Current Hypertension Reports (2019) 21: 37
https://doi.org/10.1007/s11906-019-0945-8

HYPERTENSION AND OBESITY (EFRAIN REISIN, SECTION EDITOR)

Check for updates

Comparison of Cardiovascular Benefits of Bariatric Surgery and Abdominal Lipectomy

Petra Rocic [1]

Published online: 5 April 2019

Abstract

Purpose of Review The purpose of this review is to examine recent evidence supporting effectiveness of bariatric surgery and abdominal lipectomy as interventional strategies aimed at reduction in incidence of cardiovascular disease (CVD) and related morbidity and mortality in obese and metabolic syndrome patients.

Recent Findings While several studies show reduction in CVD risk factors in patients who have undergone both the Roux-en-Y gastric bypass and sleeve gastrectomy, very few demonstrate actual improvements in cardiovascular function, or a decrease in CVD events or CVD-related mortality. Consequently, the cardiovascular benefits of the less invasive sleeve gastrectomy in comparison to the gastric bypass are also unclear. Striking new data on large patient samples demonstrate significant positive correlation between gastric bypass and CVD risk factor reduction only in patients who are diabetic or > 50 years of age at the time of surgery, with no significant differences in non-diabetic and younger patients and with significant side effects. On the other hand, a markedly less invasive removal of abdominal subcutaneous adipose tissue via lipectomy consistently and significantly improved CVD risk factors as well as cardiovascular function in the very few studies available.

Summary Overall, neither the potential nor the definitive cardiovascular benefits of either of the commonly used bariatric surgical or the various lipectomy procedures have been adequately explored. Future basic science and clinical studies have the opportunity to understand the mechanisms and long-term consequences of both approaches and develop personalized approaches with higher benefit to side effect ratios.

Keywords Gastric bypass · Sleeve gastrectomy · Abdominal lipectomy · Cardiovascular disease (CVD)

Introduction

Obesity and related comorbidities, including metabolic syndrome, are well-established risk factors for cardiovascular disease (CVD) and mortality [1]. Weight gain and increased adiposity directly affect cardiovascular structure and function. Independent of other factors, an increase in body weight directly corresponds to an increase in blood pressure for every individual [2]. Vice versa, weight loss results in decrease in blood pressure for every individual. These mechanisms are related to direct activation of the sympathetic nervous system and the renin-angiotensin system (RAS) by the expanded abdominal adipose tissue. Hypertension is a leading cause of cardiac dysfunction and failure. Accordingly, obese individuals were shown to have a minimum of double the risk of developing left ventricular hypertrophy and heart failure compared to normal weight individuals [3]. Of course, obesity is also the major risk factor for developing type II diabetes, which itself is one of the major risk factors for developing CVD. In fact, the Framingham score, a widely accepted metric used to calculate risk of developing CVD, uses fasting blood glucose, diagnosis of diabetes, blood pressure, presence of left ventricular hypertrophy, total and HDL cholesterol, tobacco use, and family history to estimate individual risk of dying from CVD in general and isolated risk of dying from coronary heart disease, myocardial infarction, stroke, peripheral vascular disease, and heart failure within 4–10 years [4].

Obesity has become a national epidemic; approximately 40% of adults in the USA are obese (BMI > 30 kg/m^2) [5] and nearly 70% are overweight (BMI 25–30 kg/m2) (https://www.cdc.gov/nchs/data/hus/hus17.pdf). This correlates with

This article is part of the Topical Collection on *Hypertension and Obesity*

✉ Petra Rocic
petra_rocic@nymc.edu

[1] Department of Pharmacology, New York Medical College, BSB 502, 15 Dana Road, Valhalla, NY 10595, USA

46% of the population being hypertensive [6]. Weight loss has been associated with decrease in blood pressure and other CVD risk factors as well as overall and CVD-related mortality. However, reaching a healthy weight range (BMI < 30 kg/m^2) has proven to be problematic for both overweight and obese patients. While the current guidelines recommend a low fat-low carbohydrate diet and exercise to accomplish weight loss for overweight individuals, it is the general consensus that for morbidly obese patients (BMI > 35 kg/m^2) and obese patients (BMI > 30 kg/m^2) who are persistently unable to lose weight in response to diet and exercise, bariatric surgery (sleeve gastrectomy or the Roux-en-Y gastric bypass) is the most effective intervention to prevent development of CVD and early morbidity and mortality due to CVD. However, some recent studies have questioned this approach in light of emerging serious long-term complications and side effects associated with the Roux-en-Y gastric bypass. Sleeve gastrectomy generally results in similar weight reduction and is associated with significantly fewer complications, but it is unclear whether it can provide long-term positive cardiovascular benefits associated with the Roux-en-Y gastric bypass. On the other hand, review of studies using large volume lipectomy in the abdominal area reveals intriguing positive effects on CVD risk factors and cardiovascular function itself, with minimal long-term side effects. Therefore, this review will examine recent evidence for and against effectiveness of these approaches with respect to reduction in cardiovascular risk factors, improvement in cardiovascular function, and impact on CVD-related morbidity and mortality.

Cardiovascular Benefits and Complications of the Roux-en-Y Gastric Bypass

The Roux-en-Y gastric bypass accounts for ~ 40% of bariatric surgeries performed today [7]. Overall, human studies present favorable results with respect to marked improvement of CVD risk factors and decreased morbidity and mortality in obese patients who have undergone gastric bypass in comparison to standard pharmacological treatment. Ten-year CVD risk estimated using Framingham scoring was significantly reduced 2 years after gastric bypass surgery. Bariatric surgery even improved CVD risk factors (blood pressure, plasma glucose, HOMA-IR, total and LDL cholesterol, and triglycerides) in obese patients in whom these parameters were within normal range at the time of surgery [8]. Furthermore, at 10-year follow-up, the number of CVD events was lower than that predicted for these patients before undergoing surgery [9]. A retrospective Swedish study on a large number of patients from the Scandinavian Obesity Surgery Registry evaluated the effect of the Roux-en-Y gastric bypass on total mortality, CVD-related death, and non-fatal myocardial infarction (MI) and reported a 58% relative risk reduction in total mortality, a 49% risk reduction in non-fatal MI and a 59% risk reduction in CVD-related mortality in the group which had undergone gastric bypass. Five-year absolute risk of death was 1.8% vs. 5.8% in the control group [10•]. At 10-year follow-up, the adjusted hazard ratio for CVD-related death was 0.47 for patients who have undergone surgery, with MI and cancer being the most frequent causes of death but occurring at half the rate as in the control, non-surgical intervention group [11]. At 15-year follow-up, the adjusted hazard ratio for CVD-related death was 0.47 for patients who have undergone surgery, and 0.67 for MI or stroke specifically [12] vs. the control patient group that received standard pharmacological therapy. These long-term studies offer particularly important information regarding the long-term cardiovascular benefits of gastric bypass. Another valuable study, with a 7-year follow-up, demonstrated a 40% reduction in all-cause mortality and 56% reduction in coronary artery disease-related mortality in the surgery group, which rose to 92% in diabetic patients [13].

The overall favorable assessment of the gastric bypass, however, includes several important limitations. Most of the studies report improvement in cardiovascular benefits, but in fact measure only CVD risk factors and do not assess actual cardiovascular function, cardiovascular events, or CVD-related morbidity or mortality. Long-term data on CVD-related mortality among patients who have undergone gastric bypass are currently limited to a total of two studies [10•, 13] which, although favorable, cannot form a solid basis for a universal therapeutic approach. Related, morbidity and mortality due to non-CVD but gastric bypass-related causes have been rarely studied and even less frequently reported. Younger patients appear especially at increased risk of developing life-long and symptomatic complications, including anemia (46%), hyperparathyroidism (45%), low vitamin B12 (16%), and other micronutrient deficiencies (magnesium, zinc, calcium) [14], which can contribute to development of more severe complications including severe anemia, loss of bone density, and immune system dysfunction. Also, there was a significant and alarming increase in suicide (vs. matched controls) in patients who have undergone gastric bypass within 5 years post-procedure [15•].

Furthermore, CVD risk reduction among patients who have undergone this procedure compared with severely obese persons from a general population in some studies is relatively small (~ 1.6% at 2-year follow-up and ~ 5% at 10-year follow-up) [9]. Moreover, important parameters are often overlooked and underplayed. For example, in the same study which emphasized the improvement of CVD risk factors, especially in diabetic patients, 2 years after gastric bypass, systolic blood pressure did not decrease [9], and these patients remain hypertensive according to the 2017 American Heart Association Guidelines [6]. Since systolic blood pressure is a major determinant of end organ damage, this information is significant and, contrary to reported beneficial effects of gastric bypass may in fact predict no such effect at all. Thus, the body of evidence in support of overwhelming benefits of gastric bypass on cardiovascular outcomes may not be as strong as it first appears.

Recently, multiple large studies and meta-analyses show that only patients who are diabetic and/or > 50-year old at time of surgery actually experience significant cardiovascular benefits [9, 16, 17]. In one study, 10-year CVD risk assessed by Framingham scoring at 2 years after gastric bypass surgery was reduced 3.58 ± 1.11% in patients who were diabetic at the time of surgery, but only 1.31 ± 0.02% in patients without diabetes. Similarly, the Framingham score was decreased 3.41 ± 0.75% in patients over 50 years of age, but only 0.99 ± 0.18% in patients younger than 50 [9]. Importantly, in a study which looked at actual mortality within 7 years after surgery in patients who had undergone gastric bypass vs. equivalent control subjects, overall mortality and deaths from CVD and diabetes were decreased in patients who were diabetic at the time of surgery but not in non-diabetic patients [15•]. The decrease in CVD-related mortality strongly correlated with the decrease in diabetes-related mortality; however, the nature of the link between the two has not been adequately explored, and it remains uncertain whether diabetes remission alone or additional factors attributed to Reux-en-Y gastric bypass account for its effect on CVD-related mortality [15•].

Thus, careful evaluation of cardiovascular benefits vs. adverse effects of the Reux-en-Y gastric bypass indicate that this highly invasive surgical procedure likely has significant overall positive therapeutic impact in diabetic patients and patients over 50 years of age, but its overall benefit to non-diabetic obese patients and obese patients under 50 years of age is not so clear.

Cardiovascular Benefits and Complications of Sleeve Gastrectomy

Sleeve gastrectomy is today the most common form of bariatric surgery [7] due to its significantly more favorable side effect and post-surgical complication profile. Both Reux-en-Y gastric bypass vs. sleeve gastrectomy result in significant weight loss, but discrepancies between weight loss achieved by the two interventions have been reported. Most studies report similar weight loss at 1–2-year follow-up, the time period when maximal weight loss (25–30%) typically occurs [11, 18–20]. But at longer follow-up intervals, when weight stabilizes, weight loss is typically significantly greater for gastric bypass. At 5-year follow-up, Reux-en-Y patients lost 57% and sleeve gastrectomy patients 49% of excess weight [21•]. At 10-year follow-up, weight loss stabilized at 25% in bypass vs. 16% in sleeve gastrectomy patients [11].

The effect of sleeve gastrectomy on CVD risk factors and cardiovascular disease and mortality is also significant, but how they compare to the Reux-en-Y gastric bypass is less clear. Several studies showed equivalent or similar effect of both surgical interventions on CVD risk factors. At 1-year follow-up, a US study reported equivalent risk reduction based on Framingham and ASCVD 10-year scoring between the two groups of patients [22]. A study that measured media to intima ratio as an index of early cardiovascular disease showed that this parameter was equally improved in gastric bypass and sleeve gastrectomy patients 1 year after surgery [23]. A meta-analysis of data from 15 clinical trials in China demonstrated equivalent improvements in type II diabetes, hypertension, dyslipidemia, and sleep apnea at 3- and 5-year follow-up, but noted a significant increase in complications and negative side effects with the Reux-en-Y bypass [19].

However, other studies indicate significant differences between the two surgical procedures and their effects on CVD risk factors, CVD, and related mortality. A study showed that although both gastric bypass and sleeve gastrectomy decreased blood pressure at 2 years after surgery, this relatively small (− 5.1 mmHg in Reux-en-Y and − 2.1 mmHg in sleeve gastrectomy) blood pressure-lowering effect was sustained at the 10-year follow-up only in the Reux-en-Y group [24]. In a different meta-analysis of clinical data from Chinese hospitals, the blood pressure lowering effect of gastric bypass was both absolutely greater and significantly greater in comparison to that of sleeve gastrectomy at 1-year follow-up [18]. Similarly, in the same study, total and LDL cholesterol, triglycerides, and HOMA-IR were significantly more improved in the gastric bypass vs. the sleeve gastrectomy group [18]. At 5-year follow-up, clear differences were seen between the two groups in multiple parameters in a large multicenter clinical trial in Finland (SLEEVEPASS); complete or partial remission of type II diabetes occurred in 45% of bypass vs. 37% of sleeve gastrectomy patients, dyslipidemia medication could be discontinued in 60% of Reux-en-Y vs. 47% of sleeve gastrectomy patients and medication for hypertension in 51% of Reux-en-Y vs. 29% of sleeve gastrectomy patients [21•]. There was, however, increased morbidity in the gastric bypass group (26% vs. 19%) largely due to typical complications and side effects discussed earlier. The reasons for these disparate results are not clear but could be, at least in part, accounted for by differences in weight loss, especially at longer time points. Because of individual patient variability within intervention groups with respect to weight loss, a meta-analysis which stratified patients according to weight loss might be useful. Also, most studies in patients who have undergone sleeve gastrectomy focus on short-term and/or surrogate endpoints of cardiovascular function, such as CVD risk factors and CVD risk assessment, and long-term studies tend to combine data for all bariatric surgical procedures vs. nonsurgical management. Therefore, functional and long-term data from sleeve gastrectomy patients would also improve the ability to accurately compare the cardiovascular benefit of the two surgical procedures.

Cardiovascular Benefits and Complications of Large Volume Lipectomy

Large volume lipectomy was developed primarily as a treatment for weight reduction and improvement of mobility in obese patients and for esthetic reasons. However, a growing number of studies indicate that these far less invasive procedures also result in significant CVD risk lowering. Significant reduction of inflammatory markers (IL-6, IL-1β, TNF- α, CRP) and leptin, a significant increase in adiponectin, decrease in LDL, triglycerides and increase in HDL, and normalization of insulin, glucose and HOMA-IR were reported by multiple studies in response to both vacuum-assisted subcutaneous fat liposuction (aspirate volume ~ 3540 ml = 3 kg) [25] and abdominoplasty, aka, surgical removal of abdominal fat [26, 27]. Furthermore, surgical removal of subcutaneous fat by abdominoplasty resulted not only in decreased TNF-α, IL-6, and leptin and increase in adiponectin, but also in improved cardiac function as measured by echocardiography 2 months post-surgery, which correlated with weight loss. Results in the abdominoplasty group in this study were compared to matched controls who lost equivalent amounts of weight by diet alone but saw no improvements in these inflammatory markers and adipokines [28•].

In contrast, two studies repost lack of an effect of lipectomy on CVD risk factors or insulin resistance. However, in the first study, CVD risk factors or cardiovascular function were in fact never evaluated; insulin resistance was the only parameter measured [29]. The second study involved only 15 female patients in whom subcutaneous abdominal adipose tissue was removed by liposuction and concluded that lipectomy had no effect on insulin resistance. A recent review reported mixed results regarding effect of subcutaneous adipose tissue liposuction per se on inflammatory marker reduction, leptin and adiponectin levels and cholesterol [30]. Of the total of 12 studies examined, leptin was reported to significantly decrease in four and IL-6 and TNF-α in 2 studies. Adiponectin increased in 2, while 10 studies reported significant increases in insulin sensitivity [30]. A large meta analysis which included all available human studies (28 in total) which investigated the effect of all forms of lipectomy on CVD risk factors concluded that lipectomy (removal of an average of 3 kg of adipose tissue in obese patients BMI 30–35 kg/m^2) had overall beneficial effects on CVD risk factors (inflammatory markers, cholesterol and triglycerides, leptin and adiponectin) and especially on insulin resistance [31]. Also, all studies reported weight loss significantly greater than that induced by lipectomy alone at 2–5-year follow-up, countering the notion that direct removal of adipose tissue stimulates its growth.

Out of these and other studies, including animal studies, several factors have emerged as key determinants of the cardiovascular benefits of the large volume lipectomy procedures and may explain these inconsistent findings. First, the type of lipectomy performed, surgical subcutaneous adipose tissue removal (abdominoplasty) vs. vacuum-assisted subcutaneous adipose tissue liposuction, may be relevant. Second, and related, the adipose tissue depot, subcutaneous vs. omental vs. mesenteric, being targeted certainly makes an important difference in outcomes. In a study in obese human patients undergoing unrelated abdominal surgery, biopsies of three different types of abdominal adipose tissue, subcutaneous, omental, mesenteric and periaortic, clearly demonstrated that only mesenteric and omental fat cells are larger and less vascularized and exhibit similar inflammatory profiles with elevated inflammatory macrophage infiltrates, with elevated IL-6, IL-1β, MCP-1, and TNF-α expression [32•]. This is a characteristic of profile of dysfunctional adipose tissue, which is associated with dysregulated adipokine production, including increased inflammatory cytokine secretion, increased leptin, and decreased adiponectin production. Moreover, expansion of adipose tissue with these characteristic has been well correlated with progressive metabolic dysfunction which culminates in development of insulin resistance and type II diabetes. In fact, in this particular study, larger adipocyte size of the mesenteric adipocytes was associated with 79% higher odds of having metabolic syndrome [32•]. Adipocyte size and inflammatory cytokine amounts in subcutaneous fat, which is the only adipose tissue depot that has been targeted by any lipectomy procedure in humans, are significantly lower (~ 1/2 that in mesenteric or omental adipose tissue, on average) [32•]. And yet, as discussed in this section of the review, beneficial effects of removal of even only a (comparatively) small volume of subcutaneous abdominal adipose tissue not only on CVD risk factors but also on cardiovascular function cannot be denied. Also, in comparison with gastric bypass, lipectomy is a minimally invasive intervention with no long-term side effects and few complications.

Mechanisms through which lipectomy confers beneficial effects on CVD risk factors and cardiovascular function remain largely unknown. Furthermore, potential overlap and differences in the mechanistic effects and signal transduction pathways between the two interventions have not been explored. In our preliminary studies in an obese and hypertensive metabolic syndrome rat model, the JCR:LA-cp rat [33], surgical removal of ~ 90% of the omental and mesenteric fat (=~ 10% of total body weight of the animal) at 12 weeks of age resulted in a more significant decrease in systolic and mean arterial blood pressure as well as a further improvement in left ventricular ejection fraction in comparison to Reux-en-Y gastric bypass surgery, at 24 weeks of age (12 weeks post-surgical intervention) (Rocic, unpublished observations 2012–2018). These differences appear to be due to the fact that while intra-abdominal lipectomy and Reux-en-Y gastric bypass had equivalent effects on improving microvascular function (as assessed by acetylcholine-mediated vasodilation), only intra-abdominal lipectomy improved large artery compliance (Rocic, unpublished observations 2012–2018), which is the major determinant of systolic blood pressure. The molecular mechanisms that underlay these differential effects are currently the subject of study in our laboratory, but likely involve elevated production of 20-hydroxy-5,8,11,14-eicosatetraenoic acid (20-HETE) by the expanded and dysfunctional adipose tissue in the JCR:LA-cp animals. 20-HETE is a ω-hydroxylation product of arachidonic acid with known vasoactive properties [34, 35] which we have recently shown to have differential effects on large artery compliance in healthy vs. metabolic syndrome animals [36]. 20-HETE has been shown to be increased in obese and metabolic syndrome patients [37]. We include these preliminary observations in this review to offer an idea of a possible mechanism by which lipectomy targeted to an appropriate adipose tissue compartment can exert significant positive effects on cardiovascular function. Since large artery compliance is a major determinant of systolic blood pressure, this may be especially relevant in light of the demonstrated lack of an effect of Reux-en-Y gastric bypass on systolic blood pressure in a recent human study [9].

Conclusions and Future Directions

Whether reduction in weight alone, reduction in adipose tissue volume per se, other factors, especially changes in the gastrointestinal microbiome, or a combination are responsible for cardiovascular benefits of bariatric surgery remains uncertain despite significant concentration of effort in this area. Moreover, whether or not the two most commonly used types of bariatric surgery, the Reux-en-Y gastric bypass and sleeve gastrectomy, lead to equivalent or similar improvements in CVD risk factors, projected CVD risk and/or especially cardiovascular disease, major clinical events and patient survival is not entirely clear at this time. Because of demonstrated significant differences in post-surgical complications, side effects, and lifestyle quality between the two procedures, definitive answers to these questions are important. Thus, further long-term comparative studies and analysis are urgently needed.

In the meantime, mounting evidence indicates that reduction in adipose tissue volume alone may confer significant cardiovascular benefit. However, the full potential of lipectomy as an intervention to reduce and/or delay the incidence of CVD in obese patients remains unexplored. The multifactorial reasons discussed in this review in large part underlay this current predicament. Focus on CVD risk factors and lack of inclusion of actual cardiovascular function, cardiovascular events and CVD-related mortality, combined with somewhat biased representation of gastric bypass vs. lipectomy cemented gastric bypass, and later sleeve gastrectomy, as interventions of choice for reduction of CVD risk in obese patients, without adequate exploration of possibilities lipectomy might offer. Technical difficulties at the level of basic science research further contributed. High post-surgical mortality rate, around-the-clock post-surgery care and high experimental cost of comparing the effectiveness of the Reux-en-Y gastric bypass or sleeve gastrectomy to intra-abdominal lipectomy in obese animal models, which are relevant to the human population undergoing these procedures, prevents widespread interest in this area and thus identification of mechanisms which would encourage clinical application.

The available clinical evidence suggests that the cardiovascular benefits of the Reux-en-Y gastric bypass outweigh common complications in patients with diabetes and over 50 years of age at the time of surgery. However, with the question of long-term effectiveness of sleeve gastrectomy with regard to cardiovascular disease, major clinical events and CVD-related mortality currently without a definitive answer, we suggest that there is sufficient evidence that further exploration of lipectomy procedures, specifically surgical removal of intra-abdominal adipose tissue depots (omental and mesenteric fat), should be considered as an area for future investigation with specific possible application to younger obese patients, obese patients without diabetes, and those patients with high surgical risk factors. Overall, more mid- and long-term clinical studies which assess cardiovascular function, cardiovascular events, and CVD-related morbidity and mortality (vs. CVD risk factors) are needed to definitively evaluate the cardiovascular and overall benefits of the common bariatric surgery and lipectomy procedures.

Compliance with Ethical Standards

Conflict of Interest The authors declare no conflicts of interest relevant to this manuscript.

Human and Animal Rights and Informed Consent All animal experiments referred to in this review were performed in accordance with the Animal Welfare Act and were approved by the IACUCs of New York Medical College and the University of South Alabama.

References

Papers of particular interest, published recently, have been highlighted as:
• Of importance

1. Prospective Studies Collaboration, Whitlock G, Lewington S, Sherliker P, Clarke R, Emberson J, et al. Body-mass index and cause-specific mortality in 900 000 adults: collaborative analyses of 57 prospective studies. Lancet. 2009;373:1083–96.
2. Hayashi T, Boyko EJ, Leonetti DL, McNeely MJ, Newell-Morris L, Kahn SE, et al. Visceral adiposity is an independent predictor of incident hypertension in Japanese Americans. Ann Intern Med. 2004;140:992–1000.
3. Lavie CJ, Milani RV, Ventura HO. Obesity and cardiovascular disease: risk factor, paradox, and impact of weight loss. J Am Coll Cardiol. 2009;53:1925–32.
4. D'Agostino RB Sr, Vasan RS, Pencina MJ, Wolf PA, Cobain M, Massaro JM, et al. General cardiovascular risk profile for use in primary care: the Framingham heart study. Circulation. 2008;117: 743–53.
5. Hales CM, Carroll MD, Fryar CD, Ogden CL. Prevalence of obesity among adults and youth: United States, 2015-2016. NCHS Data Brief. 2017;288:1–8.
6. Benjamin EJ, Virani SS, Callaway CW, Chamberlain AM, Chang ARCS, Chiuve SECM, et al. American Heart Association Council on epidemiology and prevention statistics committee and stroke statistics subcommittee: heart disease and stroke Statistics-2018 update: a report from the American Heart Association. Circulation. 2018;137:e67–e492.
7. Angrisani L, Santonicola A, Iovino P, Vitiello A, Zundel N, Buchwald H, et al. Bariatric surgery and Endoluminal procedures: IFSO worldwide survey 2014. Obes Surg. 2017;27:2279–89.
8. Goday A, Benaiges D, Parri A, Ramón JM, Flores-Le Roux JA, Pedro Botet J. Obemar group: can bariatric surgery improve cardiovascular risk factors in the metabolically healthy but morbidly obese patient? Surg Obes Relat Dis. 2014;10:871–6.
9. Pereira PR, Guimarães M, Morais T, Pereira SS, Nora M, Monteiro MP. Diabetic and elder patients experience superior cardiovascular benefits after gastric bypass induced weight loss. Front Endocrinol. 2018;9. https://doi.org/10.3389/fendo.2018.00718.
10.• Eliasson B, Liakopoulos V, Franzén S, Näslund I, Svensson AM, Ottosson J, et al. Cardiovascular disease and mortality in patients with type 2 diabetes after bariatric surgery in Sweden: a nationwide, matched, observational cohort study. Lancet Diabetes Endocrinol. 2015;3:847–54. **This is one of the two studies which evaluated the effect of gastric bypass on CVD outcomes (CVD death, fatal and non-fatal myocardial infarction and all-cause death), thus providing valuable data with respect to functional effectiveness of gastric bypass**.
11. Sjöström L, Narbro K, Sjöström CD, Karason K, Larsson B, Wedel H, et al. Swedish obese subjects study: effects of bariatric surgery on mortality in Swedish obese subjects. N Engl J Med. 2007;357: 741–52.
12. Sjöström L, Peltonen M, Jacobson P, Sjöström CD, Karason K, Wedel H, et al. Bariatric surgery and long-term cardiovascular events. JAMA. 2012;307:56–65.
13. Adams TD, Gress RE, Smith SC, Halverson RC, Simper SC, Rosamond WD, et al. Long-term mortality after gastric bypass surgery. N Engl J Med. 2007;357:753–61.
14. Inge TH, Jenkins TM, Xanthakos SA, Dixon JB, Daniels SR, Zeller MH, et al. Long-term outcomes of bariatric surgery in adolescents with severe obesity (FABS-5+): a prospective follow-up analysis. Lancet Diabetes Endocrinol. 2017;5:165–73.
15.• Lent MR, Benotti PN, Mirshahi T, Gerhard GS, Strodel WE, Petrick AT, et al. All-Cause and Specific-Cause Mortality Risk After Roux-en-Y Gastric Bypass in Patients With and Without Diabetes. Diabetes Care. 2017;40:1379–85. **This study on a large sample of patients presents striking new data demonstrating that while the Reux-en-Y gastric bypass confers large CVD benefits in patients who are diabetic at the time of surgery, minimal or no benefit is observed in non-diabetic patients. Furthermore, the study finds, non-CVD, but gastric bypass-related mortality is a significant complication of this intervention**.
16. Ribaric G, Buchwald JN, McGlennon TW. Diabetes and weight in comparative studies of bariatric surgery vs conventional medical therapy: a systematic review and meta-analysis. Obes Surg. 2014;24:437–55.
17. Romeo S, Maglio C, Burza MA, Pirazzi C, Sjöholm K, Jacobson P, et al. Cardiovascular events after bariatric surgery in obese subjects with type 2 diabetes. Diabetes Care. 2012;35:2613–7.
18. Wei JH, Chou RH, Huang PH, Lee WJ, Chen SC, Lin SJ. Metabolic surgery ameliorates cardiovascular risk in obese diabetic patients: influence of different surgical procedures. Surg Obes Relat Dis. 2018;14:1832–40.
19. Yang P, Chen B, Xiang S, Lin XF, Luo F, Li W. Long-term outcomes of laparoscopic sleeve gastrectomy versus Roux-en-Y gastric bypass for morbid obesity: results from a meta-analysis of randomized controlled trials. Surg Obes Relat Dis. 2019;S1550-7289: 31203–6.
20. Kang JH, Le QA. Effectiveness of bariatric surgical procedures: a systematic review and network meta-analysis of randomized controlled trials. Medicine. 2017;96:e8632.
21.• Salminen P, Helmiö M, Ovaska J, Juuti A, Leivonen M, Peromaa-Haavisto P, et al. Effect of Laparoscopic Sleeve Gastrectomy vs Laparoscopic Roux-en-Y Gastric Bypass on Weight Loss at 5 Years Among Patients With Morbid Obesity: The SLEEVEPASS Randomized Clinical Trial. JAMA. 2018;319:241–54. **This is a large clinical trial which demonstrated that at 5 year follow-up, neither weight loss nor CVD risk factors (type II diabetes, dyslipidemia, hypertension) were equivalent between gastric bypass vs. sleeve gastrectomy groups of patients**.
22. Blanco DG, Funes DR, Giambartolomei G, Lo Menzo E, Szomstein S, Rosenthal RJ. Laparoscopic sleeve gastrectomy versus Roux-en-Y gastric bypass in cardiovascular risk reduction: a match control study. Surg Obes Relat Dis. 2018;S1550-7289: 31148–51.
23. Gómez-Martin JM, Aracil E, Galindo J, Escobar-Morreale HF, Balsa JA, Botella-Carretero JI. Improvement in cardiovascular risk in women after bariatric surgery as measured by carotid intima-media thickness: comparison of sleeve gastrectomy versus gastric bypass. Surg Obes Relat Dis. 2017;13:848–54.
24. Hallersund P, Sjöström L, Olbers T, Lönroth H, Jacobson P, Wallenius V, et al. Gastric bypass surgery is followed by lowered blood pressure and increased diuresis - long term results from the Swedish obese subjects (SOS) study. PLoS One. 2012;7:e49696.
25. Giugliano G, Nicoletti G, Grella E, Giugliano F, Esposito K, Scuderi N, et al. Effect of liposuction on insulin resistance and vascular inflammatory markers in obese women. Br J Plast Surg. 2004;57:190–4.
26. Vinci V, Valaperta S, Klinger M, Montanelli A, Specchia C, Forcellini D, et al. Metabolic implications of surgical fat removal: increase of adiponectin plasma levels after reduction Mammaplasty and abdominoplasty. Ann Plast Surg. 2016;76:700–4.
27. Cuomo R, Russo F, Sisti A, Nisi G, Grimaldi L, Brandi C, et al. Abdominoplasty in mildly obese patients (BMI 30-35 kg/m2): metabolic, biochemical and complication analysis at one year. In Vivo. 2015;29:757–61.

28.• Marfella R, Grella R, Rizzo MR, Barbieri M, Grella R, Ferraraccio F, et al. Role of subcutaneous abdominal fat on cardiac function and proinflammatory cytokines in premenopausal obese women. Ann Plast Surg. 2009;63:490–5. **This study demonstrated significant improvement not only in circulating adipokines and inflammatory cytokines, but, importantly, also in the myocardial performance index measured by echocardiography 2 months after abdominoplasty (surgical removal of subcutaneous abdominal adipose tissue), thus demonstrating that lipectomy does improve functional cardiovascular outcomes**.
29. Fabbrini E, Tamboli RA, Magkos F, Marks-Shulman PA, Eckhauser AW, Richards WO, et al. Surgical removal of omental fat does not improve insulin sensitivity and cardiovascular risk factors in obese adults. Gastroenterology. 2010;139:448–55.
30. Sailon AM, Wasserburg JR, Kling RR, Pasick CM, Taub PJ. Influence of large-volume liposuction on metabolic and cardiovascular health: a systematic review. Ann Plast Surg. 2017;79:623–30.
31. Crahay FX, Nizet JL. Metabolic and cardiovascular consequences of suction-assisted lipectomy: systematic review. Ann Chir Plast Esthet. 2016;61:270–86.
32.• Kranendonk ME, van Herwaarden JA, Stupkova T, de Jager W, Vink A, Moll FL, et al. Inflammatory characteristics of distinct abdominal adipose tissue depots relate differently to metabolic risk factors for cardiovascular disease: distinct fat depots and vascular risk factors. Atherosclerosis. 2015;239:419–27. **This study demonstrated key morphological and functional differences in different fat depots with respect to production of adipokines known to mediate CVD in humans, thus emphasizing the need for utilizing this knowledge in further exploration of potential for lipectomy as an interventional strategy for reduction and/or delay of incidence of CVD in obese and metaboic syndrome patients**.
33. Hutcheson R, Terry R, Chaplin J, Smith E, Musiyenko A, Russell JC, et al. MicroRNA-145 restores contractile vascular smooth muscle phenotype and coronary collateral growth in the metabolic syndrome. Arterioscler Thromb Vasc Biol. 2013;33:727–36.
34. Garcia V, Gilani A, Shkolnik B, Pandey V, Zhang FF, Dakarapu R, et al. 20-HETE signals through G-protein-coupled receptor GPR75 (Gq) to affect vascular function and trigger hypertension. Circ Res. 2017;120:1776–88.
35. Rocic P, Schwartzman ML. 20-HETE in the regulation of vascular and cardiac function. Pharmacol Ther. 2018;192:74–87.
36. Soler A, Hunter I, Joseph G, Hutcheson R, Hutcheson B, Yang J, et al. Elevated 20-HETE in metabolic syndrome regulates arterial stiffness and systolic hypertension via MMP12 activation. J Mol Cell Cardiol. 2018;117:88–99.
37. Peterson SJ, Vanella L, Gotlinger K, Jiang H, Singh SP, Sodhi K, et al. Oxidized HDL is a potent inducer of adipogenesis and causes activation of the Ang-II and 20-HETE systems in human obese females. Prostaglandins Other Lipid Mediat. 2016;123:68–77.