SERUM LEVEL OF LEPTIN AND GHRELIN AS SUCCESS MARKER OF LAPAROSCOPIC SLEEVE GASTRECTOMY- A PROSPECTIVE COHORT STUDY

Surgery

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ABSTRACT

Introduction- Leptin binds to its receptors influences the activity of various hypothalamic neurons and the expression of various orexigenic and anorexigenic neuropeptides. Ghrelin being an orexigenic hormone plays an important role in initiating food intake and ending meal.

Material and methods- The prospective observational study were performed after Laparoscopic Sleeve Gastrectomy (LSG) for obesity as per the recommendation of WHO guideline. Post-operatively all patients were assessed with serum level of Leptin and Ghrelin level and their relation with their weight and BMI.

Discussion- On Univariate analysis, Only BMI was significantly affecting Leptin expression with beta coefficient of .431 (p= .004). Univariable regression analysis for Ghrelin showed no correlation with age, weight and BMI

Conclusion- LSG is an effective procedure for obesity showed decrease in serum level of Leptin and Ghrelin on subsequent follow-ups. Only BMI was found to have significant correlation with the Leptin expression

KEYWORDS

LSG, Leptin , Ghrelin

INTRODUCTION-

World Health Organization has declared obesity a global epidemic as its prevalence has risen very rapidly in recent decades. Obesity has been identified and declared as a disease 30 years ago when the WHO listed obesity as a disease condition in its International Classification of Diseases in 1979 [1]

There are many ways to define the obesity by different organization like CDC, OSSI, WHO etc but the most widely and commonly used formula to calculate the obesity is of WHO. According to WHO, BMI between 30.00-34.99 labelled as Class I,35-39.99 as class II and >40 as class III**. The BMI is defined as a person's weight in kilograms divided by the square of his/her height in meters (kg/m^2).** The indication for surgical treatment of obesity is morbid obesity which is defined as a BMI more than 40 or BMI more than 35 with obesity-associated co-morbid conditions such as hypertension, diabetes, cardiovascular **diseases.**[2]

In India it is affecting about 5% of the country's **population.**[3] ICMR-INDIAB Study (Phase-I) study showed that obesity rates are high in urban residents than the rural residents with an incidence of 30–65% of adult urban **population.**[4,5] As per a study conducted by Undavalli VK et al, in India, the prevalence of generalized, abdominal and combined obesity was found to be 56%, 71.2% and 51.3%, **respectively.**[6] India with 30 billion populationis 3rd highest in the World after US and **China.**[7-9] Prevalence of obesity in India is up to 50% in women and 32.2% in men in the upper strata of the society.[10] In Delhi alone, the prevalence of obesity stands at 33.4% in women and 21.3% in men.[11]

3. Leptin

Leptin is a hormone which contains 167 amino acids and is maly secreted by the adipocytes. The hypothalamus senses nutritional state of the body through signal is provided by Leptin hormone. Leptin decreases intake of food through upregulation of the neuropeptides like α-melanocyte-stimulating hormone that is known to be anorexigenic. Leptin concurrently downregulates the orexigenic factors like neuropeptide Y.

4. Ghrelin

Ghrelin is a 28-amino-acid peptide predominantly secreted in the stomach and stimulates appetite and growth hormone (GH) release. The term Ghrelin is based on 'Ghre' meaning 'grow' in reference to its ability to stimulate GH release. Approximately 60–70% of circulating Ghrelin is secreted by the stomach, with most of the remainder originating in the small intestine. In the stomach, the Ghrelin-containing cells are more abundant in the fundus than in the pylorus.

5. Relationship of Leptin, Ghrelin and obesity

Leptin functions as a feedback mechanism that signals to key regulatory centers in the brain to inhibit food intake and to regulate body weight and energy homeostasis. After Leptin is released by the adipose tissue into the bloodstream, it crosses the BBB and binds to the hypothalamic Leptin receptors, giving information about the status of the body energy stores.

By binding to its receptors, Leptin influences the activity of various hypothalamic neurons and the expression of various orexigenic and anorexigenic neuropeptides. Regulation of the effects of Ghrelin on hypothalamic neurones (Ghrelin blocks Leptin's action through the activation of the hypothalamic NPY/Y1 receptor pathway) is one of the important mechanisms by which Leptin may control food intake and body weight.[12]

Leptin play a role in short-term regulation of food intake and body weight. Leptin is produced not only by adipose tissue, but also in small amount by the stomach. Therefore, it has been suggested that Leptin might play a role in the control of meal size in cooperation with other satiety peptides. It has been shown that several intestinal peptides induce gastric Leptin release.[12]

Ghrelin, which is an orexigenic intestinal hormone, causes an increase in food intake. Ghrelin plays an important role in initiating food intake and ending meal. Increase in hunger Ghrelin levels after weight loss due to diet and exercise supports the hypothesis that Ghrelin has a role in long-term regulation of body weight.[13]

MATERIALS AND METHODS

The prospective observational study was conducted in Department of Surgery, PGIMER & DR. RML Hospital, New Delhi on 30 patients between 1 November 2017 to 31 March 2019.

Inclusion criteria were morbid patients of >18years with good psychological status.**Patients with** upper abdominal surgery**,** Severe reflux disease**,** Hiatus hernia **&** Gastric ulcer were not included in the study. Detailed history, demographic profile and investigations including Leptin and Ghrelin were done on all patients. The efficacy of LSG were assessed in terms of changes in Leptin and Ghrelin on follow up period at 4,12 and 24 weeks

STATISTICAL ANALYSIS

Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean (±SD) and median. Normality of data was tested by Kolmogorov-Smirnov test. If the normality was rejected then non parametric test was used.

Quantitative variables were compared using Independent t test/Mann-Whitney Test between the two groups and paired t test/ Wilcoxon signed rank test were used for comparison between pre and post-operative stage. Univariate linear regression was used to assess the significant factors affecting Leptin and Ghrelin. A p-value of <0.05 was considered statistically significant. The data was entered in MS EXCEL spreadsheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0.

Observations

In our study, mean (±SD) age of the patients was 41.07 ± 9.4 years. Majority of the patients (43.33%) belonged to age group 41-50 years followed by 33.33% of 31-40 years of age group. 73.33% of the patients were females.

Mean (±SD) weight of patients before surgery was 115.3 ± 14.36 kg which declined to 97.13 ± 12.88 kg, 86.43 ± 13.29 kg, and 76.52 ±

13.57 kg after 4, 12 and 24 weeks respectively after surgery. The finding was statistically significant on comparison with pre-op weight

Table 1:-Comparison of weight before and after surgery at different time intervals

Weight in kg	Mean ± Stdev	Median(IQR)	P value
Before surgery	115.3 ± 14.36	112(108 - 126)	
After 4 weeks of surgery	97.13 ± 12.88	95(90 - 105)	<.0001
After 12 weeks of surgery	86.43 ± 13.29	85(75 - 93)	<.0001
After 24 weeks of surgery	76.52 ± 13.57	72(70 - 80)	<.0001

There was a significant statistical difference in the weight of patients when compared before and after 4, 12, and 24 weeks of surgery.

Table 2:- Two BMI group were compared at different time intervals

BMI in kg/m^2	<40 kg/m^2(n=3)		>=40 kg/m^2 (n=27)		P value
	Mean ± Stdev	Median(IQR)	Mean ± Stdev	Median(IQR)	
Before surgery	36.85 ± 1.75	37.37(35.518 - 38.060)	47.55 ± 3.44	47.75(45.573 - 49.127)	<.0001
After 4 weeks of surgery	31.87 ± 1.86	32.66(30.470 - 33.065)	39.83 ± 3.62	40.4(37.015 - 42.385)	0.001
After 12 weeks of surgery	27.31 ± 1.34	27.21(26.317 - 28.327)	35.61 ± 3.73	35.84(33.050 - 38.153)	0.001
After 24 weeks of surgery	25.39 ± 1.22	25.4(24.470 - 26.300)	31.32 ± 3.97	30.38(28.250 - 33.330)	0.019

The above table shows that there is difference between mean (±SD) BMI of patients between two BMI groups were statistically significant before surgery and also at each follow up visit. There was no significant statistical difference between two BMI groups in terms of mean (±SD) body weight after 24 weeks of surgery (P>0.05).

Table 3:-Comparison of Serum Leptin level.

Leptin in ng/mL	Mean ± Stdev	Median(IQR)	P value
Before surgery	31.31 ± 2.54	32.02(30.650 - 32.640)	

Table 4:-Comparison of Leptin level between two BMI group

Leptin in ng/mL	<40 kg/m^2(n=3)		>=40 kg/m^2 (n=27)		P value
	Mean ± Stdev	Median(IQR)	Mean ± Stdev	Median(IQR)	
Before surgery	24.91 ± 0.59	25.2(24.472 - 25.283)	32.02 ± 1.38	32.15(30.835 - 32.813)	0.005
After 4 weeks of surgery	20.24 ± 0.21	20.34(20.085 - 20.377)	27.11 ± 1.86	27.31(26.053 - 28.395)	0.005
After 12 weeks of surgery	16.96 ± 1.16	16.62(16.155 - 17.842)	23.69 ± 2.58	24(21.663 - 25.453)	0.005
After 24 weeks of surgery	12.87 ± 0.56	12.65(12.500 - 13.287)	19.94 ± 3.22	21.31(16.400 - 22.300)	0.006

Comparison of Leptin level of study subjects were compared at different time intervals between two BMI group which were found significant as shown in table below

Table 5:- Serum Ghrelin level at different time intervals.

Ghrelin in fmol/mL	Mean ± Stdev	Median(IQR)	P value
Before surgery	105.79 ± 6.92	107.36(101 - 109.890)	

Table 6:-Comparison of Serum Ghrelin between two BMI group.

Ghrelin in fmol/mL	<40 kg/m^2(n=3)		>=40 kg/m^2 (n=27)		P value
	Mean ± Stdev	Median(IQR)	Mean ± Stdev	Median(IQR)	
Before surgery	97.56 ± 9.57	92.43(91.845 - 104.557)	106.7 ± 6.13	107.43(101.478 - 109.972)	0.027
After 4 weeks of surgery	30.51 ± 4.39	28.6(27.707 - 33.798)	33.12 ± 2.32	32.8(31.537 - 34.938)	0.101
After 12 weeks of surgery	29.28 ± 4.17	27.45(26.610 - 32.400)	33.09 ± 2.26	33(31.495 - 35.100)	0.016
After 24 weeks of surgery	30.22 ± 3.98	29.21(27.440 - 33.260)	33.04 ± 2.59	33.04(31.500 - 34.590)	0.108

The difference between mean (±SD) Ghrelin level between two BMI groups was statistically significant before surgery and after 12 weeks of surgery. The difference between mean (±SD) Ghrelin level of patients between two BMI groups was not statistically significant after 4 and 24 weeks of surgery.

Table 7:-Univariate linear regression for Leptin after 24 weeks of surgery

Leptin (ng/mL) after 24 weeks of surgery as dependent variable	Unstandardized Coefficients		P value	95.0% Confidence Interval for B	
	B	Std. Error		Lower Bound	Upper Bound
Age in years	-.014	.080	.860	-.177	.149
Weight (kg) before surgery	.094	.049	.066	-.007	.194
BMI (kg/m^2) before surgery	.431	.139	.004	.145	.717

(right column, continuation of tables)

After 12 weeks of surgery	23.02 ± 3.2	23.68(21.240 - 25.310)	<.0001
After 4 weeks of surgery	26.42 ± 2.74	26.84(24.800 - 28.320)	<.0001
After 24 weeks of surgery	19.09 ± 3.82	21.1(15.275 - 22.045)	<.0001

The study subjects were compared after different time intervals of surgery with pre-op level and were found statistically significant

After 4 weeks of surgery	32.86 ± 2.61	32.72(31 - 35.230)	<.0001
After 12 weeks of surgery	32.71 ± 2.67	32.9(31.270 - 34.800)	<.0001
After 24 weeks of surgery	32.7 ± 2.84	32.91(31.350 - 34.595)	<.0001

Blood sugar (mg/dL) before surgery	-.081	.057	.168	-.197	.036

Univariate linear regression for Leptin after 24 weeks of surgery which showed no correlation with age, and weight. Only BMI was significantly affecting Leptin expression with beta coefficient of .431 (p= .004) i.e. with the increase in BMI by 1 kg/m2, Leptin expression significantly increased by .431 ng/mL as shown in Table 20.

Table 8:-Univariate linear regression for Ghrelin after 24 weeks of surgery

Ghrelin (fmol/mL) after 24 weeks of surgery as dependent variable	Unstandardized Coefficients		P value	95.0% Confidence Interval for B	
	B	Std. Error		Lower Bound	Upper Bound
Age in years	.047	.056	.415	-.069	.162
Weight (kg) before surgery	.018	.037	.638	-.059	.094

BMI (kg/m2) before surgery	.208	.109	.066	-.015	.432
Blood sugar (mg/dL) before surgery	-.068	.040	.103	-.150	.015

Univariate linear regression of Ghrelin expression showed no correlation with age (p=0.415), weight (p=0.638) and BMI (p=0.066).

DISCUSSION

Obesity is a chronic, complex, and relapsing disease that has reached epidemic levels across the globe including developing countries including India. The health consequences of obesity range from serious chronic conditions to increased risk of premature death. Bariatric surgery has emerged as an acceptable treatment for morbid obesity achieving meaningful and sustained weight loss.

LSG has emerged as a widely accepted Bariatric procedure. Existing data demonstrate that LSG can be an effective and safe procedure for super-obese/ high-risk patients either as a single operation or as a bridge to more definitive surgery.[14]. Serum levels of Leptin and Ghrelin play some roles in weight loss after LSG. The most pronounced effect of the bariatric surgery is changes in dietary habits of patients.[15]

A prospective observational study was conducted in Department of Surgery, PGIMER & Dr. RML Hospital and New Delhi on 30 patients from 1 November 2017 to 31 March 2019. Efficacy of LSG was assessed in terms of changes in weight and BMI and correspondingly change/ trends of change in Leptin and Ghrelin after LSG at 4, 12, and 24 weeks in follow-up period.

In our study, mean (±SD) age of the patients was 41.07 ± 9.4 years. Majority of the patients (43.33%) belonged to age group 41-50 years followed by 33.33% patients of 31-40 years of age group. Most of the patients (73.33%) were females.

Mean weight of patients before surgery was 115.3 ± 14.36 kg which declined to 97.13 ± 12.88 kg, 86.43 ± 13.29 kg, and 76.52 ± 13.57 kg after 4, 12, and 24 weeks of surgery respectively. It was found statistically significant.

Our results were comparable to that of studies by Erol V et al,[16] and Hady HR et al.[17] Study by Erol V et al, reported preoperative mean (±SD) weight of patients 120.6 (91-147) kg, which reduced significant weight loss on 2, 4 and 8 week post LSG.

On basis of BMI, patients were divided into low BMI <40 kg/m^2 and high BMI ≥40 kg/m^2. The difference between mean (±SD) body weight of patients between two BMI groups was statistically significant before surgery and also after 4 and 12 weeks post LSG but after 24 weeks of surgery, it was comparable but not statistically significant. It might be because of lack of strict diet control / change of dietary pattern over period of time.

Our finding are on the pattern of finding of Mui WL et al,[18] who reported that patients with BMI >35 kg/m^2 seemed to obtain more significant weight loss from LSG compared with patients with a BMI <35 kg/m^2. Boza C et al,[19] found that the patients with a preoperative BMI >40 kg/m^2 achieved significant % of EWL in comparison with the patients with BMI <40 kg/m^2 (50.2% vs 72.7%) at 5 years. Wang X et al,[20] also found that patients with a BMI <40 kg/m^2 could achieve significant weight loss from LSG compared with patients with a BMI ≥40 kg/m^2.

In a similar study by Elbanna H et al[14] mean(±SD) preoperative BMI in Group I (BMI <50 kg/m^2) was 46.8 ± 8.2 and that in Group II (BMI >50 kg/m^2) was 60.8 ± 8.8. Mean (±SD) postoperative BMI in Group I (BMI <50 kg/m^2) was 29.7 ± 4.3 and that in Group II (BMI >50 kg/m^2) was 36.5 ± 5.1. Statistically significant difference was noted in preoperative and postoperative BMI (P<0.001).

In our study, the mean (±SD) Leptin level of the patients preoperatively was 31.31 ± 2.54 ng/mL. The mean (±SD) Leptin level after 4 weeks, 12 weeks, and 24 weeks of surgery reduced to 26.42 ± 2.74 ng/mL, 23.02 ± 3.2 ng/mL, and 19.19 ± 3.82 ng/mL respectively. The difference between preoperative and postoperative mean (±SD) Leptin level were statistically significant (P value <0.0001).

In a study conducted by Kalinowski et al,[21] Leptin levels decreased

significantly 1 month after surgery and continued to decrease at 6 and 12 months after LSG. As per a study by Erol V et al,[16] Leptin levels were 11.16 ng/mL (median) in preoperative blood samples, while 8th week postoperative hormone levels were 4.39 ng/mL, the difference being statistically significant (p<0.01).

Before surgery, mean (±SD) Leptin level of patients of low BMI group was 24.91 ± 0.59 ng/mL and that of high BMI group 32.02 ± 1.38 ng/mL. The difference between mean (±SD) Leptin level of patients between two BMI groups was statistically significant before surgery, after 4, 12, and 24 weeks of surgery (P<0.05).

In our study, the mean (±SD) Ghrelin level of the patients preoperatively was 105.79 ± 6.92 fmol/mL. The mean (±SD) Ghrelin level after 4 weeks, 12 weeks, and 24 weeks of surgery reduced to 32.86 ± 2.61 fmol/mL, 32.71 ± 2.67fmol/mL, and 32.7 ± 2.84fmol/mL respectively. The difference between preoperative and postoperative mean (±SD) Ghrel in levels were statistically significant (P value <0.0001).

Statistically significant changes of Ghrelin levels were also seen in a similar study by Hady HR et al.[17] Similar study by Erol V et al,[16] showed preoperative Ghrelin levels were 25.72 pg/mL (median), whiles 8th week postoperative hormone levels were 14.16 pg/mL, the difference being statistically significant (p<0.01). Similar results were seen in the study by Vigneshwaran et al,[22] and Langer et al,[23] where postoperative serum Ghrelin levels of patients having undergone LSG were reported to decrease significantly. In our study the mean (±SD) Ghrelin level of the patients were higher in comparison to the western patients probably because of the difference in type of obesity.

Before surgery, mean (±SD) Ghrelin level of the patients in low BMI group was 97.56 ± 9.57 fmol/mL and that of high BMI group was 106.7 ± 6.13 fmol/ml. The difference between mean (±SD) Ghrelin level of patients between two BMI groups was statistically significant before surgery and after 12 weeks of surgery . The difference between mean (±SD) Ghrelin level of patients between two BMI groups was not statistically significant after 4 and 24 weeks of surgery (P>0.05). This is the probably the first study in which levels of Leptin and Ghrelin were measured and compared in low BMI (BMI<40) and high BMI group (BMI≥40).

In our study, univariable regression analysis for Leptin showed no correlation with age (p=0.860) and weight (p=0.066). Only BMI was significantly affecting Leptin expression with beta coefficient of .431 (p= .004) i.e. with the increase in BMI by 1 kg/m^2, Leptin expression significantly increased by .431 ng/mL.

In a study by Verdeş G et al,[24] univariable regression analysis for Leptin showed no correlation with age (*p*=0.2655), glycemia (*p*=0.9918), and BMI (*p*=0.8592). Results of their study regarding Leptin levels in visceral fat did not correlate with BMI. In our study, BMI was significantly affecting Leptin expression, although study by Knerr I et al, found a positive correlation.[25]

Univariable regression analysis for Ghrelin showed no correlation with age (p=0.415) weight (p=0.638) and BMI (p=0.066). So none of the factors was significantly affecting Ghrelin expression.

As per study by Verdeş G et al also, univariable regression analysis for Ghrelin showed no significant correlation between Ghrelin and age (*p*=0.9228), glycemia (*p*=0.7441), and BMI (*p*=0.3917).

CONCLUSION

It can be concluded that LSG is an effective procedure showing favourable outcomes in terms of weight loss and decrease in BMI along with significant decrease in serum level of Leptin and Ghrelin on subsequent follow-ups. Only BMI was found to have significant correlation with the Leptin expression.

REFERENCES
1. Buchwald H. Consensus conference statement bariatric surgery for morbid obesity: Health implications for patients, health professionals and third party payers. J Am Coll Surg2005;200:593-604.
2. 14. Kriplani AK. Laparoscopic surgery for morbid obesity. Apollo Medicine 2009;6(4):305-321.
3. World Health Organization. Obesity and Overweight [Internet]. 2016 [cited 2 September 2016]. Available from http://www.who. int/media centre/ factsheets/fs311/en/.
4. 6. Misra A, Khurana L. Obesity and the metabolic syndrome in developing countries. J

Clin Endocrinol Metab 2008;93(11):9-30.
5. Pradeepa R, Anjana RM, Joshi SR, Bhansali A, Deepa M, Joshi PP, et al. Prevalence of generalized and abdominal obesity in urban & rural India- the ICMR-INDIAB Study (Phase-I) [ICMR- INDIAB-3]. Indian J Med Res 2015;142:139-150.
6. Undavalli VK, Ponnaganti SC, Narni H. Prevalence of generalized and abdominal obesity: India's big problem. Int J Community Med Public Health 2018;5:1311-1316.
7. Mohan V, Deepa R. Obesity and abdominal obesity in Asian Indians. Indian J Med Res 2006;123:593-596.
8. India facing obesity epidemic: experts. The Hindu 2007-10-12.
9. Yoon K, Lee J, Kim J, Cho J, Choi Y, Ko S, et al. Epidemic obesity and type 2 diabetes in Asia. Lancet 2006;368(9548):1681-1688.
10. Gopalan C. Obesity in the urban middle class. NFI Bulletin 1998;19:1-4.
11. Gopinath N, Chadha SL, Jain P, Shekhawat S, Tandon R. An epidemiological study of obesity in adults in the urban population of Delhi. J Assoc Physicians India 1994;42:212-215.
12. Klok MD, Jakobsdottir S, Drent ML. The role of Leptin and Ghrelin in the regulation of food intake and body weight in humans: a review. Obesity Rev 2007;8:21-34.
13. Çalapkorur S, Köksal E. The relation between laparoscopic sleeve gastrectomy and Ghrelin. Int J Med Res Health Sci 2017;6(7):29-35.
14. Elbanna H, Ghnnam W, Negm A, Youssef T, Emile S, El Metwally T, et al. Impact of preoperative body mass index on the final outcome after laparoscopic sleeve gastrectomy for morbid obesity. Ulus CerrahiDerg2016;32:238-243.
15. Bužga M, Zavadilová V, Holéczy P, Švagera Z, Švorc P, FoltysA, et al. Dietary intake and Ghrelin and Leptin changes after sleeve gastrectomy. VideosurgeryMiniinv 2014;9(4):554-561.
16. Erol V, Aydin C, Uğurlu L, Turgut E, Yalçın H, Arslan FD. Changes in Ghrelin, Leptin and ınsulin levels after laparoscopic sleeve gastrectomy. Ege Journal of Medicine. Epub ahead of print. Available from dergipark.gov.tr/download/article-file/462666. [Accessed March, 2019].
17. Hady HR, Dadan J, Golaszewski P, Safiejko K. Impact of laparoscopic sleeve gastrectomy on body mass index, Ghrelin, insulin and lipid levels in 100 obese patients. WideochirInne Tech Maloinwazyjne 2012;7(4):251-259.
18. Mui WL, Ng EK, Tsung BY, Lam CC, Yung MY. Laparoscopic sleeve gastrectomy in ethnic obese Chinese. ObesSurg 2008;18(12):1571-1574.
19. Boza C, Daroch D, Barros D, et al. Long-term outcomes of laparoscopic sleeve gastrectomy as a primary bariatric procedure. SurgObesRelat Dis 2014;10(6):1129-1133.
20. Wang X, Chang X, Gao L, Zheng C, Zhao X, Yin K, et al. Effectiveness of laparoscopic sleeve gastrectomy for weight loss and obesity-associated co-morbidities: a 3 year outcome from Mainland Chinese patients. SurgObes Related Dis 2016;12(7):1307-1311.
21. Kalinowski P, Paluszkiewicz R, Wróblewski T, Remiszewski P, Grodzicki M, BartoszewiczZ,et al. Ghrelin, Leptin, and glycemic control after sleeve gastrectomy versus Roux-en-Y gastric bypass-results of a randomized clinical trial. SurgObesRelat Dis 2017;13(2):181-188.
22. Vigneshwaran B, Akshat W, Sandeep A, Wahal A, Aggarwal S, Priyadarshini P, et al. Impact of sleeve gastrectomy on type 2 diabetes mellitus, gastric emptying time, glucagon-like peptide 1 (GLP-1), Ghrelin and Leptin in non-morbidly obese subjects with BMI 30–35.0 kg/m2: A prospective Study. ObesSurg 2016;26(12):2817-2823.
23. Langer FB, Reza Hoda MA, Bohdjalian A, Felberbauer FX, Zacherl J, Wenzl E, et al. Sleeve gastrectomy and gastric banding: effects on plasma Ghrelin levels. ObesSurg2005;15:1024-1029.
24. Verdeş G, Duţă CC, Popescu R, Mituleţu M, Ursoniu S, Lazăr OF. Correlation between Leptin and Ghrelin expression in adipose visceral tissue and clinical-biological features in malignant obesity. Rom J MorpholEmbryol2017;58(3):923-929.
25. Knerr I, Herzog D, Rauh M, Rascher W, Horbach T. Leptin and Ghrelin expression in adipose tissues and serum levels in gastric banding patients. Eur J Clin Invest 2006;36(6):389-394.