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Effect of Weight Loss on Pro-inflammatory Cytokines Post Sleeve Gastrectomy among Obese Children and Adolescents

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Abstract

Introduction: Low-grade inflammation is a common occurrence in obesity, type 2 diabetes mellitus (T2DM) and cardiovascular disease (CVD). In obesity, increased levels of interleukins and other inflammatory cytokines in the circulation may partly reflect a spillover from the adipose tissue.

Methodology: A prospective study was carried out to assess the levels of pro-inflammatory factors (TNF-α, IL-1β, and IL-6), dietary intake, fasting blood glucose and lipid profile before and 6 months after sleeve gastrectomy (SG), among 21 morbidly obese children and adolescents aged ≤ 18 years.

Results: Subjects achieved significant decrease in all anthropometric measurements and sleep apnea 6 months after SG. A significant increase in high density lipoprotein (HDL) and a significant decrease in fasting glucose (FG) levels and IL-1β levels was observed 6 months post-surgery ($p \leq 0.05$). The reductions in body mass index (BMI), hip circumference and triglyceride (TG) levels significantly correlated with IL-6 concentrations and the reduction in hip circumference and mid arm circumference correlated significantly with IL-1β levels post-surgery. Linear regression showed the role of BMI and energy intake to predict the decreased level of IL-1β after surgery.

Conclusion: Sleeve gastrectomy represents a safe method for downregulating the inflammatory state that could lead to CVD and insulin resistance (IR) in obese children and adolescents. The significant decrease in IL-1β, increase in HDL and resolution of sleep apnea after SG can reduce CVD risk factors among morbidly obese children and adolescent, whereas the significant decrease in FG can reduce IR risk factors.

Keywords: *Inflammation; Sleeve Gastrectomy; Cytokines; Obesity*

Introduction

There has been a growing concern about obesity worldwide. Childhood obesity is already an epidemic of the 21st century in some areas and on the rise in others [1]. Currently, more than 1 billion adults worldwide are overweight, at least 300 million are clinically obese, and nearly 43 million children younger than 5y were overweight in 2010 [2]. Childhood obesity affects all countries of all socioeconomic groups irrespective of age, sex, or ethnicity and these children become susceptible to the development of chronic diseases such as type II diabetes and cardiovascular disease [3-5].

In most obese patients, obesity is associated with low-grade inflammation of white adipose tissue (WAT) resulting from chronic activation of the innate immune system which can subsequently lead to insulin resistance (IR), impaired glucose tolerance and even diabetes. WAT is the physiological site of energy storage as lipids. In obesity, WAT is characterized by an increased production and secretion of a wide range of inflammatory molecules including TNF-α and interleukin-6 (IL-6), which may not only have local effects on WAT physiology but also systemic effects on other organs. Recent data indicates that obese WAT is infiltrated by macrophages, which may be a major source of locally-produced pro- inflammatory cytokines. Adipocytes release many factors (e.g. Leptin, TNF-α, and IL-6) that have a role in complement activation and inflammatory cytokine production [6]. In addition, the infiltrated macrophages probably contribute to the pathogenesis of IR. Most of them are overproduced during obesity [7].

In obesity, increased levels of interleukins and other inflammatory cytokines in circulation may partly reflect a spillover from the adipose tissue (AT) [8] which is infiltrated by macrophages and other inflammatory cells in morbid obesity, and secretes numerous soluble mediators, including adipocytokines such as adiponectin, Leptin and many cytokines such as TNF-α, IL-6 and IL-1 family [9]. Several studies showed raised plasma levels of inflammatory cytokines (TNF- α, IL-6 and IL-1β) in heart failure patients [10] as well as in IR and T2DM patients [11].

Weight loss is known to reduce low-grade inflammation in both AT [12] and plasma [13]. Obese children and adolescents have been found to have multiple risk factors associated with metabolic syndrome [14] which is defined as a group of CVD risk factors that include abdominal obesity, diabetes and raised FG concentrations, dyslipidemia, hypertension [3,15,16] and sleep disordered breathing [17]. This syndrome develops in childhood and is prevalent among overweight children and adolescents [18-22]. It has been hypothesized that chronic low- grade inflammation associated with obesity, including childhood obesity [23] may explain the development of the obesity-related pathologies, such as type 2 DM and CVD [24,25]. Moreover, these inflammatory factors might play an important role in the development of IR that triggers related co- morbidities of metabolic syndrome [26-29].

Weight reduction in obese persons of any age decreases obesity-related medical complications and increases physical function and quality of life [30]. The current therapeutic tools used for weight control are pharmacotherapy, lifestyle and surgical interventions. Historically, there has been little success in anti-obesity drug development mainly because of low efficiency and undesirable side effects [31]. Although surgical weight-loss procedures are on the rise, the occurrence of nutritional deficiencies of micronutrients and macronutrients arising from these surgeries has been recognized for decades, but the prevalence and severity depends on the type of surgery without clear explanation of the underlying mechanism [32]. SG is one of the surgical techniques that aims to treat morbid obesity by both restrictive and probably hormonal action [33]. It is shown to be as safe and effective in pediatric cases as in adult cases [34]. This study is the first to demonstrate the beneficial effects of weight loss post SG on the level of the pro-inflammatory cytokines post SG among morbidly obese children and adolescents, in addition to the assessment of the effect of these cytokines on the dietary intake.

Materials and Methods

Study design

The study is a prospective study, in which blood biochemical analysis, including pro-inflammatory cytokines, anthropometric and dietary intake measurements were carried out at baseline and 6 months after SG.

Subjects and study setting

Morbidly obese children and adolescents, with a BMI percentile for age ≥ 95^{th}% (CDC Growth Charts) [35] aged≤ 18 y/o undergoing SG between 30 May 2009 to 30 November 2010 were included in the study. All subjects attended the obesity clinic at King Saud University (KKUH), Riyadh, Kingdom of Saudi Arabia.

The exclusion criteria for the subjects was the presence of diabetes, hypertension, history of cardiac, kidney or liver disease, use of medications known to effect body weight (such as steroids), a weight loss of ≥ 5 Kg in last two months prior to undergoing SG, use of anorectic agents in the prior 6 months, psychiatric conditions and depression and a history of smoking.

Questionnaires

A previously published Pre-coded structured questionnaire [36], which was modified and validated then distributed prior to surgery and 6 months post operatively. It was divided into 3 main parts: family history, socio-demographic data and dietary habits which included a 3-days dietary recall and a 7-days food frequency questionnaire. Patients were interviewed separately along with their parents and all the 3 parts of questionnaire were filled. Before surgery and during the subjects' follow up session blood samples were taken (0.5 ml for our study) by a trained nurse.

Nutrient intake was calculated using The Food Processor (Nutrition and Fitness Software 2010 - 2011), with data obtained from Nutrient Contents of Traditional Foods [37].

The Food frequency questionnaire was used to assess the qualitative and the quantitative aspects of the food consumed by the participants over a period of 7 day which included the five major food groups, in addition to the beverages and the consumption of the junk food since it poses the greatest risk to health and wellbeing [38].

Anthropometric measurements

The weight was recorded to the nearest 0.2 Kg using appropriate international standard scale (Digital Person Scale, ADAM Equipment Inc., USA) without shoes and with light clothing. The height was recorded to the nearest 0.5 cm using the same scale (Digital Person Scale) while standing without shoes, facing front against the scale. BMI is a measure of body fatness. It was calculated by the equation: BMI = Weight/(Height in meters). The participants were classified as morbidly obese according to their BMI for age 2 - 20 years, according to the CDC Growth Reference [35].

Fat distribution was assessed using waist-hip ratio (WHR), which is the relation between waist circumference at the narrowest level between the lowest rib and the umbilicus [39] and the circumference of the hip at the largest level between the waist and the knees. Waist and hip circumferences were measured by non-stretchable tape measure, subject in the standing position with light clothing (social reason) and recorded to the nearest 0.1 cm.

Biochemical assessment

Blood was withdrawn after an overnight fast and collected into 10-ml vacutainers (Vacutainer, Franklin Lakes, NJ). Tubes were centrifuged at 800 x g for 10 min at 4°C and the serum was transferred into polystyrene tubes and stored at -80°C until required. The time from collection until centrifugation did not exceed 2 hr. Fasting serum glucose and lipid profile were measured using routine laboratory procedures (Konelab, Finland). Inflammatory mediators including TNF-α, IL-1β and IL-6 have been measured using a MILLIPLEX MAP kit (Human Serum Adipokine, Panel B, HADK2–61K-B09 multiplex assay kit).

All biochemical measurements were taken before and 6 months after undergoing the SG in King Khalid University Hospital Laboratory, Riyadh and in the Central Lab of King Saud University.

Statistical analysis

Data was analyzed using Status Package for Social Sciences 18 (SPSS) to provide frequency tabulation for categorical variables and calculations with mean ± standard deviations (SD) for continuous variables. The analyses was done through: descriptive statistics as valid percent for categorical variable and as mean ± SD for continuous variables, estimation of population differences by using inference from the sample, using 95% confidence intervals. Paired t-test was used to test significance, Pearson correlation coefficient was used to determine the relationship between variables, linear regression analysis was used to identify the independent predictors and dependent variables, and the differences and correlations were considered to be statistically significant at $p < 0.05$.

Results

Twenty one morbidly obese patients underwent SG during the period of the study. And the results showed the followings.

Anthropometric measurements

There was a significant reduction in BMI ($p \leq 0.05$) among the subjects six months post-surgery. The mean BMI of subjects before surgery was 50.7 compared to 37 six months after SG. There were only 28.6% of subjects had BMI percentile for age ≥ 95% 6 months after surgery. Asignificant reduction was observed in all other anthropometric measurements (Waist Circumference, Hip Circumference, WHR, Midarm Circumference, and Thigh Circumference) six months post-surgery (Table 1).

Parameter (unit)	**Pre Surgery n = 21**	**Post Surgery n = 21**	**P value**
	M ± SD	**M ± SD**	
Body weight (kg)	129.40 ± 34	95.77 ± 24.28	0.000[a]
BMI (kg/m^2)	50.7 ± 11.95	37 ± 8.4	0.000[a]
WC (cm)	129 ± 23.8	96.5 ± 13.7	0.000[a]
Hip circumference (cm)	142 ± 18.9	118 ± 19.6	0.000[a]
WHR	0.91 ± 0.1	0.83 ± 0.1	0.000[a]
MAC (cm)	42.14 ± 5.6	34.43 ± 4.3	0.000[a]
Thigh circumference (cm)	74.8 ± 10.9	56.5 ± 10.4	0.000[a]
% EWL		48 ± 17.5	0.000[a]
% EBL		51.7 ± 16.5	0.000[a]

Table 1: *Comparison between anthropometric measurements of the subjects at baseline and 6 months after SG.*
Data are presented in mean (M), and standard deviation (± SD). The M values were compared using paired T-test. EWL (excess weight loss). EBL (excess BMI loss).
[a]: $P \leq 0.05$ is considered statistically significant.

Fasting blood glucose and lipid profiles

A significant reduction in FG levels and a significant increase ($p \leq 0.01$) in the level of HDL-cholesterol was observed six months post-surgery, whereas no significant difference ($p = 0.912$) was observed in low density lipoprotein (LDL- cholesterol) and total cholesterol levels between pre and post-surgery. A trend in TG level reduction was observed at the end of the study, but was not statistically significant (Table 2).

Parameter (unit)	Pre Surgery n = 21	Post Surgery n = 21	P value
	M ± SD	M ± SD	
Fasting glucose (mmol/L)	5.05 ± 0.6	4.47 ± 0.4	0.002[a]
Total cholesterol (mmol/L)	4.19 ± 0.8	4.20 ± 0.7	0.930
Triglycerides (mmol/L)	1.03 ± 0.4	0.89 ± 0.3	0.190
HDL-cholesterol (mmol/L))	1.08 ± 0.2	1.22 ± 0.2	0.002[a]
LDL-cholesterol (mmol/L)	2.59 ± 0.7	2.60 ± 0.6	0.912

Table 2: *Comparison between fasting blood glucose levels and serum lipid profile pre surgery and six months after SG.*
Data are presented in mean (M), and standard deviation (± SD). The M values were compared using paired T-test. EWL: Excess Weight Loss; EBL: Excess BMI Loss.
[a]: P ≤ 0.05 is considered statistically significant.

Dietary intake

There was a significant decrease in energy, water and other nutrient consumption after SG compared to baseline. The average energy intake pre-surgery was 4869.20 kcal/day as compared to only 793.04 kcal/day 6 months post-surgery. The main source of total calories was from carbohydrates (56.65% before surgery and 55.81% post-surgery). Consumption of fats remained almost the same with about 26% of total calories from fat sources pre and post-surgery. Protein sources made up 12.6% of total calories pre-surgery and 13.5% post-surgery (Table 3).

Parameter (unit)	Pre Surgery n = 21	Post Surgery n = 21	% of reduction	P value
	M ± SD	M ± SD		
Weight (gm)	3694.90 ± 950.5	774.27 ± 150.3	79.04	0.000[a]
Waterb (gm)	1675.00 ± 531.1	471.45 ± 185.9	71.85	0.000[a]
Energy (kcal)	4869.20 ± 1126.4	793.04 ± 132.2	83.71	0.000[a]
Fat (gm)	153.28 ± 44.1	25.20 ± 8.1	83.56	0.000[a]
Protein (gm)	161.43 ± 33.7	28.36 ± 5.1	82.43	0.000[a]
Carbohydrate (gm)	724.61 ± 177.4	115.35 ± 19.3	84.08	0.000[a]
Fiber (gm)	37.98 ± 13.7	6.38 ± 1.9	83.20	0.000[a]
Sodium (mg)	6288.50 ± 2073.8	1068.70 ± 270.1	83.01	0.000[a]
Potassium (mg)	3910.80 ± 1126.5	725.36 ± 346.1	81.45	0.000[a]
Calcium (mg)	1713.30 ± 702.2	421.67 ± 148.2	75.39	0.000[a]
Phosphorus (mg)	1998.40 ± 636.5	397.07 ± 146.6	80.13	0.000[a]
Iron (mg)	37.48 ± 13.5	5.12 ± 1.9	86.33	0.000[a]
Retinol (RE)	543.83 ± 540.2	123.69 ± 70.1	77.26	0.002[a]
Carotene (RE)	584.89 ± 506.1	95.00 ± 73.7	83.76	0.000[a]
Thiamine (mg)	3.23 (0.7)	0.47 ± 0.1	85.36	0.000[a]
Riboflavin (mg)	3.36 ± 1.1	0.66 ± 0.2	80.19	0.000[a]
Vitamin C (mg)	118.85 ± 91.8	45.92 ± 41.8	61.36	0.000[a]

Table 3: *Comparison between dietary consumption of the subjects at baseline and six months after SG.*
Data are presented in mean (M), and standard deviation (± SD). The M values were compared using paired T-test. EWL (excess weight loss). EBL (excess BMI loss).
[a]: P ≤ 0.05 is considered statistically significant.
[b]: Water is the water content in foods and juices.

Cytokines levels pre and post SG

After sleeve gastrectomy, a significant decrease in IL-1β levels 6 months post-surgery (P = 0.034) was observed. No effect was seen in the case of TNF-α or IL-6 six months post-surgery (Figure 1-3).

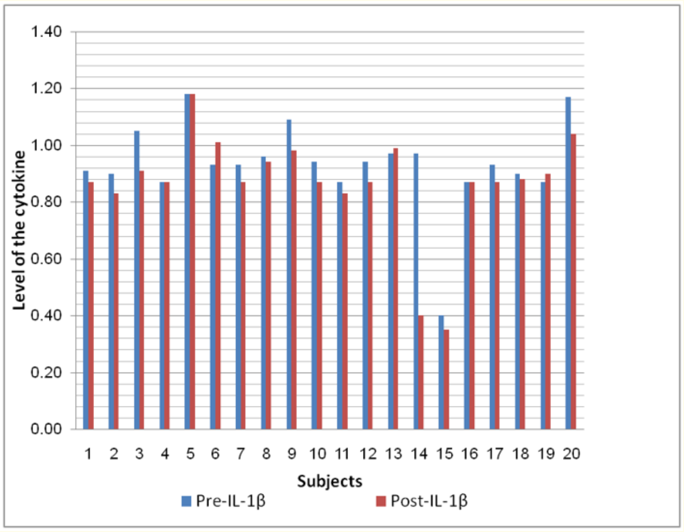

Figure 1: *Levels of IL-1β (pg/ml) of each subject at baseline and six months after the SG. Mean ± SD levels pre and post surgery for IL-1β was 0.93 ± 0.15 and 0.88 ± 0.9 respectively, with a P value of 0.034. P ≤ 0.05 was considered statistically significant.*

Parameter (unit)	IL-1β		IL-6		TNF-α	
	r	P	r	P	r	P
Fasting glucose (mmol/L)	-0.368	0.110	0.429	0.187	-0.189	0.413
Total cholesterol (mmol/L)	0.417	0.067	0.793	0.065	-0.235	0.319

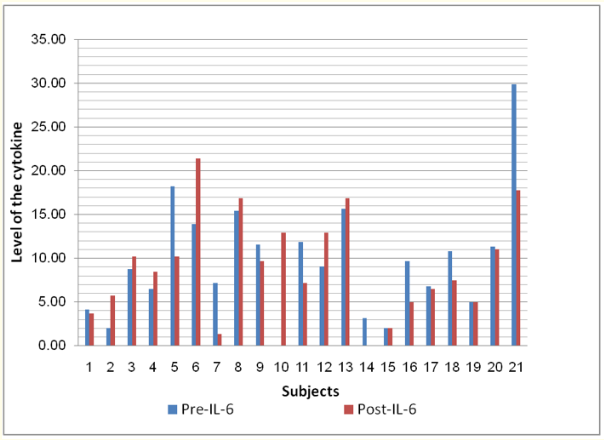

Figure 2: *Levels of IL-6 (pg/ml) of each subject at baseline and six months after the SG. Mean ± SD levels pre and post-surgery for IL-1β was 10.45 ± 6.5 and 9.37 ± 5.6 respectively, with a P value of 0.314. P ≤ 0.05 was considered statistically significant.*

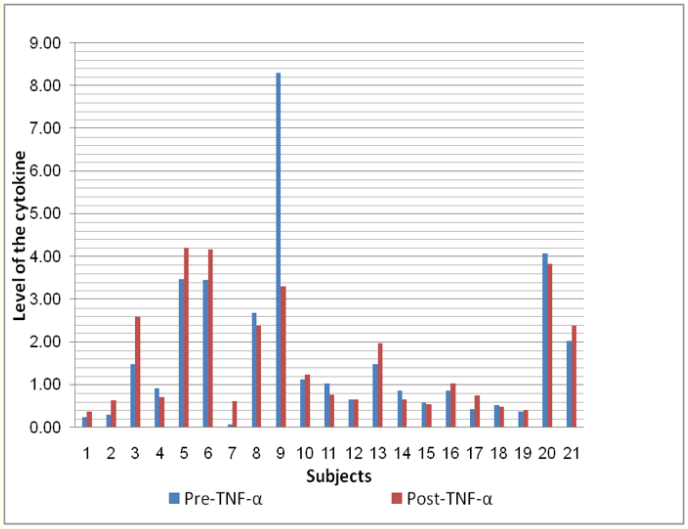

Figure 3: *Levels of TNF-α (pg/ml) of each subject at baseline and six months after the SG. Mean ± SD levels pre and post-surgery for IL-1β was 1.66 ± 1.9 and 1.60 ± 1.3 respectively, with a P value of 0.822. P ≤ 0.05 was considered statistically significant.*

Correlation between daily macro and micronutrient intake and the levels of cytokines (IL-1β, IL-6, and TNF-α) at baseline and six months after the SG

According to Pearson's correlation coefficient, only TNF-α significantly and positively correlated with dietary vitamin C intakes at baseline (P = 0.036, r = 0.46) [thus, baseline results of correlations are not presented for macro and micronutrients]. We found that protein and dietary vitamin C intake significantly correlated with IL-1β levels 6 months post-surgery. Retinol intake positively correlated with IL-6 levels after surgery. Similarly, dietary vitamin C intake pre- and post-surgery positively correlated with TNF-α level (Table 4).

Variables	r	P value
IL-1β		
Protein	0.633	0.003^a
Vitamin C	0.474	0.035^a
IL-6		
Retinol	0.491	0.028^a
TNF-α	0.584	0.005^a
Vitamin C		

Table 4: *Correlation between daily macro and micronutrient intake and the levels of cytokines (IL-1B, IL-6, and TNF-A) six months after the SG.*

(NB: Only parameters which showed significant associations were listed in the table). ^{a}*: P ≤ 0.05 is considered statistically significant.*

Correlation between anthropometric measurement and the levels of cytokines (IL-1β, IL-6, and TNF-α) at baseline and six months after the SG

Using Pearsons Correlation Coefficient, some of the anthropometric values correlated with the levels of the cytokines (IL-1β, IL-6 and TNF-α) either pre or post-surgery. At baseline, TNF-α was the only cytokine to have a positive significant correlation with waist circumference before surgery (P = 0.029, r = 0.477). IL-1β was found to have positive significant correlation with hip and mid arm circumferences (MAC) six months after surgery. BMI and hip circumference significantly correlated with IL-6 levels after surgery (Table 5).

Parameter (unit)	IL-1β		IL-6		TNF-α	
	r	P	r	P	r	P
Triglycerides (mmol/L)	0.234	0.320	0.515	0.024[a]	0.114	0.633
HDL-cholesterol (mmol/L))	0.227	0.380	-0.365	0.164	-0.235	0.364
LDL-cholesterol (mmol/L)	0.458	0.064	0.271	0.310	-0.075	0.773

Table 5: *Correlation between lipids profiles and FG and the levels of cytokines (IL-1B, IL-6, and TNF-A) at six months after the SG.*

[a]: Correlation is significant at p <0.05 level (2-tailed). Correlations have been made using Pearson correlation coefficient.

Correlation between lipids profiles and fasting blood glucose with the levels of cytokines (IL-1β, IL-6, and TNF- α) at baseline and six months after the SG

The correlation between lipid profile and FG with cytokine levels shows that TG levels positively correlated with IL-6 post surgery, otherwise, no significant correlation was found between all parameters at baseline (Table 5).

Linear regression

Linear regression was done using post IL-1β levels, IL-6 and TNF- α as dependent variable, and post BMI and energy intake as independent variables. BMI and energy intake were observed to be significant predictors (p = 0.023 and p = 0.028 respectively) for the decreased levels of IL-1β after surgery (Table 6) but not for IL-6 and TNF-α after SG (not included in the table). BMI and Energy intake did not predict the levels of IL-1β, IL-6 and TNF-α before surgery.

Dependent Variable	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std.Error	Beta	r	P
	(Constant)	-0.260	0.351		-0.740	0.469
IL-1β	Energy kcal	0.001	0.000	0.459	2.399	0.028[a]
	BMI kg/m^2	0.013	0.005	0.478	2.499	0.023[a]
	(Constant)	-4.747	7.746		-0.613	0.548
IL-6	Energy kcal	0.006	0.009	0.142	0.625	0.540
	BMI kg/m^2	0.258	0.146	0.401	1.769	0.095
	(Constant)	-0.779	1.917		-0.406	0.689
TNF-α	Energy kcal	0.001	0.002	0.079	0.337	0.740
	BMI kg/m^2	0.048	0.036	0.309	1.311	0.206

Table 6: *Linear regression of post surgical IL-1B, IL-6 and TNF-A as dependent variables and post surgical energy intake and BMI as independent variables.*

[a]: BMI and energy intake have been shown to be significant predictors for the levels of IL-1β after surgery. BMI and Energy intake did not predict the levels of IL-6 and TNF-α after surgery.

Discussion

This study was designed on our hypothesis that weight loss and dietary changes after sleeve gastrectomy (SG), may, together result in lower overall inflammation and lower levels of pro-inflammatory cytokines which could result in reduced comorbidities and better quality of life. Here, we demonstrated that the weight loss following SG markedly reduces the secretion of pro-inflammatory cytokines among morbidly obese children and adolescents. Post SG, subjects achieved significant decrease in all anthropometric measurements that include weight, BMI, waist circumference, hip circumference, WHR, MAC and thigh circumference 6 months after SG with no reported clinical complications. The mean BMI at baseline was 50.7 kg/m^2 and it declined to 37 kg/m^2 at the end of the study. The percent EWL and EBL (percent excess BMI loss) achieved by our patients at 6 months after SG (48% and 51.7%, respectively) is similar to that reported by Alqahtani., *et al*. [40] where children and adolescents showed a marked decrease in body weight and BMI after the SG.

Six months post sleeve gastrectomy all patients were relieved of the symptoms of sleep apnea compared to 33% complains at baseline. Patients also experienced a significant drop in their fasting glucose readings. These factors may result in decrease in the risk of CVD [37] and may prevent metabolic syndrome and type II diabetes. A significant increase in HDL levels was observed six months after SG which may further reduce CVD risk and exert several beneficial effects on inflammation, and haemostasis [41].

Seventy percent of the patients demonstrated a decrease in IL-1β levels after six months of surgery (Figure 1). The varied response suggests that SG can reduce levels of proinflammatory markers but may also depend of secondary factors including dietary changes adopted post surgery as evident from other studies as well [10,40-42].

It was also observed that 65% (n = 13) of the subjects who had decreased levels of IL-1β after SG were of the age of 15 - 18 yrs, indicating that IL-1β may decrease faster and easier in late adolescence or in youth compared to earlier ages of childhood period.

The nonsignificant decrease of IL-6 and TNF-α observed are in agreement with several other studies comparing levels of TNF-α and IL-6 in children and adults [43,44]. However, in our study, no significant changes in the TNF-α and IL-6 levels after surgery was observed (Figure 2 and 3), whereas some adult studies have shown that weight loss decreases TNF-α and IL-6 levels post different surgical interventions and different time periods ranging from 6 – 12 months [45,46] and only few studies conducted in children have shown a reduction in IL-6 and TNF-α levels after weight loss induced by dietary changes and exercise [47], suggesting that, regardless of how weight loss is achieved, it plays a role in decreasing circulating levels of pro-inflammatory cytokines.

Data from the 3-days dietary recall and the 7-days FFQ shows a trend toward better food choices adopted by the subjects. Positive correlations between retinol (vitamin A) and IL-6, and between vitamin C and TNF-α or IL-1β was observed which could be due to the inflammation that is commonly caused by surgeries such as SG. Genetic differences among individuals may have an impact on the ability of antioxidants to exert an anti-inflammatory effect explaining the differences in cytokine production between individuals [48].

Obesity is associated with increased risk of metabolic syndrome, which may persist from childhood and adolescence into young adulthood. Waist circumference in children is an independent predictor of IR, lipid levels, and blood pressure. In obese young people, IR is higher among those with high amounts of VAT than in those with low amounts [49]. Patients who have larger waist circumference (abdominally obese patients) usually have excess of VAT which is found to secrete higher amounts of TNF-α [50,51] that can accelerate CVD risk factors and IR in obese children [44,52]. Our findings showed that the waist circumference significantly correlated with TNF- α level before the surgery. These results are consistent with another study showing significant correlation between TNF-α and waist circumference and concluded that abdominal obesity is associated with inflammatory markers in obese and nonobese peritoneal dialysis patients [53]. High cytokine concentrations is mediated partly by increased visceral fat mass, and that may be considered an additional risk factor contributing to the increased risk of chronic heart disease (CHD) [54].

The reduction in BMI and hip circumference significantly correlated with IL-6 concentrations 6 months post-surgery, which was similarly observed in many studies. Whereas, no study has examined the link between hip and midarm circumferences with IL-1β levels. The hip circumference in women is a strong independent predictive risk factor for development of CVD or CHD than either BMI or waist circumference [55]. As IL-1β was found to be a cardiovascular risk factor [56], we can postulate that the reduction in IL-1β may play a role in decreasing risk of CVD and can be supported with the significant increase in HDL levels as a protective factor against CVD.

The indexes of obesity in our study population did not show any significant correlation with IL-1β or IL-6 before the surgery. Whereas, after surgery we found several correlations between measured cytokines and indexes of obesity, suggesting that weight reduction and diet modification may modulate the relationship between cytokines and our body.

A decrease in TG levels correlated with IL-6 concentration post surgery which was similarly seen in other studies [57-59], suggesting that age could play a role, and that decrease in weight during childhood period might show better outcomes and preventive measures.

Further studies should be conducted with larger sample size using the same age group population, in addition, studies ofthe elementary adipose tissue inflammatory response of obese children may suggest new potential targets for the treatment or prevention of the complications of obesity. Finally, comparative studies between the effect of surgical induced weight loss and weight loss by diet on the levels of these cytokines should also be considered.

Conclusion

Sleeve gastrectomy represents a safe method for downregulating the inflammatory state that could lead to CVD and insulin resistance (IR) in obese children and adolescents. The significant decrease in IL-1β, increase in HDL and resolution of sleep apnea after SG can reduce CVD risk factors among morbidly obese children and adolescent, whereas the significant decrease in FG can reduce IR risk factors.

Conflict of Interest Statement

All authors report no conflict of interest.

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