REVIEW ARTICLE

Cardiovascular Effects of Metabolic Surgery on Type 2 Diabetes

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Abstract: ***Introduction*:** Cardiovascular, together with renal disease, claims a significant proportion of morbidity and mortality in association with type 2 diabetes mellitus (T2DM) and obesity. To improve the long-term renal and cardiovascular outcome, there is the incorporation of bariatric surgery (BS), which seems to be a pivotal intervention.

***Areas Explored*:** Cohort studies and randomized controlled trial (RCT) research of BS among patients with T2DM, were conducted by screening, and then information on renal effects and the cardiovascular outcome was gathered. Metabolic surgery (MS) and BS reduce both mortality and the risk of cardiovascular disorder, chronic kidney diseases and albuminuria. MS refers to a surgical approach, the primary intent of which is the control of metabolic alterations/hyperglycemia in contrast to BS which is a mere weight-reduction therapy. Patients suffering from poor glycaemic control and other macro and micro-vascular diseases will benefit from a surgical approach. The approach implicates hypertension glomerular remission, gut microbiota shift, reduced renal inflammation and fewer instances of chronic cardiac remodelling.

***Conclusion*:** MS is beneficial where the main aim is to attain significant and long-lasting weight loss results. The RCTs have depicted the superiority which surgical mechanisms hold over medically-based therapy, for enhancing glycaemic control, and achieving remission of diabetes. This type of surgery improves life quality, reduces incidences of other obesity and diabetes related diseases like microvascular disases, sleep apnea, fatal disorder, and fatty liver disease.

Keywords: Cardiovascular, metabolic surgery, obesity, type 2 diabetes, bariatric, procedures.

1. INTRODUCTION

Obesity is a disorder characterized by excess hunger, and instances of reduced satiety, immediately after a patient takes a meal. Cardiovascular diseases, together with renal diseases, significantly account for a large proportion of morbidity, as well as excess mortality in association with obesity [1]. Type 2 Diabetes Mellitus (T2DM), and obesity constitute interrelated pandemics independently and add to the risk of a patient being affected by renal and cardiovascular diseases. Obesity is mainly prevalent in people diagnosed with T2DM. Elevated body mass index (BMI) is associated with cases of development of conjoint risk factors, for both renal and cardiovascular diseases like hypertension, dyslipidemia, systemic inflammation, endothelial dysfunction, albuminuria, and T2DM. Visceral adiposity, T2DM, dyslipidemia, and hypertension constitute modifiable risk factors, which are independent for cerebrovascular, and coronary artery disease. T2DM and hypertension are the leading causes of end-stage renal illness. Research has established metabolic surgery (MS) as the most appropriate management therapy to treat T2DM [1]. Through the utilization of observational research, accompanied by few randomized controlled trials (RCTs), the benefits of various bariatric procedures that are necessary for the population with obesity, aiming at remitting and improving the T2DM condition have been proven [2, 3]. Bariatric surgical procedures (Roux-en-Y Gastric Bypass, Sleeve Gastrectomy, Laparoscopic Adjustable Gastric Banding) benefit the patient on many aspects, including hypertension, obstructive sleep apnoea, e non-alcoholic fatty disease of the liver and osteoarthritis [4]. In addition, long-term weight outcomes for those who underwent weight-loss surgery have been found superior to those who did not undergo surgical treatment even though behavioural, dietary, psychological, physical, and medical considerations can all play a role in suboptimal long-term weight loss [5, 6]. Furthermore, it has been shown that patients undergoing MS and bariatric surgery (BS) have decreased long-term mortality compared to weight-matched controls. Studies using multiple patient settings as well as nonpatient databases confirm

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similar results of significantly improved long-term survival after MS and BS. The benefit of surgery may begin as early as 2 years postoperatively [7]. The focus is now shifting from the pure weight loss relating benefits, to the function of specific organs like the heart and kidneys. This review focuses on highlighting the evidence for MS or BS, about the cardiovascular and renal illness outcomes.

2. MATERIALS AND METHODS

A review of the literature was conducted using PubMed and Cochrane library in order to identify original articles concerning the BS and its impact on both diabetes and cardiovascular diseases. The keywords used in order to identify the articles were obesity, MS or BS, cardiovascular diseases and T2DM. The initial search included 186 articles, which remained 172 after the removal of duplicates. Furthermore, the references from all selected articles were checked in order to recognize any additional appropriate studies. 152 references were excluded because they were either irrelevant or only abstracts. It should be mentioned that the inclusion process contained only articles in English. These articles were assessed for eligibility and 10 were finally included in the review. The inclusion process is demonstrated in Fig. (**1**).

3. RESULTS

The RCT carried out on obese individuals with T2DM, which examined anthropometrics and glycemia, reported microvascular outcomes among T2DM patients. Despite the fact that individuals with established microvascular problems of diabetes benefit from the BS, they are underrepresented in the RCT by Mingrone *et al.,* [8] as compared to the CROSSROADS [9].

The duration of T2DM defines macrovascular and microvascular lesions and the prognosis of the BS. The percentage of postoperative metabolic enhancement is less pronounced in the CROSSROADS as compared to RCT performed by Mingrone *et al*., suggesting that patients with a long duration of diabetes, and recognized microvascular problems, might achieve a good outcome from BS. Diabetes remission is defined asHbA1C ≤ 6%, with no medication in STAMPEDE, while diabetes remission in the RCT by Mingrone *et al*., needed a withdrawal of plasma glucose ≤ 5.6 mmol/L and HbA1c ≤ 6.5%, with no use of hypoglycemic medication for a full year [5]. None of the studies portrayed a complete remission of T2DM despite a 5-year follow-up period. Therefore, BS is a useful procedure in this case, which assists in stratifying the patients who will benefit from the surgical therapy on the end-organ results among the cardiovascular and renal patients. Tables **1** and **2** show the renal and cardiovascular effects in RCT, following BS. In Table **1**, two RCT reports information on albuminuria defined as urine albumin: creatine rate ≥3 mg/mmol) at the five years of follow-up after a patient undergoes a BS [10].

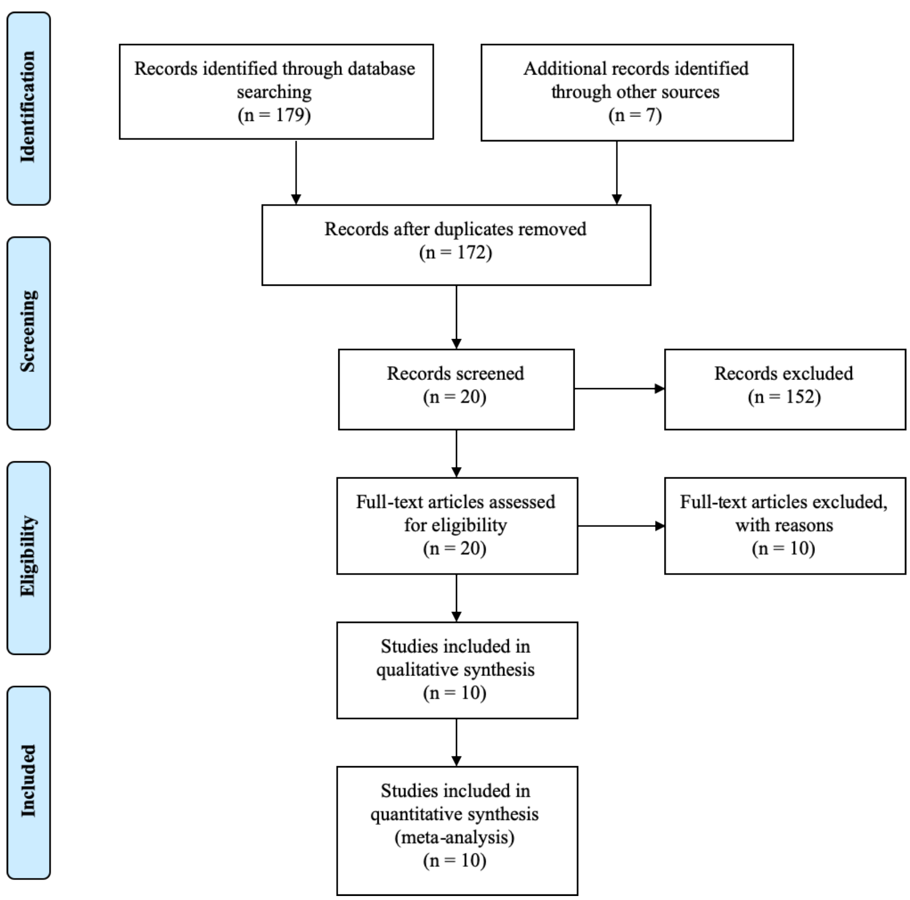

Fig. (1). PRISMA flow diagram for the current study. *(A higher resolution / colour version of this figure is available in the electronic copy of the article).*

Table 1. Baseline features, metabolic parameters, and the renal effects of bariatric surgery randomized controlled trials in obese individuals with type 2 diabetes mellitus.

Study	Study Arms	F-U (m)	N	Age (y)	Gender (% M)	T2DM Duration (y)	Weight (kg)	BMI	HbA1c (%)	Albuminuria [*n*, (%)]	SCr	eGFR
Schauer *et*	RYGB	0	50	48.3 ± 8.4	42	8.2 ± 5.5	106.7 ± 14.8	37.0 ± 3.3	9.3 ± 1.4	17 (34.0)	0.69 [0.59,	107.6
al., 2012 [10]	+ IMT	12	50	-	-	-	77.3 ± 13.0	26.8 ± 3.2	6.4 ± 0.9	-	0.81]	[98.3,
		36	48	-	-	-	80.6 ± 15.5	27.9	6.7 ± 1.3	-	-	117.9]
		60	49	-	-	-	83.4 ± 15.3	28.9	7.3 ± 1.5	9 (19.2)	-	-
		0	50	47.9 ± 8.0	22	8.5 ± 4.8	100.8 ± 16.4	36.2 ± 3.9	9.5 ± 1.7	12 (24.0)	-	-
	VSG +	12	49	-	-	-	75.5 ± 12.9	27.2 ± 3.5	6.6 ± 1.0	-	0.68 [0.57,	108.7
	IMT	36	49	-	-	-	79.3 ± 15.1	29.2	7.0 ± 1.3	-	0.82]	[96.5,
		60	47	-	-	-	81.9 ± 15.0	29.3	7.4 ± 1.6	5 (11.1)	-	118.7]
		0	50	49.7 ± 7.4-	38	8.9 ± 5.8-	106.5 ± 14.7	36.8 ± 3.0	8.9 ± 1.4	10 (20.0)	-	-
		12	41		-		99.0 ± 16.4	34.4 ± 3.7	7.5 ± 1.8	-	-	105.2
	IMT	36	40		-		100.2 ± 16.6	34.8	8.4 ± 2.2	-	0.70 [0.60,	[96.7,
		60	38		-		99.0 ± 17.0	34.0	8.5 ± 2.2	8 (21.6)	0.80]	111.7]
Dixon *et al*., 2012 [12]	LAGB + IMT	0	30	46.6 ± 7.4	50	-	105.6 ± 13.8	37.0 ± 2.7	7.8 ± 1.2	-	-	-
		24	29	-	-	-	84.6 ± 15.8	-	6.00 ± 0.82	-	-	-
		0	30	47.1 ± 8.7-	43	-	105.9 ± 14.2	37.2 ± 2.5	7.6 ± 1.4	-	-	-
	IMT	24	26		-	-	104.8 ± 15.3	-	7.21 ± 1.39	-	-	-
Mingrone *et*	RYGB	0	20	43.90 ± 7.57	40	6.03 ± 1.18	129.84 ± 22.58	44.85 ± 5.16	8.56 ± 1.40	3 (16)	-	-
al., 2015 [8]	+ IMT	24	19	-	-	-	84.29 ± 13.35	29.31 ± 2.64	6.35 ± 1.42	-	-	-
		60	19	-	-	-	90.3 ± 12.7	31.3 ± 2.5	6.7 ± 0.5	0 (0)	-	-
		0	20	42.75 ± 8.06	50	6.00 ± 1.26	137.85 ± 30.35	45.14 ± 7.78	8.88 ± 1.71	2 (11)	-	-
	BPD +	24	19	-	-	-	89.53 ± 17.84	29.19 ± 4.90	4.95 ± 0.49	-	-	-
	IMT	60	19	-	-	-	92.8 ± 14.0	30.3 ± 4.0	6.4 ± 0.4	0 (0)	-	-
		0	20	43.45 ± 7.27	50	6.08 ±	136.40 ± 21.94	45.62 ± 6.24	8.51 ± 1.24	4 (27)	-	-
		24	18		-	1.24-	128.06 ± 19.77	43.07 ± 6.44	7.69 ± 0.57	-	-	-
	IMT	60	15		-		127.1 ± 20.5	42.1 ± 5.8	6.9 ± 0.6	4 (27)	-	-
Ikramuddin	RYGB	0	60	49 ± 9	37	8.9 ± 6.1	98.8 ± 14.0	34.9 ± 3.0	9.6 ± 1.0	-	0.81 ± 0.20	-
et al., 2015	+ IMT	12	57	-	-	-	73.0 ± 13.6	25.8 ± 3.5	6.3 ± 0.9	-	-	-
[11]		24	56	-	-	-	-	26.5 ± 5.4	6.5 ± 1.6	-	-	-
		0	60	49 ± 8	43	9.1 ± 5.6-	97.9 ± 17.0	34.3 ± 3.1	9.6 ± 1.2	-	0.79 ± 0.19	-
	IMT	12	56	-	-		90.1 ± 17.0	31.6 ± 3.7	7.8 ± 1.5	-	-	-
		24	54	-	-		-	31.8 ± 6.7	8.4 ± 2.9	-	-	-
Cummings *et al*., 2016 [9]	RYGB + IMT	0	15	52.0 ± 8.3	20	11.4 ± 4.8	108.8 ± 14.9	38.3 ± 3.7	7.7 ± 1.0	-	-	-
		12	15	-	-	-	-	-	6.4 ± 1.6	-	-	-
		0	17	54.6 ± 6.3-	41.2	6.8 ± 5.2-	112.8 ± 16.5	37.1 ± 3.5	7.3 ± 0.9	-	-	-
	ILMI	12	17		-		-	-	6.9 ± 1.3	-	-	-

Abbreviations: RYGB: Roux-en-Y gastric bypass; IMT: Intensive medical therapy; VSG: Vertical sleeve gastrectomy; LAGB: Laparoscopic adjustable gastric banding; BPD: Biliopancreatic diversion; ILMI: Intensive lifestyle and medical intervention; F-U: Follow-up; m: Months; N: Size of the sample; y: Years; M: Male; T2DM: Type 2 diabetes mellitus; Kg: Kilogram; BMI: Body mass index;HbA1c: Glycated haemoglobin A1; SCr: serum creatinine; EGFR: Estimated glomerular filtration rate.

Table 2. Cardiovascular effects of bariatric surgery randomized controlled trials among obese individuals with type 2 diabetes mellitus.

Study	Study Arms	F-U (m)	N	Acute Coronary Syndrome [N, (%)]	TIA/Stroke [N, (%)]	Heart Failure [N, (%)]	Cardiovascular Death [N, (%)]	Antihypertensive Therapy	SBP(mmHg)	DBP(mmHg)
Schauer *et al.*, 2012 [10]	RYGB + IMT	0	50	-	-	-	-	39 (78)	134.6 ± 18.7	81.8 ± 10.2
		12	50	0	0	0	0	16 (33)	132.3 ± 15.5	78.3 ± 10.0
		36	48	0	0	0	0	-	136.3 ± 22.32	77.60 ± 10.42
		60	49	0	0	0	0	-	131.4 ± 18.77	75.98 ± 11.57
	VSG + IMT	0	50	-	-	-	-	33 (67)	135.8 ± 18.8	82.2 ± 11.6
		12	49	0	0	0	0	13 (27)	130.8 ± 14.3	78.6 ± 8.9
		36	49	0	0	0	0	-	131.4 ± 17.21	75.92 ± 12.57
		60	47	0	1 (2)	0	0	-	128.3 ± 11.60	74.11 ± 11.49
	IMT	0	50	-	-	-	-	31 (76)	135.5 ± 17.0	82.6 ± 11.0
		12	41	0	0	0	0	30 (77)	131.4 ± 14.0	78.2 ± 10.6
		36	40	0	0	0	0	-	136.0 ± 16.80	75.60 ± 10.43
		60	38	1 (2)	0	0	1 (2)	-	131.5 ± 14.55	77.62 ± 9.83
Dixon *et al.*, 2012 [12]	LAGB + IMT	0	30	-	-	-	-	20 (69)	136.4 ± 15.6	86.6 ± 9.4
		24	29	0	0	0	0	6 (21)	130.4 ± 19.0	85.4 ± 7.0
	IMT	0	30	-	-	-	-	15 (58)	135.3 ± 14.4	84.5 ± 9.8
		24	26	1 (4)	1 (4)	0	0	15 (58)	132.6 ± 17.7	83.1 ± 8.5
Mingrone *et al.*, 2015 [8]	RYGB + IMT	0	20	-	-	-	-	-	145.75 ± 20.54	91.50 ± 14.15
		24	19	0	0	0	0	-	132.11 ± 10.45	84.21 ± 4.79
		60	19	0	0	0	0	-	132.5 ± 6.2	84.2 ± 3.5
	BPD + IMT	0	20	-	-	-	-	-	154.50 ± 29.73	95.90 ± 12.87
		24	19	0	0	0	0	-	129.21 ± 8.04	82.37 ± 4.21
		60	19	0	0	0	0	-	129.2 ± 5.8	83.5 ± 3.0
	IMT	0	20	-	-	-	-	-	155.20 ± 34.18	96.00 ± 17.52
		24	18	0	0	0	0	-	134.44 ± 10.97	87.28 ± 9.32
		60	15	1 (7)	0	0	1 (7)	-	132.3 ± 4.2	84.0 ± 2.8
Ikramuddin *et al.*, 2015 [11]	RYGB + IMT	0	60	-	-	-	-	41 (68)	127 ± 15	78 ± 12
		12	57	0	0	0	0	23 (38)	115 ± 14	68 ± 9
		24	56	0	0	0	0	25 (42)	120 ± 23	70 ± 15
	IMT	0	60	-	-	-	-	43 (73)	132 ± 14	79 ± 10
		12	56	0	0	0	0	42 (71)	124 ± 12	74 ± 9
		24	54	0	0	1 (2)	0	37 (63)	125 ± 22	75 ± 14
Cummings *et al.*, 2016 [9]	RYGB + IMT	0	15	-	-	-	-	-	129.3 ± 20.6	77.0 ± 10.2
		12	15	0	0	0	0	-	110 ± 10	-
	ILMI	0	17	-	-	-	-	-	120.1 ± 9.6	74.8 ± 7.5
		12	17	0	0	0	0	-	116 ± 10	-

Abbreviations: RYGB: Roux-en-Y gastric bypass; IMT: Intensive medical therapy; VSG: Vertical sleeve gastrectomy; LAGB: Laparoscopic adjustable gastric banding; BPD: Biliopancreatic diversion; ILMI: Intensive lifestyle and medical intervention; F-U: Follow-up; m: Months; N: Size of the sample; TIA: Transient ischemic attack; SBP: Systolic blood pressure; DBP: Diastolic blood pressure.

The RCT research, which examined the Swedish Obese individuals, used a controlled intervention survey, which studied the impact of BS on T2DM, following an MS. The survey associated BS with a reduction in myocardial infarction. As such, 38 events among all the 345 obese patients, *versus* 43 events among 262 patients in the control group , having the log-rank p = 0.017; and the adjusted ratio of hazard (HR) 0.56 (95% Cl 0.34-0.93); p=0.025) were examined

Table 3. Mean changes in body mass index and glycated haemoglobin from the specific bariatric procedures.

Bariatric Procedure	BMI (kg/m^2)			HbA1c (%)		
	Pre-Surgery	Post-Surgery	Mean Reduction (95%CI)	Pre-Surgery	Post-Surgery	Mean Reduction (95%CI)
AGB	37	29.5	7.5 (5.9-9.1)	7.8	6	1.8 (1.3-2.3)
SG	41.3	28.3	13.0 (10.1-15.9)	7.9	6	1.9 (1.0-2.8)
RYGB	34.6	25.8	8.8 (5.2-12.4)	8.2	6.1	2.1 (1.3-2.9)
BPD	50.5	34.6	15.9 (11.8-20.0)	8	5.2	2.8 (2.1-3.5)

Abbreviations: AGB: Adjustable gastric banding; SG: Sleeve gastrectomy; RYGB: Roux-en-Y gastric bypass; BPD: Biliopancreatic diversion; BMI: Body mass index; HbA1c: Glycated haemoglobin A1.

[11]. The outcomes showed no effect of BS on stroke incidences. The impact of BS on reducing myocardial infarction prevalence was stronger among individuals having a higher serum total cholesterol, as well as triglycerides at a baseline level, where the interaction p-value = 0.02 in both the traits. BMI (of interaction p-value = 0.12) was not associated to the surgery outcome. BS seems like a remedy to reduce incidences of myocardial infarction among obese patients, who have T2DM. It is therefore efficient to integrate preoperative BMI with the metabolic parameters to maximize on the benefits accruing from BS [1, 8, 12-19].

The RCT of BS in T2DM demonstrates a significant reduction in the requirement for the antihypertensive medication, to lower and control blood pressure, as compared to those medically treated as evident in Table **2** [2, 20-22]. For instance, the STAMPEDE shows absolute variations in systolic, as well as diastolic blood pressure, At 5-year follow-up, it was -3 ± 23 as well as -6 ± 13 mmHg at the RYGB + IMT arm, -8 ± 20 as well as -8 ± 15 in the VSG + IMT sleeve, and -4 ± 20 and -4 ± 11 in the IMT arm separately. There was no significant difference among the groups that were observed. BS lowered the death rate by cardiovascular events [23-30]. Moreover, at the baseline study, all three types of BS reduced chances of albuminuria when follow-up was emphasized. Additionally, the occurrence of microvascular and macrovascular outcomes reduced by performing a BS [30-45]. This can be explained since all types of BS reduce the HbA1c levels and provide better glycaemic control (Table **3**) [14].

The meta-analysis of weight loss, together with the remission of T2DM assessed in RCT and observable studies (OBS) in a regular therapeutic period of over seventeen months, showed the excess weight loss (EWL) for BS to be 75.3%, and common treatment group showed 11.3%. The corresponding T2DM remission proportions were 63.5% and 15.6%, respectively. The limitation of meta-analysis is that OBS is incorporated, and surgery is not directly compared to a more vigorous intervention of weight loss [14, 46-48]. More so, the technique is criticized for not having a standard definition of diabetes remission. Also, it lacks a clear specification on how bariatric processes are applied, and there are no definite criteria for performing BS among T2DM patients [48, 49].

BS leads to enhanced cardiovascular and renal illness outcomes by emphasizing on the putative mechanisms. After RYGB, a patient can achieve about 25% weight loss [50]. The reduction of the adipose tissue mass, as well as the systemic inflammation, is the outcome of BS that improves the peripheral insulin confrontation. Thus, morbid diabetes undergoes a complete remission [51-53]. Another result from BS is the alteration in the adipocytokine signal. There is a reduction of plasma leptin after an obese patient with T2DM undergoes a BS, thereby losing weight [54]. The decline of leptin secretion lowers hypertension and tachycardia which are due to the activation of the sympathetic nervous system. This leads to lower blood pressure after BS [55].

Moreover, BS results in natriuresis as patients who undergo gastric bypass are likely to experience lower blood pressure. As such, an increase in urinary sodium elimination is a significant determinant of the postoperative limitation of blood pressure after RYGB. There is a strong dose-relationship between BMI and the risks related to hypertension. The outcome of BS on blood pressure examined under meta-analysis defines hypertension as systolic BP ≥140mm Hg, and diastolic BP ≥90 mmHg. The performance of surgery lowers the risk of hypertension by more than half of the risk factors within a follow-up period of more than two years. When an RYGB surgery is performed, the resultant outcome remits about 38.2% of the hypertension risk factors. If a hypertensive patient undergoes a ten years follow-up after the RYGB surgery, then the patients experience a systolic reduction of about (-5.1 mmHg, 95% CI -7.1 to -3.1 mmHg) and a diastolic decrease of (–5.6mmHg, 95%CI -6.7 to -4.4mmHg). MS and BS lead to significant improvement of the pulmonary arterial pressures, discontinuation of the pulmonary vasodilatory therapy and a decrease in diuretic need among patients with obesity and pulmonary hypertension. MS helps to measure the cardiac function and determine the ventricular size and functioning among patients with pulmonary hypertension. Moreover, the MS improves leptin and lipid metabolism, which are potential mediators of pulmonary vascular disease. To understand the natriuresis post-RYGB, physiological responses of the cardiac natriuretic peptide structure are seen as the determinants of the treatment of renal sodium of postoperative weight loss [56].

Moreover, weight loss through BS promotes the increased release of the natriuretic peptide, which causes a reduction in circulating neprilysin. Neprilysin is a significant peptidase that takes part in the degradation of the natriuretic peptides [57].

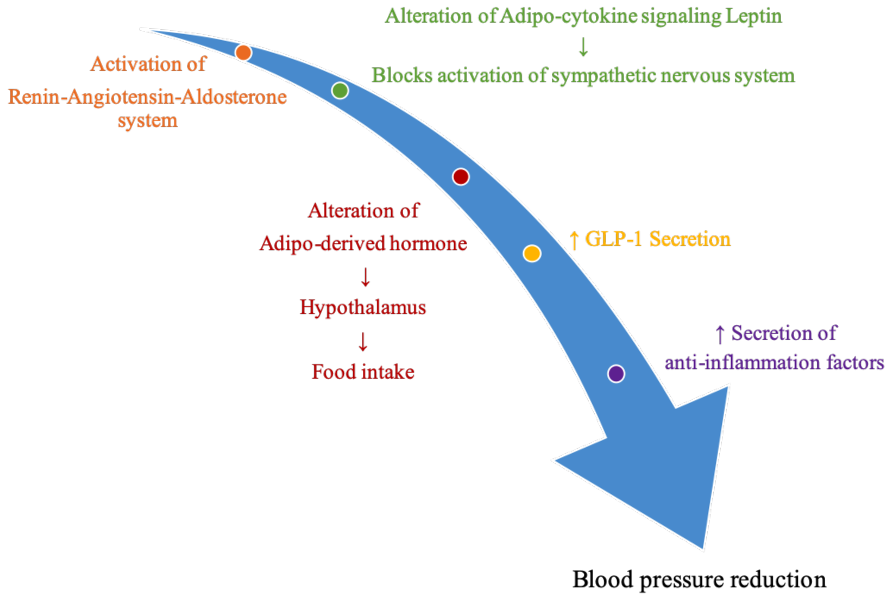

Fig. (2). Mechanisms by which bariatric surgery leads to decreased blood pressure. *(A higher resolution / colour version of this figure is available in the electronic copy of the article).*

Surgery lowers heart failure rates since MS and BS decrease the left ventricular (LV) mass and the relative wall thickness. Consequently, this improves the LV diastolic function, thereby reducing the left atrium diameter. BS provides a bridge for patients having advanced heart failure to cardiac transplantation. Safe MS could be performed to patients with the heart failure by transplanting the failing organ. In addition, the obese patient can achieve sufficient weight loss postoperatively to the cardiac transplantation. MS is enough for cardiac repair. Patients with obesity may have maladaptive LV modelling. The above condition may progress to non-ischemic dilated cardiomyopathy, together with heart failure, which is a clinical syndrome. The weight that a patient losses after BS may lower and reverse the obesity-associated LV remodelling. The surgery is associated with improvements in the cardiac structure together with enhanced cardiac functioning. Also, the surgery improves the right ventricle (RV) structure and operation. Improved cardiac imaging, after BS, brings about a clinically meaningful outcome since the incidence of heart failure is lower. BS improves long-term cardiovascular outcomes and brings about a positive renal and heart result [58-60].

BS limits all-cause deaths and the risk of cardiovascular disease. Also, it lowers progressive prolonged kidney disease and albuminuria. Patients suffering from poor glycaemic control together with those suffering from microvascular diseases, may benefit more from a surgical approach. As such, BS results in the low sympathetic drive. In addition, it enhances natriuresis. A higher volume of urine and the excretion of sodium predict low blood pressure when the gastric bypass surgery is performed. A patient who undergoes an RYGB surgery experiences an increase in urine and sodium excretion, which is essential to determine the postoperative reduction in blood pressure after the performance of the surgery. Moreover, the surgical approach assists in the diminution of glomerular hypertension. Surgery helps in the alteration of glomerular hemodynamics in obese patients since it activates the renin-angiotensin-aldosterone system (RAAS). Reduced tubuloglomerular feedback raises the intra-glomerular blood pressure among diabetic patients affected by kidney disease. Patients may experience shifts in gut microbiota after undergoing an MS. Surgery alters the gut microbiome, which improves energy homeostasis, weight loss and release of incretin. Gut microbiota shifts after RYGB results in the improvement of glycemia as well as blood pressure control due to enhanced GLP-1 secretion that originates from colonic L-cells among the T2DM patients. MS leads to a reduction in both systemic as well as renal inflammation since it targets many pathophysiological processes which enhance the inflammatory cytokines. The above leads to an increase the secretion of anti-inflammation factors and improves renal functioning after the BS. When a patient undergoes RYGB within a follow-up period of 12 months, the outcome is a comparable decline in urinary creatinine ratios. Moreover, BS results in the alteration of both the adipocytokine signalling Leptin and an adipocyte-derived hormone, which act on the human hypothalamus and lower the intake of food. Thus, the energy expenditure is increased. The reductions of plasma leptin, after a patient undergoes BS, are proportional to the weight loss that the patient achieves. The above confirms that leptin secretion is proportional to the adipose tissue mass. The postoperative drop in the flow of leptin minimizes tachycardia and hypertension, which is caused by the activation of the sympathetic nervous system (Fig. **2**). The above accounts for the reduction of blood pressure when a patient undergoes BS, therefore, it leads to a reduction in the chronic cardiac remodelling and improvement in lipoprotein profiles of the patient leading to improvements in the patient's health [58-60].

MS and BS limit microvascular disease [61, 62]. The rate of the disease affecting the coronary artery, or occurrences of cerebrovascular, reduces when therapeutic intervention is applied. BS shows effective outcomes in controlling HbA1c and benefits cardiovascular patients by improving glycaemic control. This is why rigorous medication alone, is not sufficient to improve the therapeutic macrovascular results, paving the need for BS [62]. A patient with a therapeutic condition of an HbA1c rate less than 7.0%, a low-density lipoprotein saturated fat level lower than 100mg/dL, and systolic blood pressure of less than 130mm Hg will only maintain a triple endpoint if such a patient is exposed for a five-year therapeutic follow-up period. If no changes in health will be experienced within the follow-up period, it is advisable that the patient must undergo an MS to maintain a triple endpoint. A high population of patients suffering from obesity undergo a therapeutic lifestyle control, thereby losing about 9.6% of their total weight which is less effective when compared to BS [63, 64]. Obese patients who undergo a surgical intervention, experience a mean weight loss of about 21.8%. Since the triple endpoint is an appropriate goal over glycaemic control, advances in such multiple parameters above are achieved mainly with the performance of BS. Pharmacological agents contribute to a modest loss of weight outcomes of about 5-10 kg, within 2-4 years. BS achieves a more drastic weight loss of 25-75kg in the same period. The surgical procedure has been established as a most operative and durable intervention for an obese population. The surgical approach maintains weight loss for an extended period even beyond 20 years [62-64]. Surgery is the only intervention identified by researchers to reduce mortality in the long run consistently. This approach improves clinically appropriate endpoints that include the remission of various comorbidities and the lowering of cardiovascular risks together with serious cardiovascular events. Moreover, surgery reduces appetite and induces satiety to the patients aiming at reducing weight. Surgical intervention alters the patient's food taste and preferences to limit more food intake. Also, obese patients who have undergone surgery are in a position to increase the rate of energy expenditure, as the surgical approach enhances the burning of calories. A bariatric surgical intervention could be used to improve the aversion effect. The negative outcome entails symptoms like the dumping syndrome, and alteration of the bowel habit of the patient that result in behavioural changes. The aversion effect and altered bowel habit have a significant contribution to weight loss effects among obese patients. The relative contributions of mechanisms above vary depending on the procedure applied. Altered satiety together with hunger is the essential factor in most bariatric surgical procedures [64].

Cardiovascular challenges affecting aged people include the following; hypertension, inflammation, dyslipidemia, and T2DM [65-67]. It is essential to reverse the incidences of obesity among the elderly , by performing BS to realize the cardiovascular benefits like reduction in mortality rate [68-70]. BS helps to improve the cardiovascular risk profile of the aged and reduce the risk of myocardial infarction. Surgery reduces the risk factor of myocardial infarction by about 46% within a follow-up period, among patients with T2DM and obesity. It also reduces incidences of stroke and eventually limits death [71-77]. Modern BS proves to have an excellent safety profile, as compared to limitations emanating from the surgery such as nutritional deficiencies, and the long need for dietary supplementation [78-80]. Additionally, vitamin and mineral rates may be altered after an MS and BS, any signs of deficiency should be adequately corrected if identified after a postoperative time. Patients may show a deficiency in calcium, vitamin D, vitamin B12, and iron just after an MS and BS. Also, there are incidences of low parathyroid hormone levels; which are ought to be checked on such a situation to ensure the patient takes more calcium. The actual serum calcium rates will be maintained normal, at the expense of the skeletal absorption. The above facts show the necessity for the application of BS intervention [78-80].

CONCLUSION

MS is beneficial when it aims for significant and long-lasting weight loss results. Emphasis should be given on appropriate patient selection with a long-term period of follow-up. The RCT has depicted the superiority which surgical mechanisms have over medically based therapy, for enhancing the glycaemic control which includes a reduction in peripheral insulin resistance. Moreover , BS reduces hepatic insulin resistance leading to the release of insulin with the unchanged total amount of insulin released and achieving remission of diabetes. Thus, this observational information suggests reduced macrovascular incidences and lower mortality rates. There are other additional outcomes which MS and BS bring to patients such as improved life quality, reduction in incidences of other obesity and diabetes related diseases like microvascular disease, sleep apnea, fatal disorder, and fatty liver disease.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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