Annals of Bariatric Surgery

*Original Article*

# Therapeutic effects of obesity surgery on glucose control in patients with type 2 diabetes

Saeed Safari [1], Amir Samadi Afshar [1*], Mahdi Alemrajabi [1], Massoud Baghai Wadji [1], Nahid Hashemi Madani [2]

Received: Feb 04,2021/ Published Online: Feb 18, 2021

## Abstract

**Background:** Obesity is considered as an independent risk factor for type 2 diabetes (T2D) and other metabolic diseases. Obesity accounts for about 55% of diabetes. This study aimed to investigate the therapeutic effects of obesity surgery on glucose, HbA1C, insulin and C-peptide serum levels in the patients with T2D.

**Methods and materials:** This prospective cohort study carried out on 25 patients aged between 18-70 years who had with T2D and body mass index above 40 kg /$m^2$. Fasting blood sugar (FBS) level, HbA1C and Two-hour postprandial (2HPP), insulin level, and C-peptide were measured in all patients before surgery and the patients were fully evaluated for the presence of diabetes complications. The patients underwent Roux-en-Y Gastric Bypass (RYGB), mini-gastric bypass, and sleeve gastrectomy, and were re-evaluated 24 hours, one week, two month, and six months after surgery.

**Results**: Twenty-five people underwent (sleeve gastrectomy for 12 cases, RYGB for 7 cases and mini-bypass surgery for 6 cases). Twenty cases (80.0%) were women and five cases (20.0%) were men. The mean age of the patients was 46.16 ± 10.97 years (25-67 years). The mean fasting blood sugar, 2HPP, HbA1C, insulin, and C-peptide in general and in all three groups showed a significant decrease.

**Conclusion**: The findings of the study showed that all three surgical procedures were effective in improving T2D by six months after surgery.

**Keywords**: Type 2 diabetes, obesity surgery, sleeve, mini bypass, classic bypass.

## Introduction

Obesity is one of the most important global health problems increasing the likelihood of developing hypertension, dyslipidemia, cardiovascular disease and diabetes (1). According to the definitions, people with a body mass index (BMI) of 25 to 29.9 (kg/m2) are overweight, and people with a BMI of 30 kg/m2 are considered obese, and people with a BMI above 40 (kg/m2) is defined as morbid obesity (2). It is estimated that about 69% of the population in the United States is overweight or obese (3). Studies conducted in Iran also show that more than 21% of the populations over the age of 18 years are obese (4). Medical, psychological and economic complications of the obesity have important consequences for any societies (5, 6). Diagnostic criteria for Type 2 diabetes (T2D) are based on the fasting blood glucose (FBS)>126 mg/dl, BS>180mg/dl and HbA1C≥ 6.5% (7). Obesity is considered as an independent risk factor for T2D and other metabolic conditions. Obesity accounts for about 55% of diabetes. (7). Up to 48.8% of the patients with diabetes are obese (8).

*1. Department of General Surgery, School of Medicine, Firoozgar General Hospital, Iran University of Medical Sciences, Tehran, Iran*
*2. Endocrine Research Center, Institute of Endocrinology and Metabolism, Iran University of Medical Sciences, Tehran, Iran*

*Amir Samadi Afshar, Samadiafshar.a@iums.ac.ir*

The first treatment for the patients with T2D is to change lifestyle and weight loss. Various studies have shown that weight loss in the obese patients with T2D improves the secretion of insulin and reduces insulin resistance in these patients and reduces HbA1C levels by 0.6 to 1% (9). Reducing calorie intake and increasing physical activity are the first recommended strategies for weight loss in these patients (10). However, regime adherence of the obese patients is low leading to unsuccessful diet and exercise program, and also improvement in blood sugar control is achieved in less than 50% of the cases. Therefore, most patients need medical treatment or surgery to lose weight (11).

Bariatric surgeries can cause weight loss in two main ways including absorption and restriction. Restriction methods such as the sleeve method reduce calorie intake by reducing gastric capacity through bypassing, or creating a proximal gastric outlet. Absorption methods reduce the effect of nutrient absorption by shortening the functional length of the small intestine. A number of bariatric surgery methods such as Roux-en-Y gastric bypass (RYGB), which is the most common surgical procedure, can help to lose weight by the absorption and restriction ways (12). A number of clinical trial studies have shown that obesity surgery can lead to the remission of diabetes (13-15). It has been found that people who undergo bariatric surgery are 9.8 to 15.8 times more likely to improve diabetes than those who undergo conventional treatment (16). Therefore, obesity surgery has been introduced by the American Diabetes

*Published Online: Feb 18, 2021*

Association as an effective treatment for T2D (17, 18). Since the subject of this study has not been done to evaluate the effect of bariatric surgeries on diabetes control in Iran and also the effect of mini bypass surgery (Loop) and also, in studies, the effect of mini-gastric bypass (Loop) and also the short-term effect of these surgeries on diabetes control have not been studied, this study aimed to investigate the therapeutic effects of obesity surgery (RYGB, mini-gastric bypass, and sleeve gastrectomy) on glucose, HbA1C, insulin and C-peptide serum levels in patients with T2D.

## Methods

The study was performed as a prospective cohort on 25 patients referred to the obesity clinic of Firoozgar hospital in Tehran from April 2018 to April 2019. According to the study by Brethauer et al. (13), and using the following formula, the sample size was obtained 25.

$$n = \left( \sigma \frac{z_{1-\alpha} + z_{1-\beta/2}}{\delta - |\mu - \mu_0|} \right)^2$$

The method of sampling was convenient (non-randomized). Inclusion criteria were body mass index above 40 kg/m2, age between 18-70 years, having T2D (under previous treatment or with preoperative diagnosis). Exclusion criteria were having type I diabetes, history of major abdominal surgery, heart failure, chronic obstructive pulmonary disease (COPD), cirrhosis and liver failure, malignancy, and addiction. Fasting blood sugar, HbA1C and 2HPP, insulin level, c-peptide were measured in all patients before surgery. Then the patients underwent one of the three methods of RYGB, mini-gastric bypass and sleeve gastrectomy and were evaluated again 24 hours, one week, two month and six months after the surgery. We did not check remission but improvement in glycemic indices were investigated.

**Ethical issue:** The study was reviewed and approved by the committee of Iran University of Medical Sciences (IR.IUMS.FMD.REC.1397.225). Additionally, this study was taken from medical residential thesis of general surgery.

**Statistical analysis:** The data were analyzed through SPSS version 20. Descriptive statistics for variables were expressed in terms of their type, frequency, percentage, mean and standard deviation. In order to compare quantitative variables overtime, Friedman test as nonparametric test was used. Normality was assessed by Kolmogorov-Smirnov test. P value less than of 0.05 was considered significant.

## Results

In this study, 25 patients underwent surgery (sleeve surgery for 12 patients, classical surgery for 7 cases and mini bypass surgery for 6 patients). Regarding gender, 20 patients (80.0%) were female and 5 patients (20.0%) were male. The mean age of the patients was 46.16±10.97 years. The minimum age of the patients was 25 years and the maximum was 67 years. Regarding comorbidity, 5 patients (20%) had hypothyroidism, 3 patients had hypertension (12%), 2 patients had fatty liver (8%), 2 patients had gout (8%), and 2 patients had ischemic heart disease (8%).

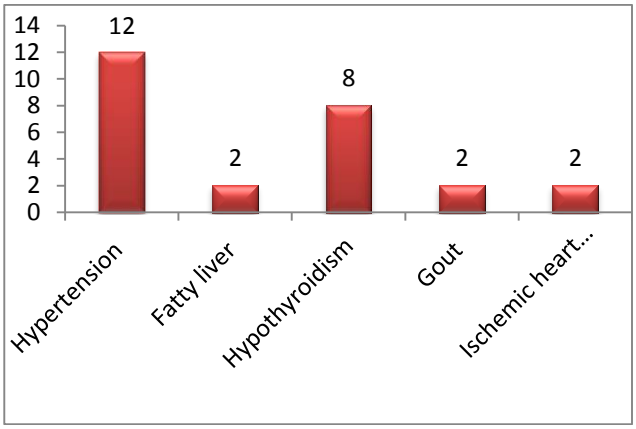


**Figure 1**: Comorbidity of the patients under went bariatric surgeries

Determination of the mean BMI before, 2 months and 6 months after obesity surgery in obese patients with T2D was presented in figure 2 and table 1.

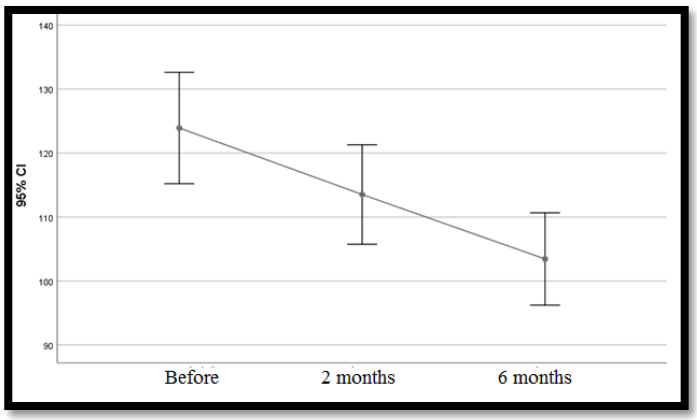


**Figure 2**: BMI before, 2 months and 6 months after obesity surgery in the patients

**Table 1**: BMI before, 2 months and 6 months after obesity surgery in the patients

| Variable | Mean | Std. Deviation | Chi-square | P value |
|---|---|---|---|---|
| BMI admission | 46.90 | 6.204 | 50 | <0.001 |
| BMI 30 days | 42.96 | 5.517 | | |
| BMI 90 days | 39.11 | 4.818 | | |

Determination of the mean FBS before and 24 hours, one week, 2 months and 6 months after obesity surgery in obese patients with T2D presented in figure 3.

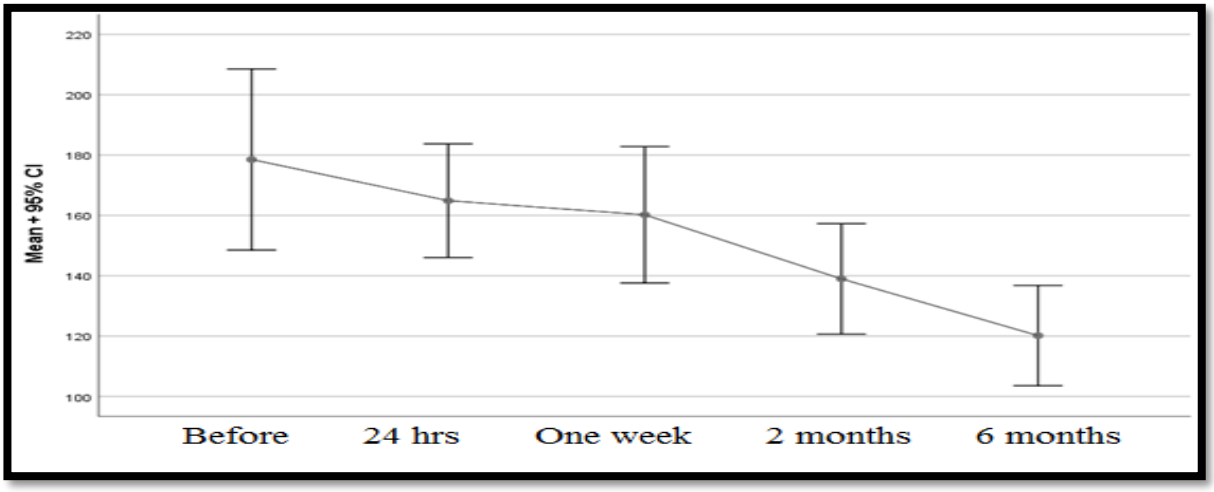


**Figure 3**: FBS before and 24 hours, one week, 2 months and 6 months after obesity surgery in the patients

**Table 2**: FBS before and 24 hours, one week, 2 months and 6 months after obesity surgery in the patients

| Variable | Mean | Std. Deviation | Chi-square | P value |
|---|---|---|---|---|
| FBS admission | 179.60 | 70.991 | 41.218 | <0.001 |
| FBS 24-hour | 164.88 | 45.666 | | |
| FBS one week | 160.20 | 54.790 | | |
| FBS 2 months | 138.96 | 44.338 | | |
| FBS 6 months | 119.76 | 39.665 | | |

The level of mean insulin, HbA1C and c-peptide decreased over the time as well. Determination of the mean 2HPP before, one week, 2 months and 6 months after obesity surgery in obese patients with T2D was presented in figure 4 and table 3.

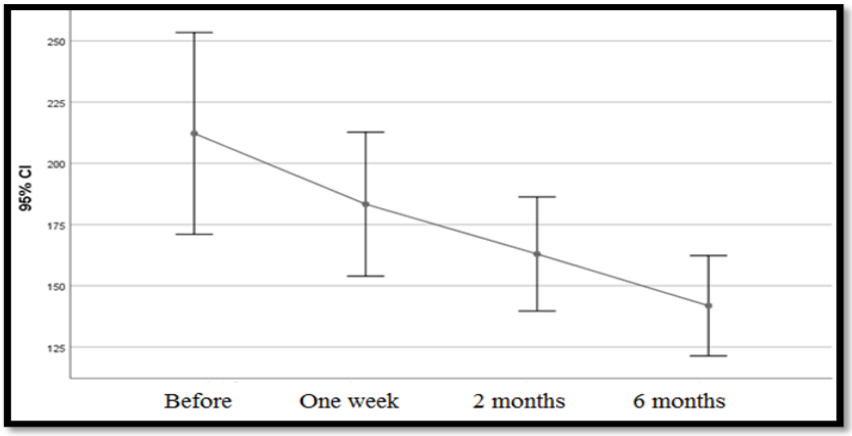


**Figure 4**: 2HPP before, one week, 2 months and 6 months after obesity surgery in the patients.

**Table 3**: 2HPP before, one week, 2 months and 6 months after obesity surgery in the patients

| Variable | Mean | Std. Deviation | Chi-square | P value |
|---|---|---|---|---|
| 2HPP admission | 212.20 | 99.805 | 18.325 | <0.001 |
| FBS one week | 183.32 | 71.256 | | |
| FBS 2 months | 162.96 | 56.460 | | |
| FBS 6 months | 141.84 | 49.588 | | |

The level of mean FBS by surgery in obese patients with T2D was presented in figure 5.

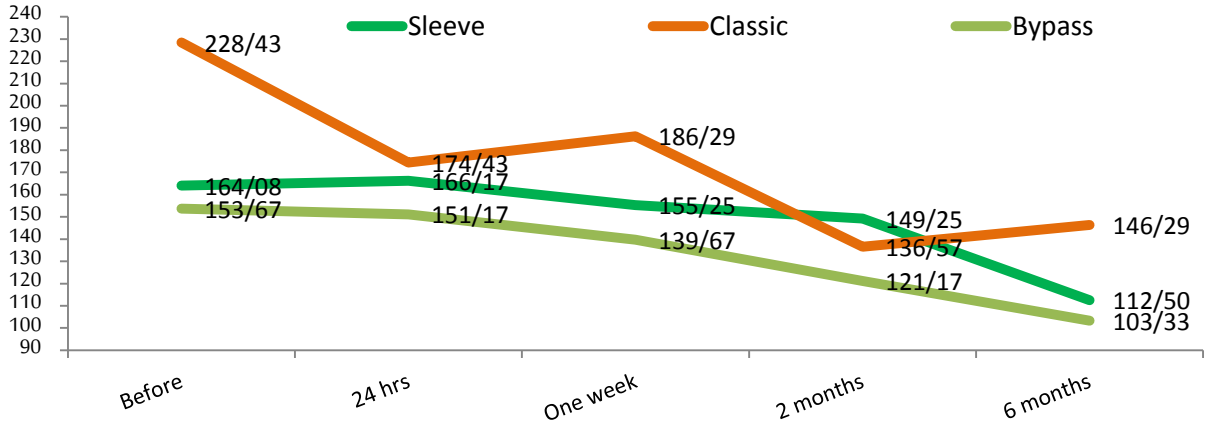


**Figure 5**: FBS before and 24 hours, one week, 2 months and 6 months by surgery in the patients

The level of mean 2HPP by surgery in obese patients with T2D was presented in figure 6.

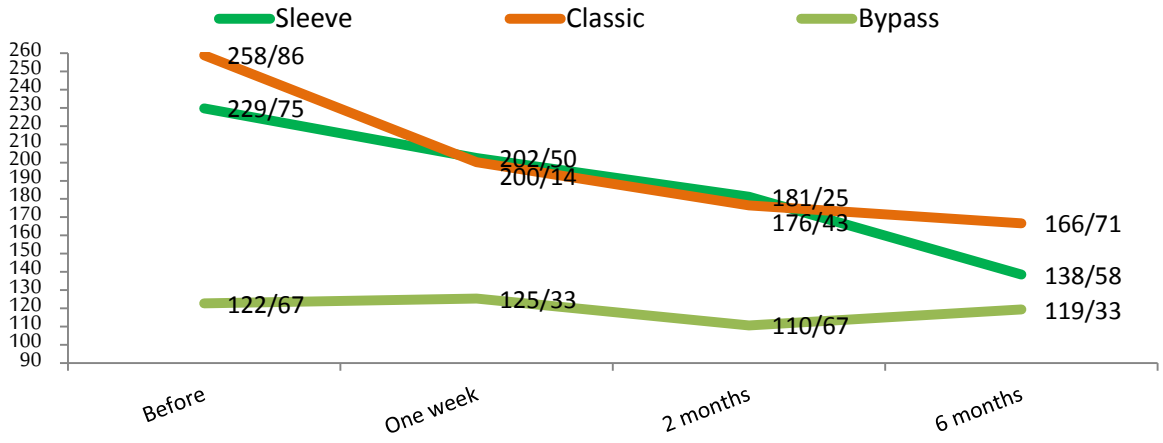


Figure 6: 2HPP before, one week, 2 months and 6 months by surgery in the patients

The level of mean HbA1C by surgery in obese patients with T2D was presented in figure 7.

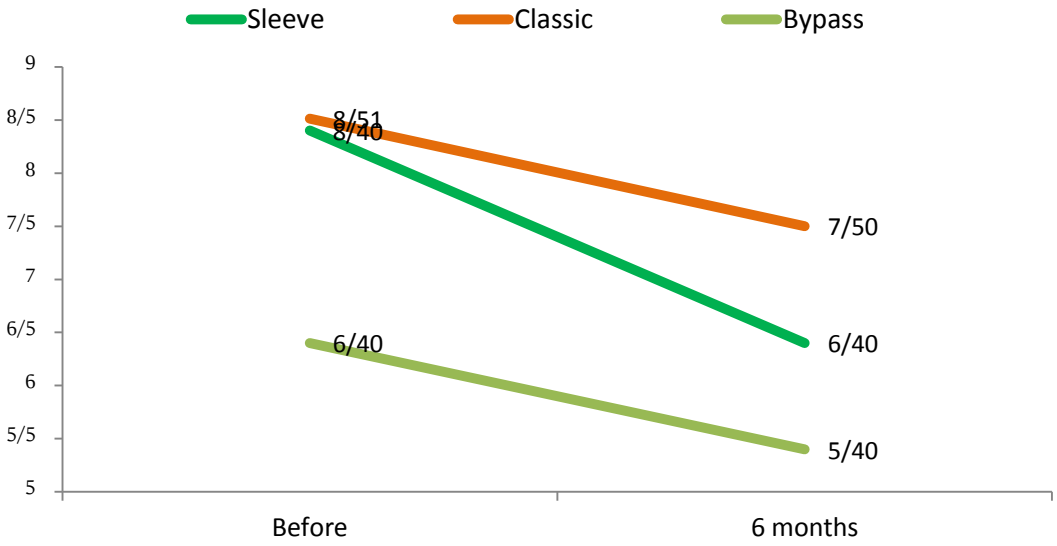


**Figure 7**: HbA1C before and 6 months by surgery in the patients

The level of mean BMI by surgery in obese patients with T2D was presented in figure 8.

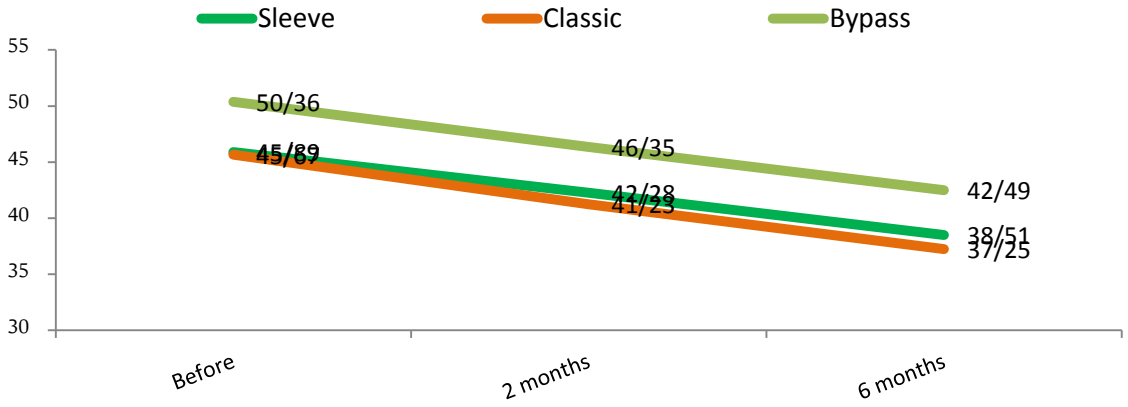


**Figure 8**: BMI before, 2 months and 6 months by surgery in the patients

The level of mean insulin by surgery in obese patients with T2D was presented in figure 9.

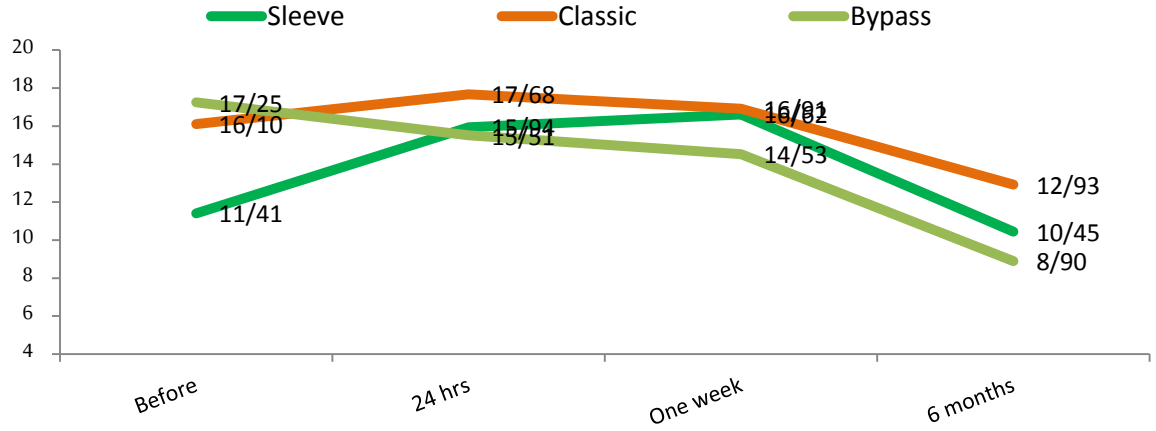


**Figure 9**: Level of insulin before, 24 hours, one week and 6 months by surgery in the patients

The level of mean c-peptide by surgery in obese patients with T2D was presented in figure 10.

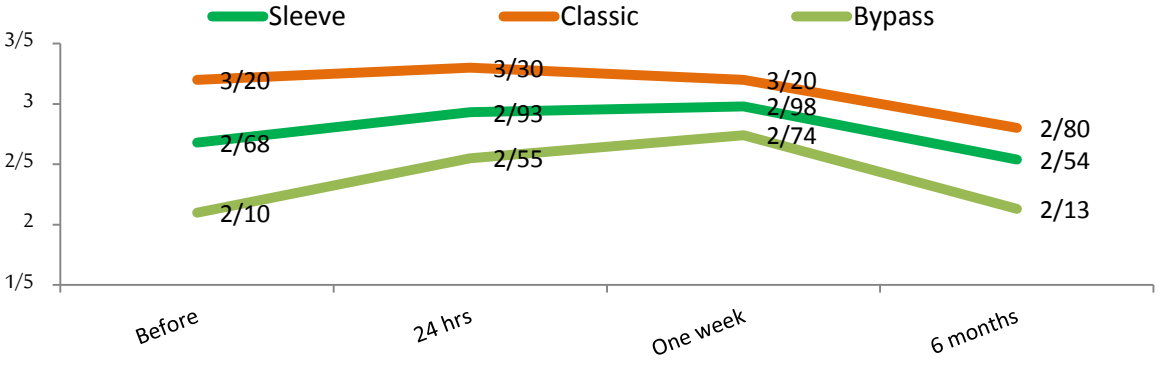


**Figure 10**: Level of c-peptide before, 24 hours, one week and 6 months by surgery in the patients.

## Discussion

In the present study, three methods of performing bariatric surgery regarding glucose control in patients with T2D were reviewed and compared. Weight loss in all patients was observed after two and six months. Following weight loss, glycemic indexes were expected to decrease mean insulin and Cc-peptide. As the obtained data show, a significant decrease was observed in all three groups. There was no significant difference between the three groups regarding these indicators. In other words, the studied obesity surgery methods had controlled blood sugar in patients due to weight loss. In a study by Dixon et al in 2019, LAGB obesity surgery was able to control diabetes in patients.

The follow-up time of patients in the present study was six months and due to the declining trend of patients' weight, it was expected that there would be a further decrease in body mass index in the coming months, which could lead to a better improvement of glucose indices in the patients with T2D . HbA1C index in a study by Mumme et al (20) was lower than the group under medical treatment three years after obesity. In a study by Muller-Stich et al (21) six months after RYGB surgery, a decrease in body mass index and a decrease in HbA1C and its normalization were observed in 15% of patients. Also, neuropathy disability score associated with diabetic neuropathy were significantly improved in these patients. Various studies have examined the effects of surgical treatment of obesity on diabetes control. Follow-up time of patients in some studies is longer and shows interesting results. In a study by Brethauer et al (13), 217 patients were studied after obesity surgery for at least five years. Weight, HbA1C and fasting glucose levels were significantly reduced. The rate of complete and partial long-term remission was 24% and 26%, respectively. In 34% of the patients, improvement compared to baseline was achieved, while in 16% of cases, there was no change.

In a study by Courcoulas et al (22), 61 obese patients were studied in three methods of lifestyle change, RYGB and LAGB surgery for a year follow-up. Relative or complete remission of T2D occurred in 40% of the patients in the RYGB group, 29% in the LAGB group, and in none of the patients in the lifestyle change group. Overall, the results of this study show the superiority of surgical treatment over lifestyle modification to control blood sugar in the patients with T2D. This study revealed that despite lifestyle changes, there was no significant change in the improvement of diabetes and reduction of medications used by patients. In contrast, by performing two types of surgery, the patients showed complete or partial improvement in T2D.

In some studies, patients were followed up for three and five years. In a study by Mazidi et al (23), 152 patients underwent RYGB surgery, which significantly improved insulin secretion, insulin sensitivity and glucose homeostasis after three years (23). In a study by Aminian et al (14), patients were followed up for five years after sleeve surgery and 11% of the patients had complete remission and complete recovery was reported in up to 3% of the patients. In the present study, relative improvement was observed in all three types of surgical procedures in the patients with T2D. However, the follow-up time of patients in the present study was six months. It seems that by increasing the follow-up time of patients, better results can be recorded.

In another study, RYGB and sleeve methods were compared to control T2D. The results of this study showed that both RYGB and sleeve methods improve the glycemic control status of patients with T2D (24). The importance of the present study is to compare the three surgical methods of obesity, which could show that all three surgical methods are effective in improving T2D due to weight loss and reduction of the studied indicators six months after surgery.

## Conclusion

All three surgical methods of RYGB, mini-gastric bypass and sleeve gastrectomy were effective in improving T2D due to weight loss and reduction in all indicators by six months after surgery

**Study limitations:** One of the limitations was loss to follow-up. To reduce this problem, contact numbers of the patient and the patient's relatives were obtained and followed up. Also, the small number of patients was due to the short time of the study.

**Authors' contribution:** SS and MBW designed the study. NHM and ASA performed the experiments. ASA collected data from patients and helped in performance of experiments. MAR, SS and NHM prepared the primary draft after analysis. All authors read and signed the final paper.

***Conflicts of Interest:*** *The authors declared no conflict of interest*
***Funding:*** *This article was taken from residential thesis of Amir Samadi Afshar at Iran University of Medical Sciences. The authors would like to thank the vice chancellor of deputy research of this university for financial support and the patients participating in this study.*


***Cite this article as:*** Safari S, Samadi Afshar A, Alemrajabi M, Baghai Wadji M, Hashemi Madani N. Therapeutic effects of obesity surgery on glucose control in patients with type 2 diabetes. *Ann Bariatr Surg. 2020 (Dec);9(2).1.*

## References

1. *Jensen MD, Ryan DH, Apovian CM, Ard JD, Comuzzie AG, Donato KA, et al. 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and The Obesity Society. Circulation. 2014;129(25 Suppl 2):S102-38.*
2. *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health. Obesity research 1998;6 Suppl 2:51s-209s.*
3. *Flegal KM, Carroll MD, Kit BK, Ogden CL. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. Jama. 2012;307(5):491-7.*
4. *Rahmani A, Sayehmiri K, Asadollahi K, Sarokhani D, Islami F, Sarokhani M. Investigation of the Prevalence of Obesity in Iran: a Systematic Review and Meta-Analysis Study. Acta medica Iranica. 2015;53(10):596-607.*

5. *Wang YC, McPherson K, Marsh T, Gortmaker SL, Brown M. Health and economic burden of the projected obesity trends in the USA and the UK. Lancet (London, England). 2011;378(9793):815-25.*
6. *Finkelstein EA, Trogdon JG, Brown DS, Allaire BT, Dellea PS, Kamal-Bahl SJ. The lifetime medical cost burden of overweight and obesity: implications for obesity prevention. Obesity (Silver Spring, Md). 2008;16(8):1843-8.*
7. *Sassi F, Devaux M, Cecchini M, Rusticelli E.. The Obesity Epidemic: Analysis of Past and Projected Future Trends in Selected OECD Countries: OECD Publishing. 2009.*
8. *Esteghamati A, Larijani B, Aghajani MH, Ghaemi F, Kermanchi J, Shahrami A, et al. Diabetes in Iran: Prospective Analysis from First Nationwide Diabetes Report of National Program for Prevention and Control of Diabetes (NPPCD-2016). Scientific reports. 2017;7(1):13461.*
9. *Malin SK, Kashyap SR. Type 2 Diabetes Treatment in the Patient with Obesity. Endocrinology and metabolism clinics of North America. 2016;45(3):553-64.*
10. *Tuomilehto J, Lindström J, Eriksson JG, Valle TT, Hämäläinen H, Ilanne-Parikka P, et al. Prevention of Type 2 Diabetes Mellitus by Changes in Lifestyle among Subjects with Impaired Glucose Tolerance. New England Journal of Medicine. 2001;344(18):1343-50.*
11. *Venditti EM, Bray GA, Carrion-Petersen ML, Delahanty LM, Edelstein SL, Hamman RF, et al. First versus repeat treatment with a lifestyle intervention program: attendance and weight loss outcomes. International journal of obesity (2005). 2008;32(10):1537-44.*
12. *Elder KA, Wolfe BM. Bariatric surgery: a review of procedures and outcomes. Gastroenterology. 2007;132(6):2253-71.*
13. *Brethauer SA, Aminian A, Romero-Talamas H, Batayyah E, Mackey J, Kennedy L, et al. Can diabetes be surgically cured? Long-term metabolic effects of bariatric surgery in obese patients with type 2 diabetes mellitus. Annals of surgery. 2013;258(4):628-36; discussion 36-7.*
14. *Aminian A, Brethauer SA, Andalib A, Punchai S, Mackey J, Rodriguez J, et al. Can Sleeve Gastrectomy "Cure" Diabetes? Long-term Metabolic Effects of Sleeve Gastrectomy in Patients With Type 2 Diabetes. Annals of surgery. 2016;264(4):674-81.*
15. *Courcoulas AP, Belle SH, Neiberg RH, Pierson SK, Eagleton JK, Kalarchian MA, et al. Three Year Outcomes of Bariatric Surgery vs. Lifestyle Intervention for Type 2 Diabetes Mellitus Treatment: A Randomized Trial. JAMA surgery. 2015;150(10):931-40.*
16. *Ribaric G, Buchwald JN, McGlennon TW. Diabetes and weight in comparative studies of bariatric surgery vs conventional medical therapy: a systematic review and meta-analysis. Obesity surgery. 2014;24(3):437-55.*
17. *Care D. Standards of medical care in diabetes–2015: summary of revisions. 2015.*
18. *Dixon JB, Zimmet P, Alberti KG, Rubino F, on behalf of the International Diabetes Federation Taskforce on E, Prevention. Bariatric surgery: an IDF statement for obese Type 2 diabetes. Diabetic Medicine. 2011;28 (624-628)*
19. *Dixon JB, O'Brien PE, Playfair J, Chapman L, Schachter LM, Skinner S, et al. Adjustable gastric banding and conventional therapy for type 2 diabetes: a randomized controlled trial. Jama. 2008;299(3):316-23.*
20. *Mumme DE, Mathiason MA, Kallies KJ, Kothari SN. Effect of laparoscopic Roux-en-Y gastric bypass surgery on hemoglobin A1c levels in diabetic patients: a matched-cohort analysis. Surgery for obesity and related diseases : official journal of the American Society for Bariatric Surgery. 2009;5(1) 4-10.*
21. *Muller-Stich BP, Fischer L, Kenngott HG, Gondan M, Senft J, Clemens G, et al. Gastric bypass leads to improvement of diabetic neuropathy independent of glucose normalization--results of a prospective cohort study (DiaSurg 1 study). Annals of surgery. 2013;258(5):760-5; discussion 5-6.*
22. *Courcoulas AP, Belle SH, Neiberg RH, Pierson SK, Eagleton JK, Kalarchian MA, et al. Three-Year Outcomes of Bariatric Surgery vs Lifestyle Intervention for Type 2 Diabetes Mellitus Treatment: A Randomized Clinical Trial. JAMA Surg. 2015;150(10):931-40.*
23. *Mazidi M, Gao HK, Li L, Hui H, Zhang Y. Effects of Roux-en-Y gastric bypass on insulin secretion and sensitivity, glucose homeostasis, and diabetic control: A prospective cohort study in Chinese patients. Surgery. 2017;161(5):1423-9.*
24. *Osland E, Yunus RM, Khan S, Memon B, Memon MA. Diabetes improvement and resolution following laparoscopic vertical sleeve gastrectomy (LVSG) versus laparoscopic Roux-en-Y gastric bypass (LRYGB) procedures: a systematic review of randomized controlled trials. Surgical endoscopy. 2017;31(4):1952-63.*