INTRAGASTRIC BALLOON EFFECT ON PLASMA GHRELIN LEVELS IN PATIENTS WITH MORBID OBESITY

Mohamed Abdalla El-Sayed Abdalla[1], Mohamed Ibrahim Shoer[2], Mohamed Mahmoud Abdo[3], Hanan Hassen Omar[4], Bassam Mansour Salama[5], Ayman Amer Salm[6]

ArticleHistory:Received:18.04.2023 **Revised:**20.05.2023 **Accepted:**25.05.2023

Abstract

Background: The amount of food consumed at each meal is reduced when BIB is present in the stomach. The ghrelin hormone, which affects hunger and energy balance in the body, may not be released as much when the stomach wall is stretched.

Aim: The purpose of this study was to assess the effectiveness of ghrelin hormone blood levels and bio-enteric intragastric balloon use in treating obesity.

Patients and methods: This pre/post-interventional study was carried out on forty-two morbid obese patients of both sexes, aged 22–53 years attending to Internal Medicine, Gastrointestinal Endoscopy Department, Suez Canal University Hospitals. Patients with other medical comorbidity and patients refused to participate in the study were excluded. All patients were subjected to careful history taking and one-month specific eating regimen with recording of amount and type of food eaten. After 1 month of treatment with a low-calorie diet and physical exercise, the patients performed the BIB. The patients treated with the gastric balloon. The data from scheduled postoperative visits have been recorded, each visit body weight, waist circumference and BMI were recorded, laboratory investigations (CBC, liver enzymes, serum creatinine, lipid profile, and serum Ghrelin) were also recorded for each visit.

Results: The age of patients ranged from 22 to 53 years with mean ±SD was 35.79± 8.63 years. The mean weight at baseline was126.69± 9.79 Kg, 116.88± 9.22 Kg after 1 months, 107.60± 8.13 Kg after 1 months and 105.55± 7.68 Kg 1month After IGB removal. There is significant decline in weight throughout follow up time ($p<0.001$). There is significant increase in BMI change throughout follow up time ($p<0.001$). The mean Ghrelin level at baseline was 889.98± 155.16 pg/ml, 1137.98± 178.74 pg/ml after 1 months, 1204.98± 178.74 pg/ml after 6 months and 1072.98± 178.74 pg/ml after 1 month after removal. A significant increase in the level of Ghrelin was reported after 6 months compared to its level at baseline and after 1 month ($p<0.001$). 1month After IGB removal, Ghrelin level showed significant decrease compared to the levels after 6 months.

Conclusion: A new endoscopic method for the treatment of obesity, bioenterics intragastric balloon, can be a choice for patients with morbid obesity, who were the conservative treatment appears ineffective.

Keywords: Intragastric Balloon, Ghrelin Levels, Morbid Obesity

[1]. M.B. B.Ch. (2007), Faculty of Medicine – Zagazig University, Master of Internal Medicine (2013), Faculty of Medicine – Suez Canal University.
[2]. Professor of Internal Medicine, Faculty of Medicine, Suez Canal University, Egypt.
[3]. Professor of Internal Medicine, Faculty of Medicine, Suez Canal University, Egypt.
[4]. Assistant Professor of clinical pathology, Faculty of Medicine, Suez Canal University, Egypt.
[5]. Lecturer of infectious and endemic diseases department, Faculty of Medicine Suez Canal University, Egypt.
[6]. Assistant Professor of Internal Medicine, Faculty of Medicine, Suez Canal University, Egypt.

DOI: 10.48047/ecb/2023.12.5.278

1. INTRODUCTION

There are mutually modifiable and non-modifiable risk factors for obesity, making it a complex disease. Feeding habits are a significant controllable factor. As obesity is caused by hyperphagia, a well understanding of the mechanisms regulating food intake is crucial to the treatment of this chronic disease. By promoting a change from a negative to a neutral energy balance by boosting intake and hepatic glucose synthesis, the peptide hormone ghrelin is a critical regulator of energy metabolism [1].

The importance of ghrelin during positive energy balance is less well understood; nonetheless, studies suggest that blocking the action ghrelin may attenuate body weight gain and the development of glucose intolerance when feeding a high calorie meal [2].

The significance of ghrelin during positive energy balance is less well understood; nonetheless, a number of studies suggest that blocking the action ghrelin may attenuate body weight gain and the development of glucose intolerance when feeding a high calorie meal [2].

In contrast to lean people, most obese people (aside from those with Prader-Willi syndrome, who have higher-than-normal ghrelin levels) have lower levels of circulating ghrelin and less pronounced meal-related fluctuations [1]. Plasma ghrelin concentrations are increased by caloric restriction and cachexia.

Weight loss achieved through caloric restriction can correct ghrelin reductions connected to obesity, however weight loss through bariatric surgery has been linked to variable results for plasma ghrelin, depending on the method and the study [3].

There is research for effective therapeutic methods that would ensure a negative energy balance. In patients with morbid obesity, the conservative treatment appears ineffective. Instead, surgical procedures, although burdened with numerous complications, seem to be an effective way of permanent weight loss [4].

A therapeutic issue arises when obese patients are ineligible for or refuse the bariatric operation. For this group of patients, the bioentericsintragastric balloon (BIB), a revolutionary endoscopic technique for the treatment of obesity, may be an alternative. The stomach balloon may perhaps delay stomach emptying and improve satiety, allowing for a change in lifestyle [5].

The amount of food consumed at each meal is reduced when BIB is present in the stomach. The ghrelin hormone, which affects hunger and energy balance in the body, may not be released as much when the stomach wall is stretched [5].

- **Aim of the work**

The purpose of this study was to assess the effectiveness of ghrelin hormone blood levels and bio-enteric intragastric balloon use in treating obesity.

2. PATIENTS AND METHODS

This study was carried out as pre/post-interventional study. This study was held at Internal Medicine, Gastrointestinal Endoscopy Department, Suez Canal University Hospitals, Ismailia, Egypt in period from May 2017 to April 2018. The included study population were 42 obese patients (BMI ≥ 40 kg/m^2). The age in the studied patients was ranged from 22 to 53 years, 12 (28.6%) patients were males while 30 (71.4%) patients were females They have been recruited for the study according to the following criteria: Obese patients with BMI ≥40 kg/m^2, patients from both sexes and adult patients aged ≥ 18years were included in the study. Patients with comorbid conditions or patients' refusal were excluded from the study.

- **METHODS**

•An informed written consent was taken from all the participants before taking any data or doing any investigations.

•All patients were subjected to careful medical history. Before the study, the patients were instructed to follow a specific eating regimen. The patients instructed to record the amount and type of foods eaten, checked once a month. After 1 month of treatment with a low-calorie diet (1500 kcal/d) and physical exercise (a 45 min walk, five times a week), the patients performed the BIB. The balloon (Inamed Health; Santa Barbara, CA) was endoscopically placed in the stomach and filled with 500-600 ml of physiological saline with methylene blue. The following visits have been scheduled: at the recruitment of the patients; 1 month after the placement of the balloon; at the removal of the BIB (6 months); and 1 month after the balloon removal.

•On each visit the study subjects underwent complete medical examination, anthropometric measurements (body weight, waist circumference) and serum levels of ghrelin. Six months after the placement of BIB, the patients had the balloon removed with the endoscopic evaluation of the esophagus, stomach, and duodenum to detect any potential complications caused by the therapy. The study was approved by the local ethical committee of Suez Canal University. Each patient was given a written informed consent before admission to the study. All patients underwent the following laboratory investigations:CBC, liver function test, kidney function test. The circulating ghrelin was measured with the human radioimmunoassay (RIA) kit for total ghrelin (Linco Research) with the standard curve range of 100–10,000 pg/ml and the detection limit of the method of 93 pg/ml. The intraassay & inter-assay curves will be 10 and 17.8%, respectively.

- **STATISTICAL ANALYSIS**

Data was collected, coded then entered as a spread sheet using Microsoft Excel 2016 for Windows, of the Microsoft Office bundle; 2016 of Microsoft Corporation, United States. Data was analyzed using IBM Statistical Package for Social Sciences software (SPSS), (IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp). The Kolmogorov-Smirnov test was used to verify the normality of distribution. Continuous data was expressed as mean ± standard deviation, median & IQR while categorical data as numbers and percentage. A statistical value <0.05 was considered as significant. P-value < 0.05 was reflected statistically significant.

3. RESULTS

The age in the studied patients was ranged from 22 to 53 years with mean ±SD was 35.79± 8.63 years.

Regarding gender, 12 (28.6%) patients were males while 30 (71.4%) patients were females with male to female ratio was 0.4: 1 as in **Table 1.**

Table 2showed anthropometric measurements that were recorded in the studied patients. The mean weight, height and BMI were 126.69± 9.79 kg, 1.66± 0.06 m and 45.77± 3.71Kg/m^2 respectively. The mean waist circumference in studied cases was 137.40± 15.58 cm. The mean ideal body weight was 61.04± 4.07. The mean excess weight (EW) was 65.65± 8.99 Kg while the mean EW% was 51.63± 3.91 Kg.

Table 3 showed that the mean hemoglobin level was 13.00± 1.05 g/dl and the mean WBCs was5.01± 1.31x10³/ml. In addition, the mean platelets count was 242.90± 72.29x10³/ml. The mean urea level was 1320.14± 4.33 mg/dl while the mean creatinine level was 0.97±0.17 mg/dl. The mean AST level was 26.62± 4.89 U/L while the mean ALT level was 28.24± 5.33 U/L. The mean total cholesterol level was 214.94± 29.86 mg/dl while the mean triglyceride level was 219.74± 41.82 mg/dl. The mean LDL level was 135.74± 16.14 mg/dl while the mean HDL was 47.43± 7.33 mg/dl.

In **Table 4**, regarding weight: The mean weight at baseline was126.69± 9.79 Kg, 116.88± 9.22 Kg after 1 months, 107.60± 8.13 Kg after 1 months and 105.55± 7.68 Kg 1month After IGB removal. There is significant decline in weight throughout follow up time (p<0.001). Regarding waist circumference: The mean waist circumference at baseline was 137.40± 15.58cm, 129.98± 14.32 cm after 1 months, 119.45± 15.56 cm after 1 months and 118.76± 13.56 cm 1month After IGB removal. There is significant decline in waist circumference throughout follow up time (p<0.001).

In **Table 5** regarding BMI: The mean BMI at baseline was 45.77± 3.71 Kg/m^2, 42.21± 3.25 Kg/m^2 after 1 month, 38.86± 2.85 Kg/m^2 after 6 months and 38.13± 2.86 Kg/m^2 1month After IGB removal. There is significant decline in BMI throughout follow up time (p<0.001). Regarding BMI change: The mean BMI change after 1 months was 3.56± 1.16, 6.92± 1.59 after 1 months and 7.64± 1.69 1month After IGB removal. There is significant increase in BMI change throughout follow up time (p<0.001).

The mean EW after 1 months was 9.81± 2.94, 19.10± 4.07 after 6 months and 21.14± 4.49 after 1 year. There is significant elevation in EWL throughout follow up time (p<0.001). The mean EWL% after 1 months was 14.94± 4.06, 29.06± 4.68 after 6 months and 32.17± 5.09 after 1 year. There is significant increase in EWL% throughout follow up time (p<0.001) as shown in table 6.

The mean Ghrelin level at baseline was 889.98± 155.16pg/ml, 1137.98± 178.74 pg/ml after 1 months, 1204.98± 178.74 pg/ml after 6 months and 1072.98± 178.74pg/ml after 1 year. A significant increase in the level of Ghrelin was reported after 6 months compared to its level at baseline and after 1 month (p<0.001). 1month After IGB removal, Ghrelin level showed significant decrease compared to the levels after 6 months as shown in table 7.

Regarding complication: it was noticed that belching was the most frequent complication reported in 30 (71.4%) patients followed by nausea in 29 (69%) patients. 18 (42.9%) patients complained from vomiting, 8 (19%) patients had halitosis and 15 (35.7%) patients suffered from reflux.

Table 1. Distribution of socio-demographic characteristics among the studied patients.

Parameters		**Studied patients (n=42)**	
		N	**%**
Gender	**Male**	12	28.6%
	Female	30	71.4%
Age (years)	**Mean± SD**	35.79± 8.63	
	Median	36.5	
	Range	22.0- 53.0	

SD: standard deviation,

Table 2. Anthropometric measurements in the studied patients

	Mean	**SD**	**Studied patients (n=42)**		
			Median	**Minimum**	**Maximum**
Weight (Kg)	126.69	9.79	126.50	109.00	145.00
Height (m)	1.66	0.06	1.66	1.56	1.78
BMI (Kg/m^2)	45.77	3.71	45.47	40.16	52.60
Waist circumference (cm)	137.40	15.58	138.00	109.00	165.00
Ideal body weight (Kg)	61.04	4.07	60.62	53.54	69.70
EW	65.65	8.99	67.89	50.11	81.83
EW%	51.63	3.91	51.62	45.22	58.17

SD: standard deviation, **EW:** excess weight, **BMI:** body mass index

Table 3. Laboratory findings in the studied patients

	Mean	SD	Studied patients (n=42)		
			Median	Minimum	Maximum
Hemoglobin (g/dl)	13.00	1.05	12.90	10.50	14.70
WBCs (x10³/ml)	5.01	1.31	4.60	2.80	9.10
Platelets (x10³/ml)	242.90	72.29	230.50	118.00	423.00
Serum Urea (mg/dl)	20.14	4.33	19.50	14.00	36.00
Serum creatinine (mg/dl)	0.97	0.17	0.90	0.70	1.30
AST (U/L)	26.62	4.89	26.00	18.00	38.00
ALT (U/L)	28.24	5.33	27.00	20.00	38.00
TC (mg/dl)	214.94	29.86	219.50	154.00	280.00
TGS (mg/dl)	219.74	41.82	210.50	157.00	340.00
LDL (mg/dl)	135.74	16.14	131.00	110.00	168.00
HDL (mg/dl)	47.43	7.33	49.00	34.00	59.00

SD: standard deviation, **WBCs:** white blood cells**, TC:**total cholesterol, **TGS:**triglycerides

Table 4. Weight and waist circumference at baseline, 1 months, 6 months and after 1 month of IGB removal in the studied patients.

		Mean	SD	Median	Minimum	Maximum	Test value	p- value
Weight (Kg)	**At baseline**	126.69	9.79	126.50	109.00	145.00	132.4	**<0.001**
	After 1 months	116.88	9.22	115.00	101.00	136.00		
	After 6 months	107.60	8.13	105.50	93.00	123.00		
	1month After IGB removal	105.55	7.68	104.00	91.00	118.00		
Waist circumference (cm)	**At baseline**	137.40	15.58	138.00	109.00	165.00	117.8	**<0.001**
	After 1 months	129.98	14.32	130.50	103.00	155.00		
	After 6 months	119.45	15.56	120.00	91.00	147.00		
	1month After IGB removal	118.76	13.56	120.00	96.00	143.00		

$p \leq 0.05$ is considered statistically significant, $p \leq 0.01$ is considered highly statistically significant Analysis done by Friedman's Two-Way ANOVA Test.

Table 5. BMI and BMI changes at baseline, 1 months, 6 months and after 1 month of IGB removal in the studied patients.

		Mean	SD	Median	Minimum	Maximum	Test value	p- value
BMI (Kg/m^2)	**At baseline**	45.77	3.71	45.47	40.16	52.60	132.42	**<0.001**
	After 1 months	42.21	3.25	42.07	36.59	48.90		
	After 6 months	38.86	2.85	38.79	34.54	45.61		
	1month After IGB removal	38.13	2.86	37.68	33.75	44.38		
BMI changes	**After 1 months**	3.56	1.16	3.29	1.45	6.32	79.61	**<0.001**
	After 6 months	6.92	1.59	6.81	4.30	10.78		
	1month After IGB removal	7.64	1.69	7.51	4.41	11.90		

$p \leq 0.05$ is considered statistically significant, $p \leq 0.01$ is considered highly statistically significant Analysis done by Friedman's Two-Way ANOVA Test.

Table 6. EWL and EWL% changes at 1 months, 6 months and after 1 month of IGB removal in the studied patients.

		Mean	SD	Median	Minim um	Maxim um	Test value	p- value
EWL (Kg)	**After 1 months**	9.81	2.94	9.00	4.00	17.00	79.605	**<0.001**
	After 6 months	19.10	4.07	19.00	12.00	29.00		
	1month After IGB removal	21.14	4.49	20.50	12.00	32.00		
EWL%	**After 1 months**	14.94	4.06	14.83	6.31	24.00	79.605	**<0.001**
	After 6 months	29.06	4.68	29.47	20.47	39.82		
	1month After IGB removal	32.17	5.09	31.86	22.09	43.94		

$p \leq 0.05$ is considered statistically significant, $p \leq 0.01$ is considered highly statistically significant Analysis done by Friedman's Two-Way ANOVA Test.

Table 7. Ghrelin level at baseline, 1 months, 6 months and after 1 month of IGB removal in the studied patients.

		Mean	SD	Median	Minimum	Maximum	Test value	p- value
Ghrelin level (pg/ml)	**At baseline**	889.98	155.16	852.00	665.00	1387.00	168.9	**<0.001**
	After 1 months	1137.98	178.74	1099.50	841.00	1674.00		
	After 6 months	1204.98	178.74	1166.50	908.00	1741.00		
	1month After IGB removal	1072.98	178.74	1034.50	776.00	1609.00		

p≤0.05 is considered statistically significant, p≤0.01 is considered highly statistically significant Analysis done by Repeated ANOVA Test.

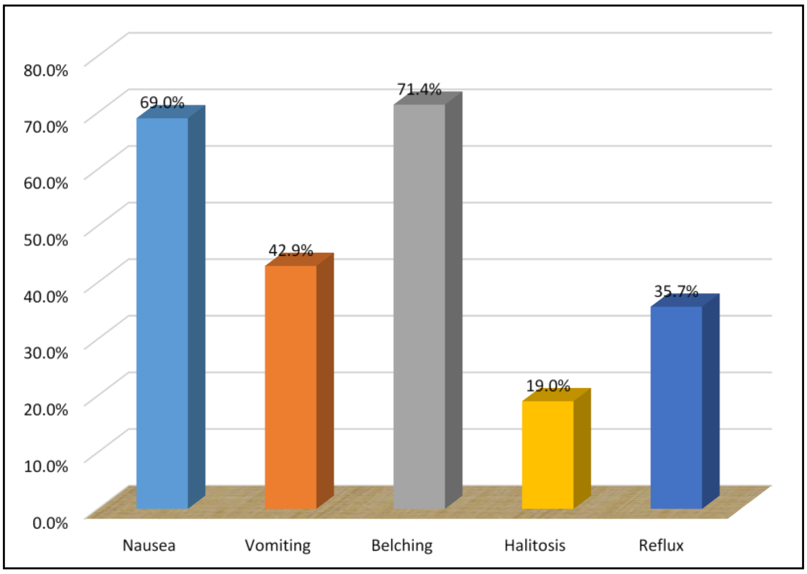

Figure 1. Distribution of studied patients regarding complications.

4. DISCUSSION

According to physician feedback, the only intragastric balloon used for several years was the Bioenterics Intragastric Balloon (BIB), and only recently have other comparable devices entered the market. By reducing mortality and morbidity risks, intragastric balloons have been crucial in the preoperative management of severely obese patients scheduled for bariatric or other elective surgery [6].
Two important hormones, ghrelin and leptin, are produced and secreted in the control of the body's energy balance [7].
The amount of food expended at each meal is reduced when IGB is present in the stomach. Stretching the stomach wall, however, might alter the hormones secreted by the gastrointestinal tract that control appetite and the body's energy balance [8]. As a result, we assessed the effectiveness of IGB in treating obesity and how it affected ghrelin levels in the blood.
Our study was carried out on 42 morbidly obese patients, age of patients ranged from 22 to 53 years with mean ±SD was 35.79± 8.63 years. There was female predominance as 30 (71.4%) patients were females while 12 (28.6%) patients were males with male to female ratio was 0.4: 1.
The purpose of an IGB is to induce weight reduction and assist with the management of obesity-related comorbidities, with adequate safety. According to **Brill** [4], patients with a BMI of 30 to 40 kg/m^2 (class I and II obesity) should consider an IGB.
In patients with severe or morbid obesity (BMI >40 kg/m^2 to >50 kg/m^2, class III and IV obesity), IGB placement can help in preparation for bariatric surgery by reducing the surgical risk or facilitate non-bariatric interventions that could not be safely performed due to weight limits (i.e., orthopedic surgery, organ transplantation) [5].
The present study showed that mean baseline BMI was 45.77± 3.71Kg/m^2 and the mean waist circumference in studied cases was 137.40± 15.58 cm. The mean extra weight (EW) was 65.65± 8.99 Kg while the mean EW percentage was 51.63%. There was significant rapid decline in anthropometric measurements BMI, weight and waist circumference after one month of IGB placement the decline in measurements continued but slower after 6months and throughout follow up time (p<0.001). The mean BMI change after 1 months was 3.56± 1.16, 6.92± 1.59 after 6 months and 7.64± 1.69 one month after IGB removal. The mean EW loss after 1 months was 9.81± 2.94 Kg, 19.10± 4.07Kg after 6 months and 21.14± 4.49Kg one month after IGB removal. The mean EWL percentage after 1 months was 14.94 %, 29.06% and 32.17% after 1,6 months and one month after IGB removal respectively. The rapid loss of weight might be attributed to the significant nausea and vomiting and gastric upset
Compatible with our study **Mohammed et al.** [9] has reported that the IGB location in the stomach for 6

months caused a statistically significant reduction in body weight and anthropometric measurements EWL was significant (5.54±3.15 and 14.33±11.37 kg at 1 month and 6 months, respectively). Three months later, the drop in body weight and other anthropometric measurements became slowly and the ultimate body mass reduction was smaller. The difference was still significant when compared with the baseline levels, the difference became not significant when compared with their values at BIB removal.

Alternatively, in a study performed by **Ganesh et al.** [10] BIB treatment has a less beneficial influence on body weight loss, about 5.9 kg after 6 months of therapy and 1.9 kg after a year. However, these results might be explained by a smaller initial BM, smaller balloon volume (450 mL) and lack of a concomitant treatment with diet and physical exercise.

In the present study, we eliminated individuals with other comorbidity such diabetes and hypertension, the laboratory data were practically within normal ranges as CBC, renal functions and liver enzymes. As measured by a decrease in the amount of medication needed or a mitigation of the methods used to treat conditions like diabetic mellitus, hypertension, and dyslipidemia, several studies have documented significant changes in patient condition as a result of IGB installation [11,12].

Endocrine as well as motor activities of the stomach, such as gastric distension, accommodation, and emptying, play important roles in the complicated, multi-factorial induction of gastric satiety. Such hormones as ghrelin, leptin, or insulin work together to modulate appetite, maintain energy balance, and mediate a number of metabolic processes [13].

Regarding the Ghrelin level in our study the mean baseline was 889.98± 155.16 pg/ml, increased after 1 month of IGB placement to 1137.98± 178.74 pg/ml, and reaching the peak level after 6 months 1204.98± 178.74 pg/ml. the level decreased significantly one month after removal of IGB to 1072.98± 178.74 pg/ml.

The results obtained by **Mohammed et al.**[9] study affirm these results as the IGB group had lost a large amount of weight in comparison with the control group and ghrelin levels increased significantly in relation to the amount of weight lost compared with the control group although there was a significant increase of ghrelin level after one month of IGB insertion, it decreased gradually to reach its baseline values at 3 months after BIB removal while in the control group, there was an insignificant decrease of ghrelin during the follow-up period (from baseline up to 3 months after BIB removal). The authors hypothesized that mechanical stimulation of gastric wall by balloon contact could probably be responsible for the increased ghrelin in the first few months after BIB placement. Also, the increased plasma ghrelin level is probably related to negative caloric balance during the first month or an adaptive phenomenon [9].

Different from our results, **Martinez-Brocca et al.** [14] revealed that the BIB-induced satiety was not mediated by a modification in the ghrelin levels. The explanation of the differences in ghrelin concentration between the studies may be the measurement of total ghrelin & the inactive form of this peptide. However, in the quoted studies, as in the present study, the total ghrelin was measured.

In the present study, IGB placement was safe and feasible. In all cases it was positioned after sedation only. Mortality and complications were absent. The intragastric balloon associated with proton pump inhibitors (PPIs) and antiemetics was well tolerated without any gastric or esophageal complications such as ulcers or erosions. The main side effect was belching reported in 30 (71.4%) followed by nausea in 29 (69%), vomiting 18 (42.9%). Fifteen (35.7%) patients suffered from reflux and 8 (19%) patients had halitosis.

In agreement with **Genco et al.** [6] who reported that the main side effect was heartburn (53.12% of patients) which was well controlled by medical therapy. Also, **Nikolic et al.** [15] showed that intragastric balloon treatment was majorly burdened with mild complications representing adaptations with the balloon in up to one third of patients. The endoscopic complication rate was low at <5%, and there were no major complications.

Serious adverse events are rare with IGBs. Migration has been reported in 1.4% of cases, small bowel obstruction in 0.3%, and gastric perforation in 0.1% of patients. Few case reports have also demonstrated intestinal obstruction that occurred due to balloon deflation with subsequent distal migration, requiring surgical removal [16–18].

5. CONCLUSION

Obesity is controlled by the balances between energy intake and expenditure. Ghrelin is reduced in those who are obese compared to normal body weight controls. Intragastric balloon therapies are a minimally invasive and temporary methodology to induce weight loss in obese patients. The balloon serves as a restrictive mechanism and promotes the feeling of satiation, as it is a space-occupying device. A new endoscopic method for the treatment of obesity, bioenterics intragastric balloon (BIB), can be an option for patients with morbid obesity, who were the conservative treatment, appears ineffective. On the other hand, surgical procedures, although burdened with numerous complications, seem to be an effective way of permanent weight loss, and Obese subjects who do not qualify for, or do not give consent to, the bariatric procedure constitute a therapeutic problem.

6. REFERENCES

1. Zigman JM, Bouret SG, Andrews ZB. Obesity Impairs the Action of the Neuroendocrine Ghrelin System. Trends Endocrinol Metab [Internet]. 2015/11/02. 2016 Jan;27(1):54–63.
2. Sovetkina A, Nadir R, Fung JNM, Nadjarpour A, Beddoe B. The Physiological Role of Ghrelin in the Regulation of Energy and Glucose Homeostasis. Cureus [Internet]. 2020 May 3;12(5): e7941–e7941.
3. Dimitriadis GK, Randeva MS, Miras AD. Potential Hormone Mechanisms of Bariatric Surgery. Curr Obes Rep [Internet]. 2017 Sep;6(3):253–65.
4. Brill J V. Reimbursement for Endoscopic Bariatric Therapies. Gastrointest Endosc Clin N Am [Internet]. 2017;27(2):343–51.
5. Cho JH, Bilal M, Kim MC, Cohen J, Endoscopy SG for EB and MT of the KS of G. The Clinical and Metabolic Effects of Intragastric Balloon on Morbid Obesity and Its Related Comorbidities. Clin Endosc [Internet]. 2021/01/29. 2021 Jan;54(1):9–16.
6. Genco A, Bruni T, Doldi SB, Forestieri P, Marino M, Busetto L, et al. BioEnterics Intragastric Balloon: The Italian Experience with 2,515 Patients. Obes Surg [Internet]. 2005;15(8):1161–4.
7. Aboulghate M, Elaghoury A, Elebrashy I, Elkafrawy N, Elshishiney G, Abul-Magd E, et al. The burden of obesity in Egypt. Front public Heal. 2021;1247.
8. Cummings DE, Overduin J. Gastrointestinal regulation of food intake. J Clin Invest [Internet]. 2007 Jan;117(1):13–23.
9. Mohammed MA, Anwar R, Mansour AH, Elmasry E, Othman G. Effects of Intragastric Balloon Versus Conservative Therapy on Appetite Regulatory Hormones in Obese Subjects. Trends Med Res [Internet]. 2014;9(2):58–80.
10. Ganesh R, Rao AD, Leese T, Baladas HG. Laparoscopic Adjustable Gastric Banding in a Patient with an Incidental <I>Para-Hiatal</I> Hernia. Obes Surg [Internet]. 2006;16(1):98–101.
11. Negrin Dastis S, François E, Deviere J, Hittelet A, Ilah Mehdi A, Barea M, Dumonceau J. Intragastric balloon for weight loss: results in 100 individuals followed for at least 2.5 years. Endoscopy [Internet]. 2009;41(07):575–80.
12. Masalaite L, Valantinas J, Stanaitis J. Endoscopic ultrasound findings predict the recurrence of esophageal varices after endoscopic band ligation: A prospective cohort study. Scand J Gastroenterol. 2015;50(11):1322–30.
13. Steinert RE, Feinle-Bisset C, Asarian L, Horowitz M, Beglinger C, Geary N. Ghrelin, CCK, GLP-1, and PYY (3-36): Secretory Controls and Physiological Roles in Eating and Glycemia in Health, Obesity, and After RYGB. Physiol Rev [Internet]. 2017 Jan;97(1):411–63.
14. Martinez-Brocca MA, Belda O, Parejo J, Jimenez L, del Valle A, Pereira JL, et al. Intragastric Balloon-Induced Satiety is Not Mediated by Modification in Fasting or Postprandial Plasma Ghrelin Levels in Morbid Obesity. Obes Surg [Internet]. 2007;17(5):649–57.
15. Nikolic M, Boban M, Ljubicic N, Supanc V, Mirosevic G, Pezo Nikolic B, et al. Morbidly Obese are Ghrelin and Leptin Hyporesponders with Lesser Intragastric Balloon Treatment Efficiency. Obes Surg [Internet]. 2011;21(10):1597–604.
16. MP D, R S, I R, S S, R P, V B. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents and adults. Yearb Paediatr Endocrinol [Internet]. 2018;
17. Müller TD, Nogueiras R, Andermann ML, Andrews ZB, Anker SD, Argente J, et al. Ghrelin. Mol Metab [Internet]. 2015 Mar 21;4(6):437–60.
18. Muniraj T, Day LW, Teigen LM, Ho EY, Sultan S, Davitkov P, et al. AGA Clinical Practice Guidelines on Intragastric Balloons in the Management of Obesity. Gastroenterology [Internet]. 2021;160(5):1799–808.