Research Article

Weight Regain Following Laparoscopic Sleeve Gastrectomy in Morbid Obesity

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Abstract: Background: Sleeve gastrectomy is the common bariatric procedure done for morbid obesity, but, there are limited studies available, specifically from South Asia. In Pakistan, no such study has been done before.

Objective: The main outcome of the study was Excess weight loss (EWL) and Weight Regain (WR) after Laparoscopic sleeve gastrectomy and to see improvement in co-morbid associated with morbid obesity.

Materials and Methods: The patients who underwent Laparoscopic sleeve gastrectomy for morbid obesity were analyzed retrospectively. From June 2017 to June 2019, in a tertiary care hospital in Pakistan. Patients whose BMI exceeds 40 kg/m² or falls between 35-39 kg/m² accompanied by one or more comorbidities, and have undergone at least three years of follow-up. Redo procedures of LSG were excluded. Data was obtained from patients' charts and hospital database, and last follow-ups were done by telephonic survey.

Result: In 171 patients 56.72% were female. Mean BMI was 48.5kg/m^2. %EWL was 77.90% and total body weight loss was (% TBWL) 39.48. Weight regain WR was 25.7 %, Regain of > 25%EWL was 14%. Increase in BMI >5/kgm^2 was 17.5%. DM remission was 70% (28 pts) while in 30% (12) improved. Hypertension in 54.28% (38) pts improved and in 45.71% (32) hypertension completely resolved. Obstructive sleep apnea was resolved completely by 93.6 % (44). Osteoarthritis improved (by 78.4 %). GERD was developed *in vivo* in 14% of patients postoperatively. Lap chole for symptomatic gall stones was done in 9.35% of post-lap sleeve gastrectomy patients during follow-up.

Conclusion: Weight regain after sleeve gastrectomy was significant, but, still the post-operative co-morbid remission was promising.

Keywords: Sleeve gastrectomy, Weight regain, BMI, Comorbid resolution, Type 2 DM, GERD, Obstructive sleep apnea, Excess weight loss, Fatty liver disease.

INTRODUCTION

In the twenty-first century, changes in population characteristics, increase urbanization, calorie-dense fast-food availability, and digitalization greatly affected the human lifestyle and food habits leading to an increase in obesity. Most of the adverse effects of obesity are noncommunicable illnesses that are preventable by preventing Obesity itself [1]. According to World Health Organization (WHO), more than 650 million people were obese globally in 2016 [2].

Obesity is related with various co-morbids including metabolic syndrome, type 2 DM, HTN, Cardiovascular diseases osteoarthritis Respiratory problems, psychological impact, depression, and gastrointestinal and breast cancer are thought to be associated with Obesity.

Sleeve gastrectomy, founded in 1999, has become a famous therapeutic modality for surgical treatment of different degrees of obesity [3]. However, weight regains after sleeve gastrectomy is a well-known complication, and is relatively high in different series [4].

Different definitions are used for Weight regain, (Table **1**) [5]. Long-term studies have reported the incidence of weight to regain following SG is significant. One study reported 5 to 39 % [6]. Weight regain leads to the recurrence of obesity-related comorbid [7]. The weight regain after sleeve gastrectomy is not fully understood, but seems multifactorial. An integrative review showed: 1) remnant antrum size, 2) bougie size, 3) increase level of appetite hormone, 4) poor lifestyle, and a lack of exercise are possible factors [8]. South Asian like India and Pakistan differ from western populations in lifestyle body composition, nutrition intake, lower lean body mass, increase visceral fat. South Asian have high visceral fat, this is so-called central obesity leads to a higher rate of metabolic syndrome, Insulin resistance, and an increase rate of cardiovascular diseases among Asian populations [9]. The purpose of this study was to see long-term results regarding excess weight loss (EWL) and weight regain (WR) after laparoscopic sleeve gastrectomy.

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Table 1. Criteria of Weight Regain after Bariatric Surgery.

Definition
1. An increase of more than 10kg from nadir weight.
2. An increase of more than 25%EWL from nadir weight.
3. An increase in BMI of 5 kg/m^2 from nadir.
4. An increase of more than 15% total body weight from nadir.
5. Weight regain to a BMI > 35 kg/m^2 after successful loss.
6. An increase of ≥15% of the lowest postoperative weight.

Kg: Kilogram; %EWL: Percent excess weight loss; BMI: Body mass index; m: Meters; T2DM: Type two diabetes mellitus.

MATERIALS AND METHODS

The study was approved by institutional review board. (Ref: 19-22.) The data was collected and analysed from a prospectively maintained database also files of patients were reviewed, from June 2016 to June 2019. Who were followed in clinics and the last follow-up was done by telephonic calls and what's app. The age was between 18 to 70 years and BMI >40 kg/m^2 or 35-39kg/m^2 with one or more obesity-related co-morbid.

The patients with Redo sleeve gastrectomy and follow-up less than 3 years were excluded. Also, patients with gastroesophageal reflux disease/Hiatus hernia, acute psychosis, alcohol addiction or drug abuser were excluded.

Preoperatively all relevant work up was done, upper gastro intestinal endoscopy has been performed in selective patients with symptoms of GERD to assess and R/O possible hiatus Hernia.

Super obese patients were put on 2 weeks of pre-op dieting to reduce liver size.

Data Collection

At pre-formed proforma, all the data were collected from the file and other recorded databases, including demographic intra-operative and post-operative results, were obtained, follow-up recorded and then each patient was called on the phone as the last follow-up to June 2022, for the of lowest recorded weight and current weight, any complications, and improvement or recurrence in co-morbid was recorded. If got weight regains (WR) or insufficient weight loss, the reason was inquired about lifestyle dietary habit, exercise.

Weight Regain

Percent %WR was defined as currently recorded weight-lowest recorded weight/pre-op weight-lowest recorded weight. We have used three common formulas used nowadays in literature [10] .

[1] Regain of > 10kg from nadir weight.
[2] Regain of > 25%EWL from nadir weight.
[3] Regain >5 BMI points from the nadir BMI.

Weight Loss

%TWL= Weight loss/initial weight x100.

Percent of Excess weight loss (%EWL) was calculated by using the formula.

%EWL=pre-operative weight--post-operative weight/pre-operative weight-ideal weightx100.

STATISTICAL ANALYSIS

Data analysis was done using by SPSS version 21.0. For continuous variables, results were shown as mean and standard deviation (SD). For continuous variables comparison between the groups was done using paired t-test, while chi square was run for categorical variables. Linear and logistic regression analyses were performed to evaluate the effects of various compounders like age, gender, bougie size, BMI. The p-value < 0.05 was considered significant.

RESULT

There were 205 patients who underwent laparoscopic sleeve gastrectomy for morbid obesity, between June 2016 and June 2019. 171 patients had complete follow-up, were included in the analysis. The 34 patients excluded from the study were 7 patient refused to participate, 12 patients follow up was incomplete and 15 patients were not available. There were 97(56.7%) female and 74(43.3%) male patients. The mean age was 35.5 years (±9.67). The mean and standard deviation of preoperative weight was 134.7(±30.38), and BMI was 48.53(±9.40) (Table **2**).

Table 2. Demographic Data Before LSG.

	Value	% (SD)(range)
Gender (Female/Male)	97/74	56.7%43.3%
Mean (age)	35.57	(± 9.6)
Median (BMI)	48.53	(± 9.40)
Mean Weight (kg)	134.71	(± 30.38)
Mean Height (in meters)	1.663	(±.101)

Hypertension was present in 40.93%(70), Diabetes was present in 23.4%(40), Osteoarthritis was prevalent in 84.2%(144), snoring in 70.8%(121), Obstructive sleep apnoea was present in 25.7 %(44). Exertional dyspnea in 84.2%(144). Low back ache 78.9% (135). Only 6.4% patients were regular exercise, rest were having sedentary lifestyles. In our cohort, 18.7%(32) were smokers.

Our mean operating time was 89.87 min (±35.75). We used 36 F bougie and the distance from the pylorus was 4-6 centimetres. We achieved average follow-up of 4 years. 85% (3 years), 38.6% (4 years), and 11.7% (5 years) (Fig. **1**).

The mean percent of excess weight loss (%EWL) was 77.90(±20.11). Percent of total weight loss (%TWL) 39.48(±

12.16). Change in mean BMI was 19.80 (±9.3). The excess weight loss was more than 50% in 88.9 % (152 patients), while 11.1 % (19 patients.) EWL was less than 50% (with insufficient weight loss).

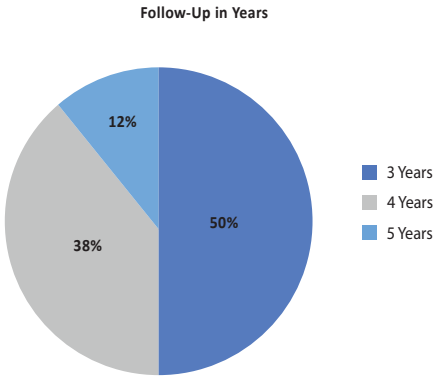

Fig. (1). Follow-Up

Weight Regains (WR)

According to formula 1 weight regain>10 kg from nadir weight was 25.7 % (44). 2) Regain of >25%EWL from nadir was 14% (24). 3) Change in BMI >5 kg /m^2, 17.5% (30) respectively. We achieved above weight regains according to 3 formulas at an average follow-up of 4 years (Table **3**).

Table 3. Weight Regain in our Cohort according to Six Standard Formulas in the Literature.

Definition of Patients with Weight Regain	n (%)
1. An increase of >10 kg from nadir	44(25.7%)
2. An increase of more than 25%EWL from nadir	24(14%)
3. An increase in BMI of 5 kg/m^2	30(17.5%)
4. An increase of >15% of total body weight from nadir	22(12.9%)
5. Weight regains to a BMI >35kg/m^2 after successful weight loss	20(11.7%)
6. An increase of ≥15% of the lowest postoperative weight	35(20.5%)

The weight regain was higher in female (Table **4**).

Table 4. Weight Regains according to Gender using >10 kg From Nadir.

Sex	n (%)
Male	17(22.9%)
Female	27(27.8%)
Total	44(25.7%)

In this cohort, DM was present in 23.4% (40). 70 % (28) DM resolved completely while in 30%(12) patients improved. 40.93% (70 patients) were hypertensive. 54.28% (38) pts improved, while 45.71% (32 patients) hypertension completely resolved. Obstructive sleep apnoea was present in 27.48% (47). 93.6 % (44) OSA completely resolved while in 8.5% (4) improved. Osteoarthritis was present in 84.2% (144) improved, in 78.4 % (113) and resolved in 21.52% (31). GERD was developed *in vivo* in 14% (24) patients postoperatively and a history of hair loss in 30% (52) temporarily which later subsided. Polycystic ovary syndrome (PCOS) was present in 13.45% (23 pts PCOS resolved in 18 pts 78.26%. Lap cholecystectomy was done in 9.35% (16) pts during follow-up for symptomatic gall stones after sleeve gastrectomy (Table **5**).

Table 5. Clinical Characteristics of the Patients undergoing Lap Sleeve Gastrectomy.

Characteristics	Pre-operative %(n)	Post-operative %(n)	
		Resolved	Improved
Hypertension	40.93% (70)	45.71% (32)	54.28% (38)
Diabetes	23.4% (40)	70% (28)	30% (12)
Obstructive Sleep Apnea (OSA)	27.4% (47)	93.6% (44)	6.3% (3)
Osteoarthritis	84.2% (144)	21.52% (31)	78.4% (113)
Polycystic ovaries (PCOS)	13.45% (23)	78.26% (18)	21.7% (5)

DISCUSSION

Sleeve gastrectomy is the common bariatric procedures done for obesity [11]. There are many are many studies in the literature addressing the results of Lap sleeve gastrectomy in obesity, but scarce data available from Asia and none from Pakistan. This study is the first one in Pakistan to look for the results of laparoscopic sleeve gastrectomy in obesity, especially in the context of excess weight loss (EWL) and weight regain (WR). And also to see improvement or resolution of obesity-related co-morbid like diabetes, and other co-morbidities. Our study includes 205 patients. We achieved 83.41% (171) patients) complete follow-up.

In our study female patients were dominant at 56.7%. like in other studies [12, 13]. The mean age was 35.5 yrs. which shows the majority were young and middle age. The major co-morbid were Diabetes Mellitus, hypertension, Osteoarthritis, and obstructive sleep apnoea. Successful surgery for weight loss was defined as % TWL more than 10% or % EWL mora than 50 %. We had a mean percent of weight loss (% TWL) of 39.48 (± 12.46), Excess weight loss (% EWL) of 77.79% (±20.11). Our results were in accordance with other studies %TWL was 31.3±8.9 and %EWL 76.3±25.5 and a similar study by Garg H, *et al*. %EWL was 72%±22.35 (25). There was an 88.9% (152

pts) %EWL was more >50% while 11.1% that is 19 pts. %EWL <50% [14].

Weight regain is a known late complication after weight loss following laparoscopic sleeve gastrectomy [15]. Insufficient weight loss is defined as achieved less than 50% EWL [16]. Weight regain and insufficient weight loss has different causative mechanisms and management [17].

Weight regain (WR) is one of the complication after sleeve gastrectomy, like in any other bariatric surgery [18] Weight Regain was the main outcome in our study, it was 25.7% by applying the formula Regain >10kg from Nadir weight. 14% by using regain>25% EWL and 17.5% by Change in BMI >5 kg /m^2, according to the standard formula used. This is comparable with the literature Shivanshu Misra *et al*. [19] weight regain was 17.6% at 3 years and 39.1 % at 5 years. Similarly according to Noel *et al*. [20] weight regain was 41.7% in long-term follow-up. In a cross sectional Saliba *et al.* reported weight regains 5.7% by two year follow up [21].

Bohdjalian *et al*. reported 19.2% weight regain after follow up for five years [22] ,while another meta-analysis showed that the percentage of weight regain was 27.8% at seven years follow up [23].The average follow-up of our cohort was 4 years ranging from 3 years to 5 years. And WR was 17.6 to 25.7%. The other secondary outcome of our study like DM was resolved completely by 70% and improved by 30% compared with the literature [24], a study by Shivanshu Misra *et al*. showed 71.4 % diabetes remission and 21.4 % improvement [25].

A study by Wang X, *et al*. at 3 years follow-up, the percentage of remission was (71.4%) while improvement was found at (17.8%) [17, 26]. There were 70 patients (40.93%) with hypertension in our cohort. Hypertension improvement seen in (54.28%) 38 patients and study by Piotr K. Kowalewski *et al*. [27]. Post sleeve gastrectomy, 28% hypertension completely resolved and in 31% patients improved. In another study by Wang X, hypertension was resolved by 43.1%.

In a study by Hamilton *et al*. obstructive sleep apnea is found in 58% obese patients [28]. Severe OSA is associated with a high risk of cardiovascular diseases, stroke and sudden death. Weight loss following Sleeve gastrectomy will result in improvement of Obstructive sleep apnea. In our study OSA completely resolved in. 90.9 % 40 patients, while in 8.5 % 4 patients Improved. Continuous positive air way pressure was not needed post-operatively. 50.7% patients had OSA preoperatively, after LSG 100% improvement was seen. Osteoarthritis was in 84.2(144) improved in 78.4 %(113) and resolved in 21.52% [22, 29]. GERD was developed *in vivo* in 14% of our cohort which is in literature (range from 11-33%) [12]. Postoperatively, history of hair loss in 30% temporarily was later on subsided. Polycystic ovary syndrome (PCOS) symptoms like menstrual irregularities, hirsutism, and hormonal abnormalities resolved in 78.26% but no clear-cut improvement in infertility could be identify as a result of bariatric surgery without a case controlled or randomized studies [30, 31]. Causes of weight regain are either primary or secondary. If the total capacity of the sleeve is more than 250 ml, it will result in primary failure. Gradual increase in the stomach size over time with increase ghrelin level lead to increase appetite resulting in secondary failure. Other factors responsible for weight regain, calorie dense diet and sedentary life style. As South In our patients there was lack of exercise, increase intake of carbohydrate poor regular follow-up and noncompliance.

The incidence of gall stones was higher, for which laparoscopic cholecystectomy was done in 9.35% of the patients postoperatively, which is comparable to a study by Hasan *et al*. [32].

LIMITATION

The limitation of this study was, last follow-up was performed on the telephone, which, may be affected by recall bias, and the comorbid improvement was analyzed on a patient narrative of discontinuing medicine and therapy prescribed by other physicians. Also, some cultural norms of eating excess meat and refined carbohydrates especially in Pushtoonkhwa (The northwest region of Pakistan), was not taken into account, which was evident from the reasons of weight regain patients interviewed.

RECOMMENDATION

Further research with larger sample size and multicentre studies are recommended to enhance the better extrapolation of results.

CONCLUSION

Laparoscopic sleeve gastrectomy successfully reduce weight in morbid obesity, with good results in remission in T2DM and the resolution obesity related comorbidities Hypertension, Obstructive sleep apnea, Osteoarthritis, and fatty liver disease. However Weight regains (WR) after Laparoscopic Sleeve gastrectomy is a clinical problem. It is well reported in the literature and obvious from this study and needs to be addressed in future studies regarding change in techniques or modifying procedure.

ABBREVIATIONS

BMI: Body Mass Index.
DM: Diabetes Mellitus.
EWL: Excess Weight Loss.
GERD: Gastroesophageal Reflux Disease.
LAG: Laparoscopic Sleeve Gastrectomy.
OS: Osteoarthritis.
OSA: Obstructive Sleep Apnea.
PCOS: Poly Cystic Ovary Syndrome.
PTS: Patients.
SD: Standard Deviation.
TBWL: Total Body Weight Loss.
WR: Weight Regain.
WHO: World Health Organization.

AUTHORS' CONTRIBUTION

- **Allauddin**: Design and Main idea.
- **Ghulam Siddiq**: Concept of the study.
- **Muhammad Sohaib Khan**: Proforma designing.
- **Gulalai Rehman**: Data analysis, Nutritional follow-up.
- **Tehreem Zahid**: Follow-up, Data analysis.

CONFLICT OF INTEREST

Declared none.

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Declared none.

REFERENCES

[1] Purnell JQ. Definitions, Classification, and Epidemiology of Obesity. South Dartmouth (MA): MDText.com, Inc 2015; Available from: https://europepmc.org/books/nbk279167. [cited 2024 Jul 17].

[2] Haththotuwa RN, Wijeyaratne CN, Senarath U. Worldwide epidemic of obesity. In: Mahmood TA, Arulkumaran S, Chervenak FA, Eds. Obesity and Obstetrics. 2nd ed. UK: Elsevier 2020; pp. 3-8.

[3] Kichler K, Rosenthal RJ, DeMaria E, Higa K. Reoperative surgery for nonresponders and complicated sleeve gastrectomy operations in patients with severe obesity. An international expert panel consensus statement to define best practice guidelines. Surg Obes Relat Dis 2019; 15(2): 173-86.

[4] Martin MJ, Topart P. "Comment on: Conversion of sleeve gastrectomy to Roux-en-Y gastric bypass: An audit of 34 patients" and "Weight loss, weight regain, and conversions to Roux-en-Y gastric bypass–10-year results of laparoscopic sleeve gastrectomy". Surg Obes Relat Dis 2016; 12(9): 1651-4.

[5] Lauti M, Lemanu D, Zeng IS, Su'a B, Hill AG, MacCormick AD. Definition determines weight regain outcomes after sleeve gastrectomy. Surg Obes Relat Dis 2017; 13(7): 1123-9.

[6] Sheppard CE, Lester EL, Chuck AW, Birch DW, Karmali S, de Gara CJ. The economic impact of weight regain. Gastroenterol Res Pract 2013; 2013(1): 379564.

[7] Chin W-L, Tu W-L, Yang T-H, Chen C-Y, Chen J-H, Hung T-T. Impact of recurrent weight gain thresholds on comorbid conditions progression following laparoscopic sleeve gastrectomy. Obes Surg 2024; 34(7): 2347-55.

[8] Yu Y, Klem ML, Kalarchian MA, Ji M, Burke LE. Predictors of weight regain after sleeve gastrectomy: An integrative review. Surg Obes Relat Dis 2019; 15(6): 995-1005.

[9] Iliodromiti S, McLaren J, Ghouri N, *et al*. Liver, visceral and subcutaneous fat in men and women of South Asian and white European descent: A systematic review and meta-analysis of new and published data. Diabetologia 2023; 66(1): 44-56.

[10] Nedelcu M, Khwaja H, Rogula T. Weight regain – how to define it? Surg Obes Relat Dis 2016; 12(5): 1-2.

[11] Chopra A, Chao E, Etkin Y, *et al*. Laparoscopic sleeve gastrectomy for obesity: Can it be considered a definitive procedure? Surg Endosc 2012; 26(3): 831-7.

[12] Capoccia D, Guida A, Coccia F, *et al*. Weight regain and diabetes evolution after sleeve gastrectomy: A cohort study with over 5 years of follow-up. Obes Surg 2020; 30(3): 1046-51.

[13] Magro DO, Geloneze B, Delfini R. Long-term weight regain after gastric bypass: A 5-year prospective study. Obes Surg 2008; 18(6): 648-51.

[14] Garg H, Aggarwal S, Misra MC, *et al*. Mid to long term outcomes of laparoscopic sleeve gastrectomy in Indian population: 3-7 year results – A retrospective cohort study. Int J Surg 2017; 48: 201-9.

[15] Ansari El W, Elhag W. Weight regain and insufficient weight loss after bariatric surgery: Definitions, prevalence, mechanisms, predictors, prevention and management strategies, and knowledge gaps - a scoping review. Obes Surg 2021; 31(4): 1755-66.

[16] Franken RJ, Franken J, Sluiter NR, *et al*. Efficacy and safety of revisional treatments for weight regain or insufficient weight loss after Roux-en-Y gastric bypass: A systematic review and meta-analysis. Obes Rev 2023; 24(10): e13607.

[17] Lauti M, Kularatna M, Hill AG, MacCormick AD. Weight regain following sleeve gastrectomy—a systematic review. Obes Surg 2016; 26(6): 1326-34.

[18] Athanasiadis DI, Martin A, Kapsampelis P, Monfared S, Stefanidis D. Factors associated with weight regain post-bariatric surgery: a systematic review. Surg Endosc 2021; 35(8): 4069-84.

[19] Misra S, Bhattacharya S, Kumar SS, Nandhini BD, Saminathan SC, Raj PP. Long-term outcomes of laparoscopic sleeve gastrectomy from the Indian subcontinent. Obes Surg 2019; 29(12): 4043-55.

[20] Noel P, Nedelcu M, Nocca D, *et al*. Revised sleeve gastrectomy: Another option for weight loss failure after sleeve gastrectomy. Surg Endosc 2014; 28(4): 1096-102.

[21] Saliba C, El Rayes J, Diab S, Nicolas G, Wakim R. Weight regain after sleeve gastrectomy: A look at the benefits of re-sleeve. Cureus 2018; 10(10): e3450. . DOI 10.7759/cureus.3450

[22] Bohdjalian A, Langer FB, Shakeri-Leidenmühler S, *et al*. Sleeve gastrectomy as sole and definitive bariatric procedure: 5-year results for weight loss and ghrelin. Obes Surg 2010; 20(5): 535-40.

[23] Clapp B, Wynn M, Martyn C, Foster C, O'Dell M, Tyroch A. Long term (7 or more years) outcomes of the sleeve gastrectomy: A meta-analysis. Surg Obes Relat Dis 2018; 14(6): 741-7.

[24] Switzer NJ, Prasad S, Debru E, Church N, Mitchell P, Gill RS. Sleeve gastrectomy and type 2 diabetes mellitus: A systematic review of long-term outcomes. Obes Surg 2016; 26(7): 1616-21.

[25] Misra S, Bhattacharya S, Kumar SS, *et al*. Long-term outcomes of laparoscopic sleeve gastrectomy from the Indian subcontinent. Obes Surg 2019; 29(12): 4043-55.

[26] Wang X, Sheng CX, Gao L, *et al*. Effectiveness of laparoscopic sleeve gastrectomy for weight loss and obesity-associated co-morbidities: A 3-year outcome from Mainland Chinese patients. Surg Obes Relat Dis 2016; 12(7): 1305-11.

[27] Kowalewski PK, Olszewski R, Walędziak MS, *et al*. Long-term outcomes of laparoscopic sleeve gastrectomy—a single-centre, retrospective study. Obes Surg 2018; 28(1): 130-4.

[28] Hamilton GS, Joosten SA. Obstructive sleep apnoea and obesity. Aust Fam Physician 2017; 46(7): 460-3.

[29] Gill RS, Al-Adra DP, Shi X, Sharma AM, Birch DW, Karmali S. The benefits of bariatric surgery in obese patients with hip and knee osteoarthritis: A systematic review. Obes Rev 2011; 12(12): 1083-9.

[30] Luo P, Su Z, Li P, *et al*. Effects of sleeve gastrectomy on patients with obesity and polycystic ovary syndrome: A meta-analysis. Obes Surg 2023; 33(8): 2335-41.

[31] Butterworth J, Deguara J, Borg CM. Bariatric surgery, polycystic ovary syndrome, and infertility. J Obes 2016; 2016: 1871594.

[32] Hasan MY, Lomanto D, Loh LL, So JBY, Shabbir A. Gallstone disease after laparoscopic sleeve gastrectomy in an Asian population - what proportion of gallstones actually becomes symptomatic? Obes Surg 2017; 27(9): 2419-23.

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