) for LSG and OAGB, respectively ($p < 0.001$). The subcutaneous abdominal fat surface area has been found to be the significant predictor of the persistence of glomerular hyperfiltration after BS.

Conclusion Both LSG and OAGB can alleviate many of the obesity-related pathological renal changes. However, postoperative hyperoxaluria remains a serious issue particularly in OAGB. Detailed radiological abdominal fat tissue analysis by CT may aid in predicting the renal outcome following BS.

Keywords Bariatric surgery · Hyperfiltration · Hyperoxaluria

Introduction

Obesity is a chronic disease characterized by accumulation of excess fat tissue, which affects body anatomy and physiology, leading to several metabolic, biochemical, and psychosocial complications [1]. It is a global health issue affecting 10.8% of men and 14.9% of women worldwide in 2014 [2], and it is expected to rise by 40% over the next decade [3]. Computerized tomography (CT) is considered to be a reference method for assessing abdominal adiposity [4]. Visceral fat, which has been reported to be strongly associated with albuminuria [5] and future cardiovascular events [6, 7], can be measured independently of the subcutaneous fat on CT images.

Obesity has been demonstrated to be associated with a higher risk of chronic kidney disease (CKD), end-stage renal disease (ESRD), nephrolithiasis, and renal cell cancer [8–11]. The increased risk for CKD and ESRD can be explained by various mechanisms; obesity-induced hypertension, insulin resistance, renin-angiotensin aldosterone system activation, dysregulation of adipocytokines, and inflammation [12, 13].

✉ Mohammed K. Nassar
m_kamal@mans.edu.eg

[1] Mansoura Nephrology and Dialysis Unit (MNDU), Internal Medicine Department, Mansoura University, Mansoura, Egypt

[2] Radiology Unit, Gastrointestinal Surgery Center, Mansoura University, Mansoura, Egypt

[3] Gastrointestinal Surgery Center, General Surgery Department, Mansoura University, Mansoura, Egypt

These changes result in glomerular hyperfiltration with subsequent albuminuria/proteinuria [14, 15]. With the progression of obesity-induced kidney damage, hyperfiltration is followed by decreasing glomerular filtration rate (GFR) and progression toward ESRD [14, 15].

Bariatric surgery (BS) is considered the most successful treatment for obesity resulting in significant and sustained loss of weight [16]. It has been reported that BS ameliorates many obesity-related comorbidities [17], and has a beneficial effect on the renal functions [18]. However, BS is considered as a risk factor for renal stones. Approximately 20% of patients develop kidney stones 10 years after operation [19]. The key mechanism of renal stones formation is hyperoxaluria and calcium oxalate super-saturation [20].

Most of the data of postoperative hyperoxaluria after BS originated from research on roux-en-Y gastric bypass (RYGB) surgery [21–23]. We assumed that there would be different renal effects of sleeve gastrectomy (SG) and one anastomosis gastric bypass (OAGB), particularly on postoperative hyperoxaluria. Accordingly, this research was conducted to determine the short-term (6 months) renal effects of BS and to compare such results between SG and OAGB. In addition, the association of abdominal fat compartments, measured by CT, with renal outcome was investigated.

Methods

Patients

This is a single-center non-randomized prospective observational study. During the period between September 2018 and June 2019, BS patients ≥ 18 years of age were recruited from the Gastrointestinal Surgery Center, Mansoura University, Egypt. Patients with CKD (eGFR < 60 mL/min/1.73 m^2), taking medications that may affect GFR or reduce proteinuria as angiotensin-converting enzyme (ACE) inhibitors or angiotensin receptor blockers (ARBs) or who are not willing to participate in the study were excluded. Sex, age, and associated comorbidities have been recorded for the included patients. The next assessments were performed prior to BS and repeated 6 months after surgery.

Surgical Interventions

Two procedures, laparoscopic SG (LSG) [24] and laparoscopic OAGB [25], were primarily performed for weight loss. The selection of LSG versus OAGB was based mainly on the patient's eating habits and lifelong commitment to multivitamin use and follow-up visits (favoring OAGB for sweet eaters and compliant patients). However, patient's choice was taken into consideration. The biliopancreatic limb in OAGB patients was 200 cm as measured from the ligament of Treitz.

Nutrition After BS

All patients were followed regularly by a nutrition consultant. In the first two weeks after surgery, patients were instructed to take enough fluids at moderate temperatures devoid of sugar or fat. They were later advised to eat well-ground soft food with a high protein content and low sugar, fat, and oxalate content while taking enough fluid.

Anthropometric Measurements

Body mass index (BMI), waist circumference [26], hip circumference [26], waist to hip ratio [27], and neck circumference [28] were measured. Body adiposity [29] and visceral adiposity [30] indices were calculated.

Laboratory Investigations

The following investigations were conducted for all patients: serum creatinine, urine analysis, 24-h urinary creatinine clearance (CL_{Cr}), protein and oxalate excretion, lipid profile, and HbA1c.

Abdominal Fat Tissue Analysis

Abdominal obesity was evaluated by CT using a 3D synapse program. Two-dimensional (2D) and three-dimensional (3D) views were assessed. This technique allows assessment of both subcutaneous and visceral fat surface area (cm^2) and volume (cm^3). The 2D technique used the specific range of Hounsfield units (HU) between − 250 and − 30 at the level of umbilicus or at the level of disc between lumbar 4 and 5 vertebra [31]. The 3D technique used the specific range of HU between − 250 and − 30 all over the abdomen, and the fat volume could be assessed in voxels and then translated into cubic centimeter for both visceral and subcutaneous fats [31].

Sample Size and Statistical Analysis

Sample size estimation was based on figures derived from the study of Chang et al. [32] Using a statistical power of 90% and two-tailed significance level of 5%, the minimum required sample size was 52 patients. Considering a possible dropout of 10%, the sample size was increased to 57 patients. Data were collected, revised, verified, and analyzed using the Statistical Package of Social Sciences (SPSS) version 21 for Windows (SPSS, Inc., Chicago, IL, USA). Medians and interquartile range (IQR) or mean ± standard deviation (SD) were used for all quantitative values, while numbers of cases and percentages (%) were used to describe qualitative variables. The significance of differences between two groups was determined by independent-sample *t* test for normally distributed variables, Mann-Whitney test for non-parametric variables,

Table 1 Clinicodemographic characteristics and anthropometric measurements

	All patients (*N* = 57)	LSG (*n* = 47)	OAGB (*n* = 10)	*p*
Clinicodemographic characteristics				
Age (years)	36.7 ± 8.88	35.8 ± 8.6	40.9 ± 9.48	0.1
Gender: *N* (%)				0.24
Male	14 (24.6)	10 (21.3)	4 (40)	
Female	43 (75.4)	37 (78.7)	6 (60)	
Diabetes mellitus: *N* (%)	10 (17.5)	6 (12.8)	4 (40)	0.06
Hypertension	9 (15.8)	6 (12.8)	3 (30)	0.18
Dyslipidemia	24 (42.1)	17 (36.2)	7 (70)	0.07
Gastro-esophageal reflux disease	15 (26.3)	9 (19.1)	6 (60)	0.01*
Obstructive sleep apnea syndrome	27 (47.4)	20 (42.6)	7 (70)	0.16
Ischemic heart disease	1 (1.8)	0	1 (10)	0.17
Anthropometric measurements				
Body mass index (BMI) (kg/m^2)				
Before	56.1 ± 9.64	55.6 ± 9.59	58.4 ± 10.03	0.4
6 months	40.9 ± 8.24	40.6 ± 8.37	42.3 ± 7.85	0.54
Percent change	− 27.1 ± 7.11	− 27.08 ± 7.45	− 27.4 ± 5.58	0.88
Neck circumference (cm)				
Before	42.2 ± 3.73	41.9 ± 3.65	43.5 ± 4.08	0.24
6 months	36.9 ± 3.43	36.8 ± 3.36	37.7 ± 3.86	0.46
Percent change	− 12.3 ± 4.88	− 12.1 ± 4.84	− 13.2 ± 5.26	0.54
Waist circumference (cm)				
Before	141.8 ± 17.49	140.2 ± 15.36	149.3 ± 24.95	0.13
6 months	110.9 ± 17.14	110.2 ± 17.07	114 ± 18.06	0.53
Percent change	− 21.7 ± 7.6	− 21.4 ± 8	− 23.3 ± 5.4	0.47
Hip circumference (cm)				
Before	155.3 ± 14.98	155.4 ± 14.29	154.5 ± 18.76	0.85
6 months	126.8 ± 14.35	126.8 ± 14.13	126.9 ± 16.14	0.99
Percent change	− 18.2 ± 6.37	− 18.3 ± 6.57	− 17.7 ± 5.6	0.8
Waist-hip ratio				
Before	0.91 ± 0.09	0.9 ± 0.07	0.96 ± 0.11	0.13
6 months	0.87 ± 0.08	0.86 ± 0.08	0.89 ± 0.06	0.3
Percent change	− 4.01 (− 8.49, − 0.81)	− 4 (− 7.7, − 0.7)	− 4.1 (− 13.2, − 0.8)	0.45
Body adiposity index (%)				
Before	56.5 ± 9.65	56.8 ± 9.55	54.9 ± 10.5	0.57
6 months	42.8 ± 8.65	43.03 ± 8.58	41.9 ± 9.41	0.72
Percent change	− 24.1 ± 8.25	− 24.1 ± 8.52	− 23.7 ± 7.24	0.86
Visceral adiposity index				
Before	2.11 (1.73, 2.66)	1.99 (1.7, 2.5)	2.75 (2.05, 3.47)	0.051
6 months	1.53 (1.09, 1.69)	1.3 (1.08, 1.62)	1.64 (1.38, 2.14)	0.059
Percent change	− 34.1 (− 51.4, − 11.8)	− 31.8 (− 51.6, − 7.2)	− 40.1 (− 51.9, − 19.2)	0.72

LSG, laparoscopic sleeve gastrectomy; OAGB, one anastomosis gastric bypass

Data expressed as mean ± SD, median (IQR) or number (%)

* Means p value < 0.05

Table 2 Laboratory investigations before and 6 months after both operations

	All patients (*N* = 57)	LSG (*n* = 47)	OAGB (*n* = 10)	p
HbA1c (%)				
Before	5.4 ± 1.2	5.2 ± 0.83	6.5 ± 1.94	0.06
6 months	4.9 ± 0.8	4.8 ± 0.71	5.2 ± 1.15	0.38
Percent change	− 7.1 (− 14.7, − 2.9)	− 4.7 (− 9.09, − 2.2)	− 20.1 (− 21.6, − 12.2)	< 0.001*
Total cholesterol level (mg/dL)				
Before	198.3 ± 41.05	192.2 ± 41.16	227.3 ± 26.39	0.01*
6 months	188.8 ± 39	188.5 ± 40.07	190.5 ± 35.42	0.88
Percent change	− 8.5 (− 14.3, 7.6)	− 7.6 (− 13.4, 11.6)	− 13.7 (− 31.8, − 5.5)	0.03*
Triglyceride level (mg/dL)				
Before	131.5 ± 51.29	120.7 ± 39.51	182.2 ± 70.15	< 0.001*
6 months	97.8 ± 34.51	93.5 ± 32.25	118.3 ± 39.11	0.03*
Percent change	− 21.2 ± 22.63	− 18.9 ± 23.1	− 31.8 ± 17.56	0.1
Serum creatinine level (mg/dL)				
Before	0.7 ± 0.13	0.68 ± 0.12	0.82 ± 0.15	0.005*
6 months	0.82 ± 0.17	0.8 ± 0.17	0.89 ± 0.17	0.16
Percent change	16.6 (0, 33.3)	16.6 (0, 33.3)	14.6 (−6.2, 25.8)	0.31
Creatinine clearance (mL/min)				
Before	224 ± 83.23	231.1 ± 83.37	190.8 ± 78.03	0.16
6 months	145.4 ± 49.09	147.7 ± 52.24	134.4 ± 29.74	0.44
Percent change	− 35.7 (− 46.7, − 17.5)	− 17.1 (− 43.7, 0.21)	− 36.5 (− 47.9, − 24.5)	0.08
Glomerular hyperfiltration (> 130 mL/min): *N* (%)				
Before	54 (94.7)	47 (100)	7 (70)	0.004*
6 months	29 (50.9)	25 (53.2)	4 (40)	0.5
Normal GFR (90–130 mL/min/1.73 m^2): *N* (%)				
Before	3 (5.3)	0	3 (30)	0.004*
6 months	28 (49.1)	22 (46.8)	6 (60)	0.5
24-h Urinary protein (mg/day)				
Before	220 (110.5, 394)	210 (86, 362)	294 (132.75, 552.5)	0.21
6 months	112 (79, 187)	117 (80, 189)	94.5 (65.25, 141.25)	0.45
Percent change	− 42.2 (− 67.6, − 17.3)	− 36.7 (− 65.7, − 17.1)	− 46.9 (− 80.9, − 28.4)	0.11
Proteinuria (> 150 mg/day): *N* (%)				
Before	36 (63.2)	30 (63.8)	6 (60)	0.54
6 months	19 (33.3)	17 (36.2)	2 (20)	0.46
24-h urinary oxalate (mg/day):				
Before	48.7 ± 15.23	49.9 ± 15.62	43.1 ± 12.25	0.2
6 months	52.1 ± 25.25	43.9 ± 17.17	90.8 ± 21.2	<0.001*
Percent change	− 5.8 (− 21.3, 40.1)	− 11.1 (− 22.6, − 1.4)	113.08 (82.5, 179.7)	<0.001*

LSG, laparoscopic sleeve gastrectomy; OAGB, one anastomosis gastric bypass

Data expressed as mean ± SD, median (IQR) or number (%)

* Means p value < 0.05

and Chi-square or Fisher exact tests for qualitative variables. Multiple logistic regression analysis was done using enter approach. All the potential variables that can predict the postoperative hyperfiltration were analyzed in 5 models. p values of < 0.05 were considered significant for all statistical analyses in this study.

Results

A total of 57 patients suffering from severe obesity who received BS were included. LSG was performed in 47 participants, and OAGB surgery was performed in 10 participants. The mean age was 36.7 years, and 75.4% of patients were

Table 3 Radiological abdominal fat tissue analysis

	All patients (*N* = 57)	LSG (*n* = 47)	OAGB (*n* = 10)	*p*
Visceral abdominal fat surface area (cm^2)				
Before	234.6 (171, 281.4)	224.1 (169.8, 266.9)	286.6 (207.7, 440.9)	0.15
6 months	113.5 (81.8, 167.7)	113.5 (85.6, 166)	125.3 (70.6, 238.5)	0.67
Percent change	− 45.9 ± 17.71	− 45.2 ± 17.61	− 48.9 ± 18.82	0.55
Subcutaneous abdominal fat surface area (cm^2)				
Before	681 (602.4, 812.8)	699.6 (602.8, 795.1)	618.2 (570.8, 878.4)	0.85
6 months	469.5 ± 137.91	478.9 ± 132.99	425.3 ± 159.14	0.26
Percent change	− 32.6 ± 18.76	− 31.07 ± 18.27	− 40.1 ± 20.21	0.16
Total abdominal fat surface area (cm^2)				
Before	966.4 ± 239.58	942.5 ± 178.89	1078.6 ± 420.26	0.33
6 months	602.8 ± 188.17	605.4 ± 174.73	590.4 ± 253.1	0.86
Percent change	− 36.6 ± 16.63	− 35.2 ± 16.03	− 43.1 ± 18.73	0.17
Visceral abdominal fat volume (cm^3)				
Before	7102 (4721, 8770)	6945 (4619, 7662)	8850 (5840, 12,524)	0.03*
6 months	3444 (2169, 4540)	3200 (2172, 4445)	3789 (2022, 5408)	0.63
Percent change	− 48.1 ± 16.97	− 47.1 ± 16.29	− 52.9 ± 20.08	0.32
Subcutaneous abdominal fat volume (cm^3)				
Before	19,492 ± 4465	19,565 ± 3870	19,620 ± 6891	0.94
6 months	11,531 ± 4048	11,752 ± 4038	10,491 ± 4139	0.37
Percent change	− 40.02 ± 18.83	− 39.1 ± 18.63	− 44.1 ± 20.23	0.45
Total abdominal fat volume (cm^3)				
Before	26,386 ± 6215	25,895 ± 4989	28,694 ± 10,292	0.42
6 months	15,012 ± 5129	15,128 ± 5024	14,464 ± 5856	0.71
Percent change	− 42.2 ± 17.42	− 41.2 ± 17.13	− 46.8 ± 18.99	0.36

LSG, laparoscopic sleeve gastrectomy; OAGB, one anastomosis gastric bypass

Data expressed as mean ± SD, median (IQR) or number (%)

* Means p value < 0.05

females. BS resulted in marked reduction in the studied anthropometric measurements 6 months after surgery, and comparable anthropometric effects were observed in the 2 forms of BS performed (Table 1).

Six months after BS, substantial reduction was observed in the 24-h CL_{Cr}, urinary protein excretion, and serum triglyceride level. HbA1c percentage and serum cholesterol level were modestly reduced. In the LSG group, the magnitude of

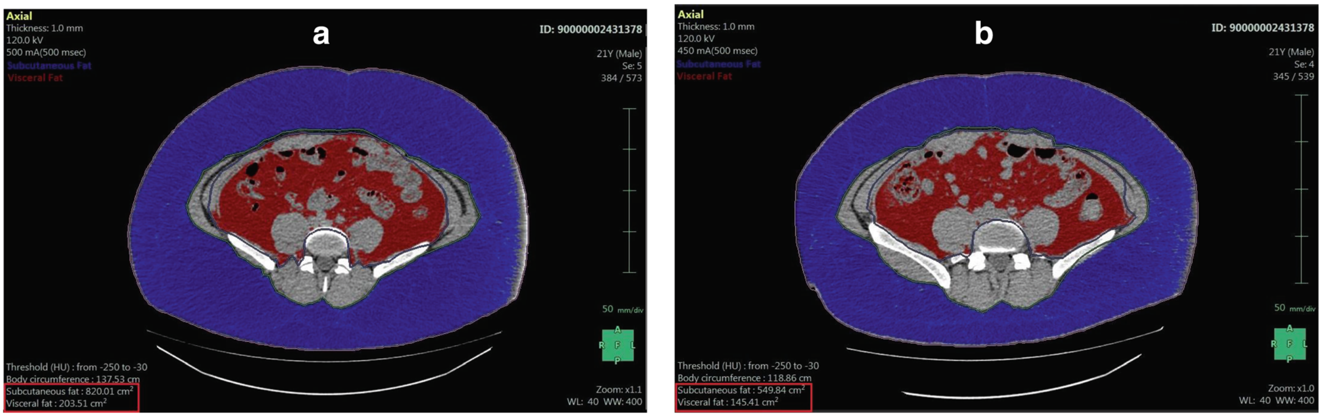

Fig. 1 Abdominal CT axial view (2D) in a LSG patient: (**a**) before operation; (**b**) 6 months after operation. Subcutaneous (blue) and visceral (red) fat surface areas (cm^2) are represented in the box at the left lower corner of each image

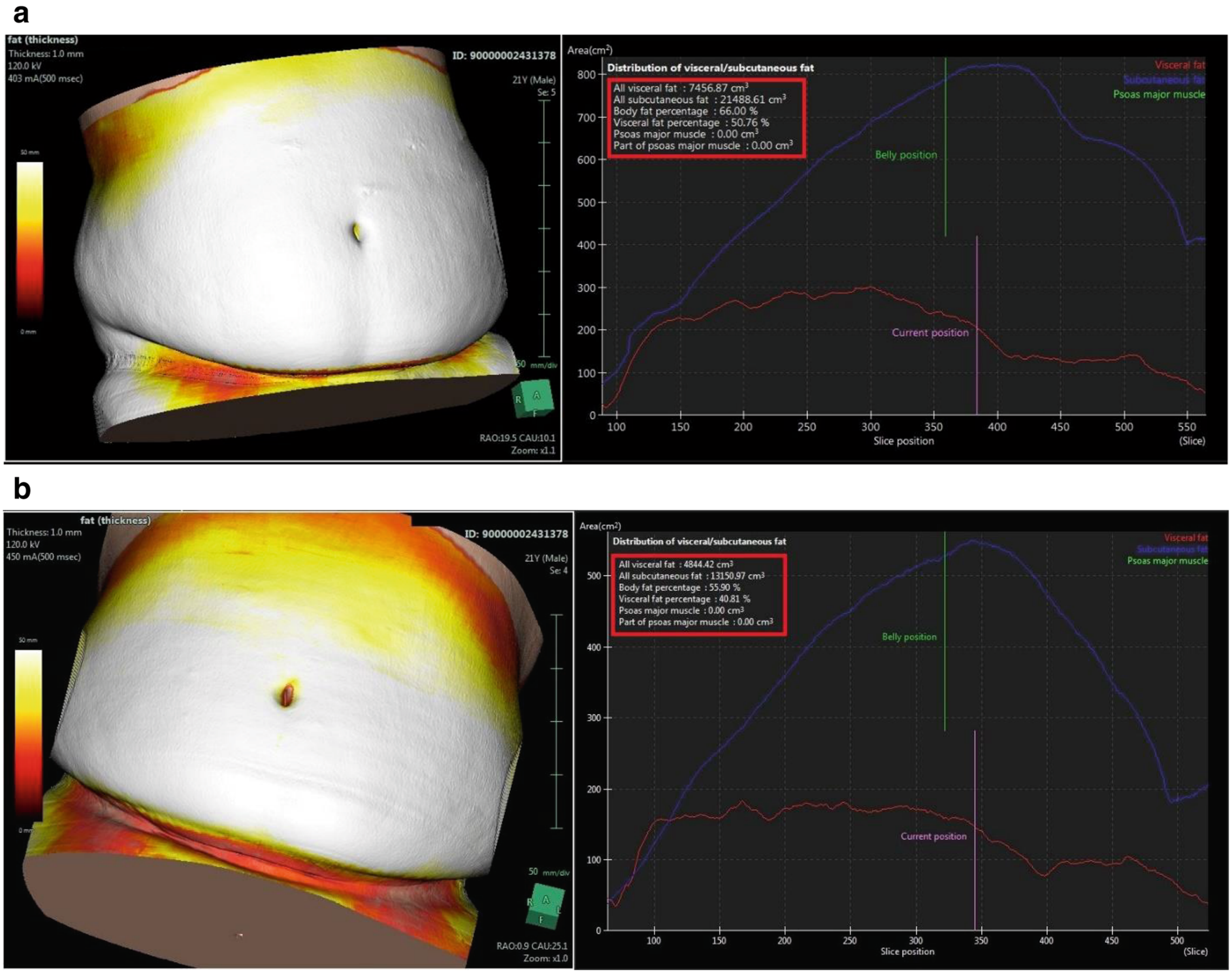

Fig. 2 Abdominal CT (3D) in a LSG patient: (**a**) before operation; (**b**) 6 months after operation. Subcutaneous (blue) and visceral (red) fat volumes (cm^3) are represented in the box with red borders at the right half

HbA1c% and the total cholesterol level reduction was lower ($p < 0.001$ and $= 0.03$, respectively). The effect of BS on urinary oxalate excretion was contradictory between the two types of performed BS. LSG resulted in a modest decrease, whereas OAGB resulted in more than one-fold increase in urinary oxalate excretion ($p < 0.001$) (Table 2).

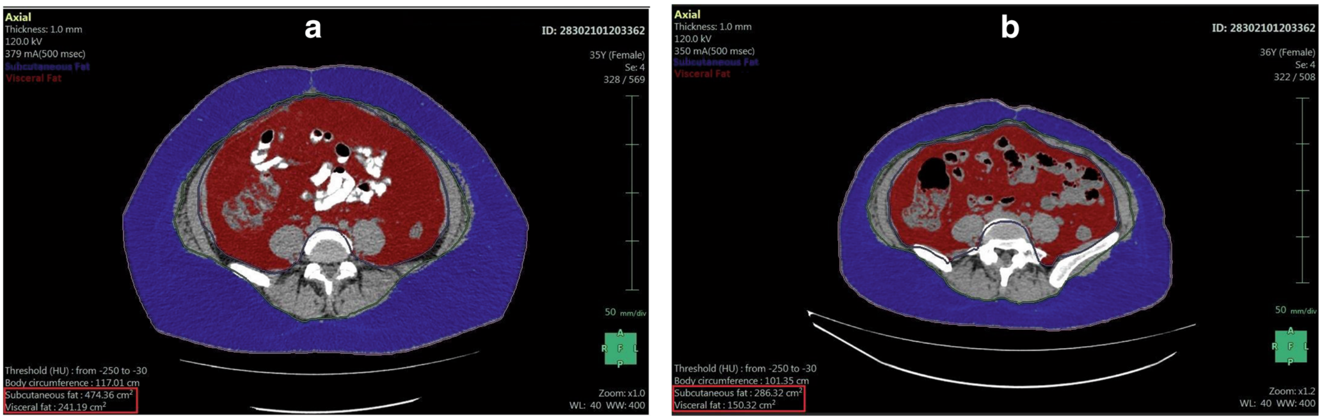

Fig. 3 Abdominal CT axial view (2D) in a laparoscopic OAGB patient: (**a**) before operation; (**b**) 6 months after operation

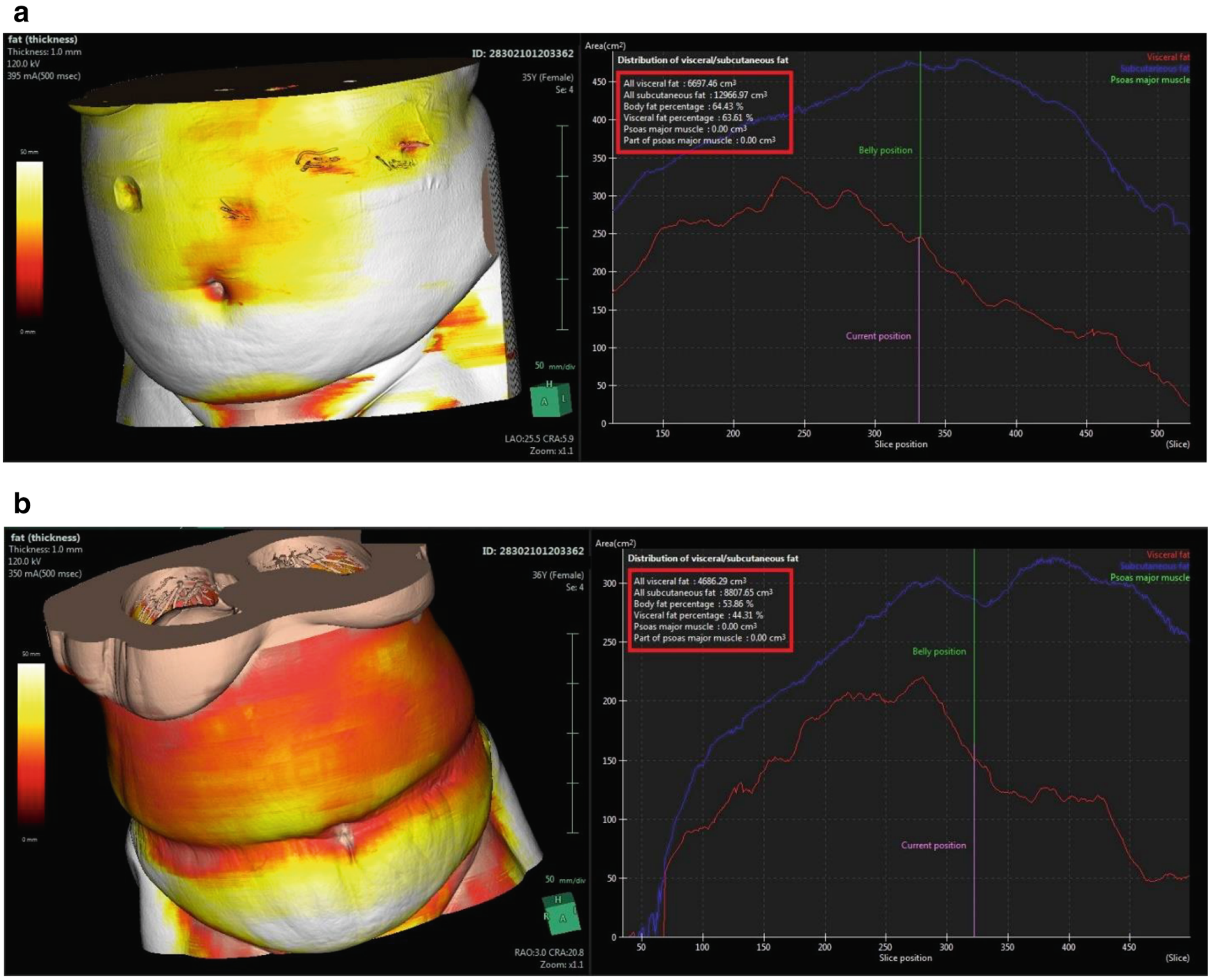

Fig. 4 Abdominal CT (3D) in a laparoscopic OAGB patient: (**a**) before operation; (**b**) 6 months after operation

A marked reduction in total, subcutaneous, and visceral abdominal fat tissue surface area and volume, assessed by CT, was observed 6 months after BS. There was no substantial difference of impact of BS type on abdominal fat tissue measurements (Table 3 and Figs. 1, 2, 3, and 4).

Glomerular hyperfiltration ($CL_{Cr} > 130$ mL/min/1.73 m^2) was evident in 54 patients before surgery. The remaining 3 patients with normal preoperative GFR belonged to the OAGB group. In 29 of those 54 patients, glomerular hyperfiltration continued six months after the operation, while the GFR in the remaining 25 patients became in the normal range. Persistent glomerular hyperfiltration was more common in male patients ($p = 0.01$) and those with obstructive sleep apnea syndrome ($p = 0.02$), with no major difference between LSG and OAGB. Patients with postoperative glomerular hyperfiltration had higher preoperative body weight and surface area, neck and waist circumferences, and higher total and subcutaneous abdominal fat surface area and volume ($p = 0.01$–0.03) (Table 4).

Six models of multivariate logistic regression, including mix of demographic, anthropometric, laboratory, and radiological variables, were developed to predict the persistence of glomerular hyperfiltration after BS. Among the studied variables, only the surface area of subcutaneous abdominal fat tissue, assessed by CT, was found to be an independent predictor for the persistence of glomerular hyperfiltration after BS (Table 5).

Discussion

Obesity is a clearly recognized global public health problem [2]. BS is one solution to this worrisome issue that has increased in popularity as it results in persistent weight loss and improvement in hard-end points, such as diabetes, sleep

Table 4 Comparison between different preoperative data regarding change of creatinine clearance after the surgery

	Preoperative hyperfiltration ($n = 54$)		p
	Postoperative hyperfiltration ($n = 29$)	Postoperative normal filtration ($n = 25$)	
Clinicodemographic characteristics			
Age (years)	35.5 ± 9.95	38.08 ± 7.04	0.3
Gender: N (%)			0.01*
Male	11 (37.9)	2 (8)	
Female	18 (62.1)	23 (92)	
Type of surgery: N (%)			0.58
OAGB	4 (13.8)	3 (12)	
LSG	25 (86.2)	22 (88)	
Diabetes mellitus: N (%)	6 (20.7)	3 (12)	0.48
Hypertension: N (%)	7 (24.1)	2 (8)	0.15
Dyslipidemia: N (%)	10 (34.5)	12 (48)	0.31
Obstructive sleep apnea: N (%)	17 (58.6)	7 (28)	0.02*
Anthropometric measurements			
Weight (kg)	156.7 ± 28.03	141.8 ± 21.19	0.03*
Body mass index (BMI) (kg/m^2)	56.9 ± 9.11	54.6 ± 9.83	0.37
Body surface area (m^2)	2.67 ± 0.27	2.51 ± 0.2	0.01*
Neck circumference (cm)	43.4 ± 3.52	40.5 ± 3.34	0.003*
Waist circumference (cm)	146.3 ± 17.5	136.2 ± 15.95	0.03*
Hip circumference (cm)	157.3 ± 15.48	152.6 ± 12.77	0.23
Waist-hip ratio	0.93 ± 0.08	0.89 ± 0.09	0.13
Body adiposity index (%)	56.03 ± 9.59	56.7 ± 9.94	0.79
Visceral adiposity index	2.08 (1.73, 2.72)	2.13 (1.58, 2.71)	0.74
Laboratory parameters			
Cholesterol level (mg/dL)	190.2 ± 32.4	202.6 ± 46.9	0.25
LDL cholesterol level (mg/dL)	119.6 ± 33.41	132.1 ± 38.27	0.2
HDL cholesterol level (mg/dL)	41.5 ± 10.39	44.5 ± 9.92	0.28
Triglyceride level (mg/dL)	136.6 ± 55.62	124.2 ± 48.73	0.39
Radiological parameters			
Visceral abdominal fat surface area (cm^2)	233.2 (166.8, 329)	230.4 (173.5, 255)	0.53
Subcutaneous abdominal fat surface area (cm^2)	746.3 ± 135.26	641.3 ± 110.81	0.003*
Total abdominal fat surface area (cm^2)	1003.2 ± 190.32	882.8 ± 202.09	0.02*
Visceral abdominal fat volume (cm^3)	7440 (5541, 9017)	5090 (4310, 7571)	0.1
Subcutaneous abdominal fat volume (cm^3)	20,465 ± 4144	18,007 ± 3968	0.03*
Total abdominal fat volume (cm^3)	27,708 ± 5511	24,153 ± 5502	0.02*

LSG, laparoscopic sleeve gastrectomy; OAGB, one anastomosis gastric bypass; LDL, low-density lipoprotein; HDL, high-density lipoprotein

Data expressed as mean ± SD, median (IQR) or number (%)

* Means p value < 0.05

apnea, and even death [33]. Moreover, BS has been proved to have favorable renal effects [20]. SG and RYGB are the two leading procedures worldwide [34]. Over the last few years, OAGB has also gained worldwide acceptance [34] based on several advantages, such as short operating times, low morbidity and mortality rates [35], as well as sustained weight loss [36] or type 2 diabetes remission results equal to or even greater than RYGB [37]. To the best of our knowledge, the disparity in renal effects between SG and OAGB has not been discussed before.

Table 5 Regression analysis for predictors of postoperative hyperfiltration

Predictor[#]	B	OR	95% CI for OR		p
			Upper	Lower	
Model 1					
Subcutaneous abdominal fat surface area (cm^2)	0.006	1.006	1.001	1.012	0.028*
Model 2					
Subcutaneous abdominal fat surface area (cm^2)	0.006	1.006	1.001	1.011	0.023*
Model 3					
Subcutaneous abdominal fat surface area (cm^2)	0.007	1.007	1.001	1.012	0.025*
Model 4					
Subcutaneous abdominal fat surface area (cm^2)	0.007	1.007	1.001	1.012	0.025*
Model 5					
Subcutaneous abdominal fat surface area (cm^2)	0.009	1.009	1	1.018	0.048*
Model 6					
Subcutaneous abdominal fat surface area (cm^2)	0.007	1.007	1.002	1.013	0.007*

B, regression coefficient; OR, odds ratio; CI, confidence interval; 2D, two dimensions; 3D, three dimensions

Model 1: gender, weight, HDL cholesterol, and subcutaneous abdominal fat surface area; model 2, obstructive sleep apnea, HDL cholesterol, and subcutaneous abdominal fat surface area; model 3: weight, waist-hip ratio, body surface area, HDL cholesterol, and subcutaneous abdominal fat surface area; model 4: neck circumference, waist circumference, HDL cholesterol, and subcutaneous abdominal fat surface area; model 5: HDL cholesterol, subcutaneous abdominal fat surface area, and total abdominal fat volume; model 6: BMI percent change, HDL cholesterol, and subcutaneous abdominal fat surface area

[#] Only statistically significant predictor is presented in the table

[*] Means p value < 0.05

Six months after BS, all anthropometric measurements decreased significantly, with no major variations between the two forms of operations performed. In accordance with these results, Kular and colleagues found in the first 2 years after BS, weight loss was similar in OAGB and LSG. Afterwards, however, the LSG displayed a lower proportion of weight loss than the OAGB operation [38]. Another study showed a greater weight loss 1 year following OAGB operation [39].

In the current study, the mean CL_{Cr} significantly decreased from 224 to 145.4 mL/min/1.73m^2 and 25 of 54 patients with preoperative glomerular hyperfiltration had normal CL_{Cr} 6 months after BS. Other studies in patients with preserved kidney function showed similar findings after BS [40–42]. A meta-analysis reported a mean GFR reduction of 25.6 mL/min/1.73 m^2 after BS [43]. The higher magnitude of CL_{Cr} reduction in the present study can be explained by the clearly higher preoperative CL_{Cr} caused by the very high BMI (56.1 ± 9.64 kg/m^2), the relatively young age of the study participants (36.7 ± 8.88 years) and the exclusion of patients taking drugs that may affect GFR, such as ACE inhibitors or ARBs. There was no difference between the two operations, either statistical or clinical, regarding the reduction of CL_{Cr}. Only subcutaneous abdominal fat tissue surface area was found to be an independent indicator for the GFR response after BS. Contrary to this finding, a study conducted by Lee et al. included 138 patients with severe obesity who had different BS procedures (RYGB, SG, and biliopancreatic bypass with duodenal switch), indicated a better resolution of glomerular hyperfiltration in female gender, lower ages, and lower preoperative BMI [44]. However, Lee and colleagues assessed the kidney function through estimated GFR (eGFR) (CKD-Epidemiology equation) and not the measured creatinine clearance, and they performed different types of BS procedures.

The median urinary protein excretions significantly decreased from 220 to 112 mg/day after BS. Several studies and meta-analyses have shown a favorable effect of BS on reducing proteinuria or albuminuria after surgery. Whether this is a direct effect of weight loss or mediated by better blood pressure and insulin resistance is unclear [18, 45]. There was no statistically relevant difference between the two operations as regards reducing the excretion of urinary protein.

Bariatric surgery has a range of renal complications, including perioperative acute kidney injury (AKI), long-term nephrolithiasis, and oxalate nephropathy [20]. AKI is relatively common after BS, with estimates varying from 2.9 to 8.5% using different definitions of AKI [46, 47]. Risk factors for AKI after BS include higher BMI, lower eGFR, preoperative use of ACE inhibitors, ARBs, and intraoperative hypotension [20]. In view of good hydration in the perioperative period and regular follow-up by a nutrition consultant, no single case of postoperative AKI occurred in this study up to six months after surgery.

The risk of kidney stones can increase following some forms of BS, which tends to be associated with the degree of fat malabsorption achieved [20]. Steatorrhea is believed to induce hyperoxaluria by increasing the formation of calcium fatty acid salts, leading to a decrease in the binding of calcium to oxalate and ultimately an increase in the absorption of oxalate [23, 48]. In the current research, there was a substantial reduction after LSG of 24-h urinary oxalate excretion and a substantial increase in 24 h urinary oxalate excretion following OAGB. It is the only research to the best of our knowledge that associated the OAGB procedure with the excretion of urinary oxalate in humans. The above-mentioned biochemical changes are similar to those reported by DeFoor and his colleagues who postulated that SG may have stone formation protective mechanisms due to lower levels of urinary oxalate excretion compared with RYGB patients and control group with obesity [49]. In addition, OAGB operation was associated with increased urinary oxalate excretion and elevation of the calcium oxalate super-saturation risk in an experimental animal study in rats [50].

This study has limitations. First, the single-center nature of the study. Second, the short duration of follow-up. Third, the different number of operated patients in the two groups, as during this observational study period, the selection criteria for BS type and patient's choice were in favor of LSG. Fourth, the amount of fat and oxalate in diet was not quantified. However, this is the first comparative research, to the best of our knowledge, between OAGB and SG that focuses primarily on the renal outcome in patients with severe obesity. Moreover, detailed assessment of the abdominal fat amount and distribution by CT and correlating them to the renal outcome are considered strengths of this study.

Conclusion

In conclusion, BS is an effective treatment of severe obesity and can relieve many of the obesity-induced renal disorders. Nevertheless, hyperoxaluria remains a serious problem following BS, particularly in malabsorptive procedures, such as OAGB.

Compliance with Ethical Standards

Conflict of Interest Amir I Bassiony, Alaa Sabry, Osama Shiha, Ahmed ElGeidie, and Mohammed K Nassar declare that they have no conflicts of interest. The study did not receive any funding. The cost of laboratory and radiological assessments was covered by the center and the authors.

Ethical Approval All procedures performed in this study were in accordance with the ethical standards of the Mansoura Faculty of Medicine Institutional Research Board (approval number: MD/17.04.129) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

References

1. Broskey NT, Obanda DN, Burton JH, et al. Skeletal muscle ceramides and daily fat oxidation in obesity and diabetes. Metabolism. 2018;82:118–23.
2. Risk N. Factor Collaboration (NCD-RisC). Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19.2 million participants. Lancet. 2016;387(10026):1377–96.
3. Kovesdy CP, Furth SL, Zoccali C, et al. Obesity and kidney disease: hidden consequences of the epidemic: Oxford University Press US; 2017.
4. Fang H, Berg E, Cheng X, et al. How to best assess abdominal obesity. Curr Opin Clin Nutr Metab Care. 2018;21(5):360–5.
5. Kim H, Kim HJ, Shin N, et al. Visceral obesity is associated with microalbuminuria in nondiabetic Asians. Hypertens Res. 2014;37(7):679–84.
6. Ladeiras-Lopes R, Sampaio F, Bettencourt N, et al. The ratio between visceral and subcutaneous abdominal fat assessed by computed tomography is an independent predictor of mortality and cardiac events. Rev Esp Cardiol (Engl Ed). 2017;70(5):331–7.
7. Fukuda T, Bouchi R, Takeuchi T, et al. Ratio of visceral-to-subcutaneous fat area predicts cardiovascular events in patients with type 2 diabetes. J Diabetes Investig. 2018;9(2):396–402.
8. Wang Y, Chen X, Song Y, et al. Association between obesity and kidney disease: a systematic review and meta-analysis. Kidney Int. 2008;73(1):19–33.
9. Hsu C-Y, McCulloch CE, Iribarren C, et al. Body mass index and risk for end-stage renal disease. Ann Intern Med. 2006;144(1):21–8.
10. Vivante A, Golan E, Tzur D, et al. Body mass index in 1.2 million adolescents and risk for end-stage renal disease. Arch Intern Med. 2012;172(21):1644–50.
11. Fox CS, Larson MG, Leip EP, et al. Predictors of new-onset kidney disease in a community-based population. JAMA. 2004;291(7):844–50.
12. Bagby SP. Obesity-initiated metabolic syndrome and the kidney: a recipe for chronic kidney disease? J Am Soc Nephrol. 2004;15(11):2775–91.
13. Griffin KA, Kramer H, Bidani AK. Adverse renal consequences of obesity. Am J Physiol Renal Physiol. 2008;294(4):F685–F96.
14. Hall ME, do Carmo JM, da Silva AA, et al. Obesity, hypertension, and chronic kidney disease. Int J Nephrol Renov Dis. 2014;7:75.
15. Garland JS. Elevated body mass index as a risk factor for chronic kidney disease: current perspectives. Diabetes Metab Syndr Obes. 2014;7:347.
16. Bray GA, Frühbeck G, Ryan DH, et al. Management of obesity. Lancet. 2016;387(10031):1947–56.
17. Piche M-E, Auclair A, Harvey J, et al. How to choose and use bariatric surgery in 2015. Can J Cardiol. 2015;31(2):153–66.
18. Afshinnia F, Wilt TJ, Duval S, et al. Weight loss and proteinuria: systematic review of clinical trials and comparative cohorts. Nephrol Dial Transplant. 2010;25(4):1173–83.
19. Tarplin S, Ganesan V, Monga M. Stone formation and management after bariatric surgery. Nat Rev Urol. 2015;12(5):263–70.
20. Chang AR, Grams ME, Navaneethan SD. Bariatric surgery and kidney-related outcomes. Kidney Int Rep. 2017;2(2):261–70.
21. Nasr SH, D'Agati VD, Said SM, et al. Oxalate nephropathy complicating roux-en-Y gastric bypass: an underrecognized cause of irreversible renal failure. Clin J Am Soc Nephrol. 2008;3(6):1676–83.

22. Duffey BG, Alanee S, Pedro RN, et al. Hyperoxaluria is a long-term consequence of roux-en-Y gastric bypass: a 2-year prospective longitudinal study. J Am Coll Surg. 2010;211(1):8–15.
23. Kumar R, Lieske JC, Collazo-Clavell ML, et al. Fat malabsorption and increased intestinal oxalate absorption are common after roux-en-Y gastric bypass surgery. Surgery. 2011;149(5):654–61.
24. Wölnerhanssen B, Peterli R. State of the art: sleeve gastrectomy. Dig Surg. 2014;31(1):40–7.
25. Solouki A, Kermansaravi M, Jazi AHD, et al. One-anastomosis gastric bypass as an alternative procedure of choice in morbidly obese patients. J Res Med Sci. 2018;23
26. Organization WH. Waist circumference and waist-hip ratio: report of a WHO expert consultation, Geneva, 8–11 December 2008. 2011.
27. Bagi SJ, Daniel EE, Rabiu KM, et al. Assessment of body weight, body mass index and waist-hip ratio on academic performance of female students in Akanu Ibiam Federal Polytechnic Unwana, Afikpo, Ebonyi State, Nigeria. 2017.
28. Zhang K, Li Q, Chen Y, et al. Visceral adiposity and renal function: an observational study from SPECT-China. Lipids Health Dis. 2017;16(1):205.
29. Bernhard A, Scabim V, Serafim M, et al. Modified body adiposity index for body fat estimation in severe obesity. J Hum Nutr Diet. 2017;30(2):177–84.
30. Nusrianto R, Tahapary DL, Soewondo P. Visceral adiposity index as a predictor for type 2 diabetes mellitus in Asian population: a systematic review. Diabetes Metab Syndr. 2019;13:1231–5.
31. Shuster A, Patlas M, Pinthus J, et al. The clinical importance of visceral adiposity: a critical review of methods for visceral adipose tissue analysis. Br J Radiol. 2012;85(1009):1–10.
32. Chang A, Van Horn L, Jacobs Jr DR, et al. Lifestyle-related factors, obesity, and incident microalbuminuria: the CARDIA (Coronary Artery Risk Development in Young Adults) study. Am J Kidney Dis. 2013;62(2):267–75.
33. Sjöström L, Lindroos A-K, Peltonen M, et al. Lifestyle, diabetes, and cardiovascular risk factors 10 years after bariatric surgery. N Engl J Med. 2004;351(26):2683–93.
34. Angrisani L, Santonicola A, Iovino P, et al. Bariatric surgery worldwide 2013. Obes Surg. 2015;25(10):1822–32.
35. Alkhalifah N, Lee W-J, Hai TC, et al. 15-Year experience of laparoscopic single anastomosis (mini-) gastric bypass: comparison with other bariatric procedures. Surg Endosc. 2018;32(7):3024–31.
36. Parmar CD, Bryant C, Luque-de-Leon E, et al. One anastomosis gastric bypass in morbidly obese patients with BMI ≥ 50 kg/m^2: a systematic review comparing it with roux-en-Y gastric bypass and sleeve gastrectomy. Obes Surg. 2019:1–8.
37. Musella M, Apers J, Rheinwalt K, et al. Efficacy of bariatric surgery in type 2 diabetes mellitus remission: the role of mini gastric bypass/one anastomosis gastric bypass and sleeve gastrectomy at 1 year of follow-up. A European survey. Obes Surg. 2016;26(5): 933–40.
38. Kular K, Manchanda N, Rutledge R. Analysis of the five-year outcomes of sleeve gastrectomy and mini gastric bypass: a report from the Indian sub-continent. Obes Surg. 2014;24(10):1724–8.
39. Plamper A, Lingohr P, Nadal J, et al. Comparison of mini-gastric bypass with sleeve gastrectomy in a mainly super-obese patient group: first results. Surg Endosc. 2017;31(3):1156–62.
40. Lieske JC, Collazo-Clavell ML, Sarr MG, et al. Gastric bypass surgery and measured and estimated GFR in women. Am J Kidney Dis. 2014;64(4):663–5.
41. Friedman AN, Moe S, Fadel WF, et al. Predicting the glomerular filtration rate in bariatric surgery patients. Am J Nephrol. 2014;39(1):8–15.
42. Saliba J, Kasim NR, Tamboli RA, et al. Roux-en-Y gastric bypass reverses renal glomerular but not tubular abnormalities in excessively obese diabetics. Surgery. 2010;147(2):282–7.
43. Navaneethan SD, Yehnert H, Moustarah F, et al. Weight loss interventions in chronic kidney disease: a systematic review and meta-analysis. Clin J Am Soc Nephrol. 2009;4(10):1565–74.
44. Lee S, Park S, Kwak MK, et al. Predictors of postoperative eGFR change and resolution of hyperfiltration in obese patients following bariatric surgery. Surg Obes Relat Dis. 2017;13(8):1353–60.
45. Li K, Zou J, Ye Z, et al. Effects of bariatric surgery on renal function in obese patients: a systematic review and meta analysis. PLoS One. 2016;11(10)
46. Weingarten TN, Gurrieri C, McCaffrey JM, et al. Acute kidney injury following bariatric surgery. Obes Surg. 2013;23(1):64–70.
47. Abdullah HR, Tan TP, Vaez M, et al. Predictors of perioperative acute kidney injury in obese patients undergoing laparoscopic bariatric surgery: a single-centre retrospective cohort study. Obes Surg. 2016;26(7):1493–9.
48. Moreland AM, Santa Ana CA, Asplin JR, et al. Steatorrhea and hyperoxaluria in severely obese patients before and after Roux-en-Y gastric bypass. Gastroenterology. 2017;152(5):1055–67. e3
49. DeFoor WR, Asplin JR, Kollar L, et al. Prospective evaluation of urinary metabolic indices in severely obese adolescents after weight loss surgery. Surg Obes Relat Dis. 2016;12(2):363–7.
50. Ormanji MS, Korkes F, Meca R, et al. Hyperoxaluria in a model of mini-gastric bypass surgery in rats. Obes Surg. 2017;27(12):3202–8.