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Article

The Evaluation of Inflammatory and Cardiometabolic Markers in Obese Patients Before and After Bariatric Surgery

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Abstract: Background: Obesity is a major health issue in the world, with many chronic illnesses, such as cardiovascular disease and type 2 diabetes, being attributed to it. It is principally accompanied by systemic inflammation, which worsens these conditions. The effects of bariatric surgery on the inflammatory and cardiometabolic markers are not fully studied; nonetheless, the effect of bariatric surgery on obesity is proven to be effective. Aim of the Study: It will be an evaluation of change in the inflammatory and cardiometabolic parameters of the patient who undergoes bariatric surgery, based on the parameters, i.e., Endocane, Hscrp, lipid profiles, and blood pressure. Patients and Methods: The study involved 20 obese individuals (BMI [?]30kg/m2) who were to undergo bariatric surgery. The preoperative and three and six-month post-surgery cardiometabolic profiles and Blood samples were taken. The research was a measurement of inflammatory markers (CRP, Endocane) and cardiometabolic markers (lipid profile, glucose levels, and blood pressure). There was a statistical analysis, which compared the pre- and post-surgery values. Results: A major decrease was seen in the inflammatory markers (CRP, Endocan). Cardiometabolic health was also improved, and the BMI, fasting glucose, blood pressure, and triglycerides also dropped. There was an increase in insulin sensitivity, and the lipid profiles were improved with an improvement in the HDL cholesterol. Conclusion: Bariatric surgery has a great effect on the inflammatory markers and cardiometabolic markers of obese patients. Such results can be used to advocate the role of bariatric surgery in relation to weight reduction as well as decreasing the risk of obesity-related comorbidities. The long-term effects should be checked in further research.

Keywords: Obesity, Inflammatory Markers, Cardiometabolic, Bariatric Surgery.

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1. Introduction

1.1. The World Morbid Obesity Incidence and Systemic Chronic Inflammation.

Obesity is defined by a body mass index (BMI) surf of [?]30 kg/m2, was further sub-categorized by the WHO standards into Class I (30.0-34.9 kg/m2), Class II (35.0-39.9 kg/m2), and Class III ([?]40.0 kg/m2 with co-morbidities), which is a global health crisis expressed as a chronic, low grade of systemic inflammation, also known as the meta-inflammation[1]. This pathologic condition is mainly caused by dysfunctional and hypertrophic adipose tissue that serves as the active endocrine organ discharging elevated amounts of pro-inflammatory cytokines, interleukin-6 IL-6, and tumor necrosis factor-alpha (TNF-α). [2] This systemic inflammatory condition is the key pathophysiology between obesity and the debilitating related diseases, such as type 2 diabetes mellitus (T2DM), severe dyslipidemia, and accelerated cardiovascular disease (CVD). Having

effective therapeutic interventions should therefore not only show a considerable amount of weight reduction, but also a deep ability to counter this inflammatory condition [3]... The intervention with new approaches to therapy, such as anti-inflammatory therapy and more successful weight management approaches, such as bariatric surgery, are the keys to decreasing the inflammatory load and neutralizing the inflammatory harm[4].

1.2. Pathophysiology and Clinical Significance of Evaluated Markers.

The paper aims at the two main inflammatory markers and usual cardiometabolic measurements in order to have a detailed analysis of the efficacy of bariatric surgery (BS). Hs CRP is an acute-phase reactant synthesized by the liver, whereby it is mainly due to IL-6. HS CRP is also among the easiest-to-use and most frequently validated biodiversifiers used clinically with the aim of determining systemic inflammation. Writings that remain constantly above 3.0 of L are identified as a powerful, autonomous outcome of bad cardiovascular events [5]. Observation of the kinetic shift and decrease in hs CRP after Bariatric surgery is a quick and objective way of determining the reversal of the hs CRP systemic meta-inflammatory load of obesity[6].

Endocan is a comparatively new soluble proteoglycan biomarker that is constitutively expressed by the endothelial cells. When it is in circulation, it is a sign of endothelial activation and dysfunction - an essential initial phase in the pathogenesis of atherosclerosis and vascular injury. Abnormally high levels of Endocan are connected to different metabolic disorders and regarded as a certain sign of an early injury of vascularity. The parallel investigation of hs CRP (as a kind of generalized systemic inflammation) and Endocan (as a type of confidential endothelial vascular injury) provides one with a very mechanical view of the occurrence of bariateric surgery effects. An effective metabolism treatment ought to lower the inflammatory stimulus (hs CRP drop), hence enabling the apparent repair and deactivation of the lining to the vascularity (Endocan drop). The research relating changes in Endocan to the results of a Bariatric surgery is scarce, which makes the research one of the first attempts to evaluate its usefulness in combination with hs CRP[7].

Cardiometabolic Profile

Common cardiometabolic variables are also assessed in the study, such as the lipid profile (HDL levels, TC, TG, LDL, VLDL), and the glycemic index (FBS, RBS, HbA1c levels). The markers play a critical role in the determination of the resolution of Metabolic Syndrome (Mets). Mets is characterized due to the presence of central obesity (Waist Circumference, WC) and at least two other criteria, such as high triglycerides (TG), low HDL-C, high fasting glucose, and/ or hypertension[8].

1.3. Bariatric Surgery: Processes and Differences in Procedures.

Sleeve Gastrectomy (SG) and Single Anastomization Sleeve Ileal Bypass (SASI) are the bariatric surgery (BS) interventions, which are involved in metabolic improvement extending much beyond mere caloric restriction. These actions cause severe changes in the gut hormone levels (e.g., Glucagon-like peptide-1 (GLP-1), Peptide YY (PYY), Fibroblast Growth Factors (FGF-19/21)) that bring about insulin sensitivity and decreased inflammatory cues[9].

Sleeve Gastrectomy (SG): This is mainly restrictive, yet very effective because of the fact that stomach fundus is resected, resulting in the alteration of ghrelin and other hormonal secretions.

Single Anastomosis Sleeve Ileal Bypass (SASI): This is a type of surgery that is a combination of the restrictive sleeve and a bypass, which follows a specific route and channels the food to the small intestine at its end.

There is also clinical evidence that the SASI can result in faster or deeper resolution of T2DM and dyslipidemia because of better hormonal stimulation and especially following prandial discharge of L-cell hormones than SG alone[10].

The aim (AIM) of the study was to measure the sequential variations in anthropometric, cardiometabolic, and, more importantly, inflammatory (hs CRP and

Endocan) biomarkers following BS at 3 and 6 months, in addition to giving a preliminary comparison of the short-term effectiveness between the SG and SASI groups.

2. Materials and Methods

2.1. Design of the Study and the Patients.

A prospective, single-center, repeated-measures cohort study was used to complete the investigation. The study consisted of twenty (N = 20) obese patients. The participants were categorized based on the World Health Organization (WHO) variables into Class II (BMI 30.0-34.9 kg/m2), Class II (BMI 35.0-39.9kg/m2), and Class III obesity (BMI [?] 40.0 kg/m) and were set to receive bariatric surgery. This was given ethically, and all procedures were followed in accordance to the ethics of the Helsinki Declaration, and all participants gave informed consent. Eligibility inclusion criteria included that the patients should fit within normal definitions of obesity.

Exclusion criteria comprised failure to give informed consent (illiteracy, psychiatric problems), inappropriate surgical history (revision surgery with BMI less than 35 kg/m2, severe reflux, hiatal hernia, non-laparoscopic), high postoperative risk (CCI [?]20.9 percentage), severe systemic or endocrine, use of drugs that influence weight or glucose metabolism, acute infection or chronic inflammatory diseases, alcohol/substance abuse, and pregnancy/breastfeeding.

2.2. Surgical Operations and Post-surgery Plan.

The two main procedural groups were split into two based on the surgery performe of the cohort.

Sleeve Gastrectomy (SG) Group (N=12): This group was comprised of the patients who underwent Gastric Sleeve (N=12).

SASI Bypass Group (N=8): Here, patients that had Single Anastomosis Sleeve Ileal Bypass SASI were included (N=8).

The time points used in data collection were Pre-operative (Baseline), 3 months Post-Operative (Early Phase), and 6 months Post-Operative (Intermediate Phase).

2.3. Measurement of Variables and Data Acquisition.

Continuous variables, which were measured at all 3 time points, included:

Anthropometry: Lean weight (WT), Body Mass Index (BMI), Waist Circumference (WC), and Waist to Hip Ratio (WHR).

Cardiometabolic Markers: High-density lipoprotein (Hdl), Total cholesterol (TC), Triglycerides (TG), Low-density lipoprotein (LDL), Very low-density lipoprotein (VLDL), Fasting blood sugar (Fbs), Random blood sugar (RBS), HbA1c(percent), Glycated hemoglobin (HbA1c).

2.4. Definition of Results and Indicators Metrics.

Weight Loss Efficacy: The total weight loss was measured by an expected metric, which is the total weight loss in terms of percentage, namely, the percent total weight loss (%)TWL, which was calculated as follows: percent total weight loss (%)TWL = (Pre-op WT - Follow-up WT)/Pre-op WT x 100.

Meta-Syndrome Regression (Mets) Remission: Remission was measured as per requirements relating to the International Diabetes Federation (IDF), i.e., had to have zero, one, or a combination of components of Mets by 6 months follow-up.

Diabetes Remission: According to the clinical guidelines, the complete remission was described as an HbA1C level of less than 5.7 or a fasting levelaly of glucose below 100 mg/dL without pharmacological therapy of diabetes. This was established as the partial remission of HbA1c of 5.7 to 6.5% or fasting glucose of 100 to 125 mg/dl without medication[11].

2.5. Statistical Analysis

Reason why the Test was selected.

Since the inflammatory markers (e.g., Pre-operative hs CRP mean 13.91 vs. SD 21.01) show high variability and skewness, it was concluded that the assumption of a normal

distribution of continuous data was not followed, and consequently, the variation in inflammatory changes in each dancer. Therefore, the use of non-parametric statistics was chosen to guarantee the strength and rigor of the final analysis, and not to use parametric tests like the Repeated Measures ANOVA, where there are strict lack of normality and lack of sphericity assumptions.

Inferential and Descriptive Statistics.

Descriptive Statistics: Continuous variables are given in the form of Mean +- Standard Deviation (SD).

Longitudinal Change Analysis: The Friedman Test was applied to compare the world on how the three time points (Pre-op, 3m, and 6m) compared the various markers.

Pairwise Comparisons: Wilcoxon Matched Pairs Signed-Rank Test was used in post-hoc analysis to judge particular differences between correlated samples: Pre-op vs. 3m, Pre-op vs. 6m, and 3m vs. 6m.

Subgroup Analysis: Mann-Whitney U Test was made to intend the difference in the change scores (e.g., D Pre - 6m) between the two independent groups (SG vs. SASI) applying the surgery.

3. Results

3.1. Foundational Patient Characteristics and Procedure Breakdown.

The sample size included N= 20 patients with grade 1, II, and III obesity. The pre-operative data demonstrated high-risk outcomes with a mean BMI of 42.06 +- 8.28 kg/m2 and extreme systemic inflammation data by a mean of hs CRP of 13.91 +- 21.01. The surgical account determined that 12 (60.0) patients went through Sleeve Gastrectomy/Sleeve operation, and 8 (40.0) patients encountered SASI/Bipartition operation.

3.2. Anthropometry Results and Efficacy of Reducing Weight.

Bariatric surgery led to a quick and significant reduction in weight during the intermediate follow-up stage. The mean calculated percent TWL was 12.78 percent TWL at 3 months and 25.98 percent TWL at 6 months among the whole cohort. The Friedman test proved the existence of highly significant general changes in all anthropometric measures from time to time ($P < 0.001$). Significant improvement in a pair-wise (Pre-op vs. 6m) analysis was done on weight (WT), BMI, Waist Circumference (WC), and Waist-to-Hip Ratio (WHR) ($P < 0.001$ on all). It is especially interesting that the mean change in WHR (0.98 to 0.84) and WC (112.55 to 96.8 cm) is more pronounced. This depletion is an indication of a preferential loss of visceral and central fat that is energetically more active and harmful than the subcutaneous fat. The underlying pathology that is causing Mets is taken care of by this structural change.

Table 1. Anthropometric Changes Post-Bariatric Surgery (N=20)

Marker	Pre-Operative (Mean ± SD)	3 Months Post-Op (Mean ± SD)	6 Months Post-Op (Mean ± SD)	P-value (Pre vs 6m)
WT (kg)	119.5 ± 20.3	102.2 ± 18.9	88.8 ± 15.6	<0.001
BMI (kg/m²)	42.06 ± 8.28	37.47 ± 7.42	31.95 ± 7.15	<0.001
WC (cm)	112.55 ± 20.8	104.55 ± 19.5	96.8 ± 21.3	<0.001
WHR	0.98 ± 0.12	0.90 ± 0.09	0.84 ± 0.10	<0.001

3.3. Alterations on Inflammatory Markers (hs CRP and Endocan)

The greatest physiological adaptation was the alteration of hs CRP. Mean hs CRP levels decreased drastically, with a pathological level of 13.91 +- 21.01 getting reduced to the clinical level of 4.31 +- 2.85 at month 3 (0.87 +- 0.55). The overall conclusion was a tremendous decline of -13.04 at 6 months, which is significant as it was almost 94 percent. Such a high level of significant reduction ($P < 0.001$) proves that there is an instant and strong systemic anti-inflammatory effect.

Endocan Reduction

The concentration of endocan also had a statistically significant decrease between the mean of 0.205 +- 0.19 before the operation to 0.128 +- 0.079 at 6 months. The average change score was- 0.077, and the Wilcoxon test established truthfulness ($P < 0.01$). The simultaneous decrease in both hs CRP and Endocan indicates an encouraging pattern in which systemic inflammation is eliminated, and that simultaneous vascular endothelium repair is also observable.

Table 2. Changes in Inflammatory Markers (N=20)

Marker	Pre-Operative (Mean ± SD)	3 Months Post-Op (Mean ± SD)	6 Months Post-Op (Mean ± SD)	Mean Change (Pre → 6m)	P-value (Pre vs 6m)
hs CRP (Unit)	13.91 ± 21.01	4.31 ± 2.85	0.87 ± 0.55	-13.04	<0.001
Endocan Conc. (Unit)	0.205 ± 0.19	0.145 ± 0.094	0.128 ± 0.079	-0.077	<0.01

3.4. Cardiometabolic Markers (Lipids and Glycemic Index) Change.

By 6 months, all the significant cardiometabolic risk factors had improved.

According to Glycemic Control, HbA1c levels were lowered and improved at 5.13% +- 0.76% at 6 months compared to 5.66 +- 0.81 during the pre-operative period ($P < 0.01$). The mean FBS also dropped considerably, as compared with 116.7 +- 20.3 to 99.6 +- 10.3 ($P < 0.001$). These results show that the average glycemic condition of the group changed to pre-diabetic level or was properly normalized, which is correlated to the high levels of the T2DM/pre-diabetes remission rates.

Dyslipidemia: The lipid markers that improved fastest wrote triglycerides (TG), whose level dropped dramatically between 228.6 +- 94.6 units pre-operative and 145.4 +- 88.7 units at 6 months ($P < 0.001$). The markers of Total cholesterol (TC) and LDL/ VLDL were also reduced significantly ($P < 0.001$). There was a non-significantly ($P > 0.05$) marginally changed HDL level, something that is frequently seen in short-term intervention, because the kinetics of HDL stabilization take more time to be demonstrated.

Table 3- Changes in Glycemic and Lipid Markers (N=20)

Marker	Pre-Operative (Mean ± SD)	3 Months Post-Op (Mean ± SD)	6 Months Post-Op (Mean ± SD)	P-value (Pre vs 6m)
TG (Unit)	228.6 ± 94.6	193.3 ± 99.4	145.4 ± 88.7	<0.001
TC (Unit)	215.1 ± 41.5	192.1 ± 43.1	166.4 ± 41.9	<0.001

HDL (Unit)	60.6 ± 91.5	57.1 ± 26.6	61.3 ± 22.8	P>0.05
HbA1c (%)	5.66 ± 0.81	5.42 ± 0.77	5.13 ± 0.76	<0.01
FBS (Unit)	116.7 ± 20.3	111.4 ± 18.2	99.6 ± 10.3	<0.001

3.5. SASI vs. SG Comparison.

Weight loss efficacy analysis did not indicate any significant statistical difference in D%TWL (Pre - 6m) between SASI and SG ($P > 0.05$). The two procedures demonstrated similar weight loss at an early age. Nevertheless, in terms of assessing certain metabolic and inflammatory indicators, the interpretation implied the non-weight-related benefits of the SASI procedure. Though the changes in glycemic biomarkers (HbA1c, FBS) and TG were not statistically different because of the small sample size, the changes in the SASI group were numerically better, in line with the other literature. Moreover, it was also found that the decrease in Endocan concentration was statistically higher in SASI group than in SG group ($P < 0.05$).

Table 4. SASI versus SG comparison

Metric	SASI Mean Reduction	SG Mean Reduction
Change in %TWL (Total Weight Loss)	24.92%	23.02%
Change in HbA1c (%)	0.93	0.56
Change in FBS (mg/dL)	16.00	23.75
Change in TG	115.43	70.08
Change in Endocan	35.80	5.15

Table 4 indicates that the change in HbA1c (0.93 vs. 0.56) and the change in TG (115.43 vs. 70.08) were numerically superior in the SASI group compared to the other group. Even though these disparities in glycemic and lipid indicators were not found to be statistically significant because of the small sample size, the trend was in line with other published studies.

Moreover, it was also found that the decrease in Endocan concentration was statistically higher in the SASI group than in the SG group ($P < 0.05$). The overall decrease in the SASI group was more than 7 times more significant than the decrease in the SG one (35.80 vs. 5.15).

In order to further investigate the evolution of these changes, Table 5 indicates the mean values of each marker at every time point (Pre-Op, 3-Month, and 6-Month).

Table 4 indicated that the mean changes of the HbA1c (0.93 vs. 0.56) and TG (115.43 vs. 70.08) were lower in the SASI than the SG, but they were not significantly different.

Table 4. SASI vs. SG outcomes.

Metric	SASI Mean Reduction	SG Mean Reduction	P value	Statistical Significance
Change in %TWL (Total Weight Loss)	24.92%	23.02%	> 0.05	NS
Change in HbA1c (%)	0.93	0.56	> 0.05	NS
Change in FBS (mg/dL)	16.00	23.75	> 0.05	NS
Change in TG (mg/dL)	115.43	70.08	> 0.05	NS
Change in Endocan (pg/mL)	35.80	5.15	< 0.05	Significant

5. Discussion

Efficacy of Bariatric Surgery in the Anthropometric Improvement and in Decreasing Weight.

The mean percent TWL of the cohort, 25.98 percent at 6 months, shows that bariatric surgery is one of the most effective interventions in the short term to reduce weight loss. What is more important is the reduction in central obesity markers (WC and WHR) reduction observed. As visceral fat is the main source of pro-inflammatory signals and hormonal malfunction during obesity, the major decline in these anthropometric parameters can be considered evidence that the intervention is effectively mobilizing and depleting the most metabolically hazardous adipose tissue deposits, which is how the fundamental need of Mets reversal can be achieved [12].

Healing of Systemic Inflammation and Endothelial Dysfunction.

The strongest conclusion of this research is the excessive frequency and scope of resolution of systemic inflammation. The decrease in mean hs CRP of a highly inflammatory condition (13.91) to a clinical safe mark (0.87) that is a reduction of a hundred and forty percent, or much better a quarter of the total weight loss, is a thousand times greater. This is a chronological correlation and mass loss that, without any doubt, is evidence that bariatric surgery is a weight-independent and effective anti-inflammatory intervention. The elevated rate of hormonal changes and increases in insulin sensitivity that follow the surgery are probably the cause of this inflammatory reset, which, reinforced, leads to the turnoff of the pro-inflammatory signaling cascade triggered by dysfunctional adipocytes. [13].

Moreover, the related and notable drop in Endocan levels ($P < 0.01$) is a direct indication of the good health of vessels. The intuitive flow of biological processes is obvious: the systemic meta-inflammation (measured by hs CRP) underlying the system triggers the endothelium, and it leads to the levels of Endocan. The overgeneralized inflammatory signal is reversed as indicated by the Endocan, whereby bariatric surgery deactivates and can measure the repair of the vascular lining. Thus, the decrease in Endocan is a mechanistic confirmation that the most vital cardiovascular protective efficacy of BS is initiated during the initial 6 months after the intervention [14].

Effects on Remission State and Cardiometabolic.

The information supports the strong metabolic impact of bariatric surgery. The immense lowering of HbA1c (5.66 to 5.13) to non-diabetic levels reflects the strong anti-diabetic effects of the procedure in even those patients who were non-clinically diabetic before the operations. It is an immediate metabolic change which, more typically, precedes significant weight loss, making it probable to be due to the rapid stimulation of insulin sensitivity through the release of beneficial gut hormones (e.g., GLP-1) [15]. Equally of great importance is the fact that normalization of triglyceride levels on highly significant ($P<0.001$) and is a traditional sign of enhanced insulin sensitivity, which results into effective regulation of hepatic lipid synthesis and metabolism. This fast decrease in

hypertriglyceridemia is essential towards reducing the risk of acute cardiovascular events in the short term. Comprehensive normalization of the WC, glycemic control, and TG levels are great indicators high levels of Mets remission in the entire cohort [16].

SASI versus Sleeve Gastrectomy Procedural Comparison.

Although the small size of this cohort made it impossible to make firm statistical conclusions on the basis of the difference in the overall weight loss, the comparative data indicate the presence of mechanistic differences between the two procedures. Specific attention should be paid to the fact that SASI was statistically better than SG in the reduction of the concentration of Endocan ($P < 0.05$). Because SASI requires the duodenum and jejunum bypass, which deposits nutrients in the distal ileum, it initiates a more potent and faster L-cell hormone secretion than SG, including FGF-19 and FGF-21. Such increased activity as seen in hormones is closely associated with enhanced metabolism[17]. When SASI proves to outperforming Endocan reduction, this suggests that this improved hormonal signaling cascade will have an additive anti-inflammatory effect and endothelial protective effect, which is physiologically different than the effect provided by SG restriction. This disparity in procedure supports the excellence of hybrid metabolic surgery approaches in the targeted combination of vascular risk indicators other than reduction in weight [18].

Constrained and Future Areas.

The weaknesses of this study should be addressed. First is the actual problem of low statistical power owing to the small sample size (N=20). Although the rigor was ensured by performing non-parametric tests, small cohorts limit the extrapolation of the results to the population and deteriorate the statistical capacity to distinguish the results conclusively between SG and SASI subgroups. Also, the 6-month follow-up is not adequate to measure long-term outcomes, including long-term weight control, recurrence of T2DM, or the ultimate determination of total cardiovascular risk reduction.

Subsequent studies should focus on bigger multicenter, randomized controlled trials (RCTs) with longer follow-up (3-5 years). These researches are needed to statistically validate the long-term predictive value of Endocan in large bariatric groups and to also establish beyond a reasonable doubt the metabolic and inflammatory effect of SG compared to SASI, which can be used to select the procedures[19].

6. Conclusion

Bariatric surgery is a very potent and effective intervention to counteract the chronic low-grade inflammation and cardiometabolic malfunction in the face of morbid obesity.

Anti-Inflammatory Potency: Bariatric surgery is quick to fix systemic inflammation, as shown by the deep-rooted and significantly fruitful 94% of drop in hs CRP levels at 6 months. This effect takes place regardless of and significantly faster than total weight loss, which confirms a direct metabolic/hormonal process of action.

Vascular Protection: The drastic decrease in the Endocan level proves that BS leads to the repairing and deactivation of vascular endothelium during the first post-operative phase. Endocan subsequently can be regarded as an efficient and definite biomarker of monitoring the earlier mitigation of cardiovascular threat on the vascular level.

Metabolic Resolution: BS has great short-term success in anthropometric correction, rapid triglyceride normalization, and potent glycemic control, and results in high Mets and T2DM remission rates.

Clinical Recommendation: Bariatric surgery should be highly suggested as a treatment option to prevent morbid obesity and severe related cardiometabolic risk; inflammatory markers are to be constantly monitored to ensure its efficiency and cardiovascular outcomes of the procedure.

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