

The influences of bariatric surgery on hemoglobin A1c in a sample of obese patients in Saudi Arabia

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Background: Although the frequency of surgical weight loss interventions has increased in Saudi Arabia, literature describing the clinical outcomes of bariatric surgery in Saudi Arabia is limited. This study aimed to assess whether weight loss intervention improves hemoglobin A1c (HbA1c) in obese patients and to identify its associated factors.

Patients and methods: A retrospective study was carried out on 318 patients with obesity class 1 or higher (body mass index [BMI] ≥ 30 kg/m²) who underwent laparoscopic sleeve gastrectomy or Roux-en-Y gastric bypass at King Abdulaziz Medical City in Riyadh, Saudi Arabia, between January 1, 2001 and March 31, 2017. Preoperatively and 12 months postoperatively, characteristics of patients were collected. BMI reduction was calculated, based on which patients were divided into three groups (0–9, 10–14, and >14 kg/m²).

Results: The postoperative HbA1c was 5.83 ± 0.9 , while the baseline level was 6.74 ± 2.1 ($P=0.001$). Fifty-eight of the 318 patients had diabetes. We observed significantly higher HbA1c in diabetic than in non-diabetic patients preoperatively, whereas an insignificantly different HbA1c was observed postoperatively. Among those who had minimal reduction in BMI (0–9 kg/m²), we observed significantly higher HbA1c in diabetic than in non-diabetic patients, whereas among those who had large reduction in BMI (10–14 kg/m²) and (>14 kg/m²), we observed insignificant differences in HbA1c in diabetic than in non-diabetic patients.

Conclusion: Being a diabetic patient was related to a significant reduction in HbA1c levels postoperatively. The study suggests that the reduction in HbA1c levels could be modified by BMI, wherein greater reduction in BMI leads to greater reduction in HbA1c levels.

Keywords: HbA1c, diabetes, weight loss surgery, BMI, morbid obese, sleeve

Introduction

Obesity is a major public health challenge in Saudi Arabia because it can pose serious health-related issues.^{1,2} In fact, its high prevalence has been projected as 41% in males and 78% in females by 2022.³ It has been associated with a number of noncommunicable diseases,⁴ which are responsible for increasing the rate of mortality in the Saudi population.⁵ With the increased obesity prevalence in Saudi Arabia, weight loss or bariatric surgeries are becoming the most popular and effective surgical interventions in patients with obesity.

In addition to investigating substantial weight loss, several international studies have explored the associations between weight loss results from the surgical interventions and long-term health benefits such as reduction of underlying medical conditions

among morbidly obese patients.^{6–19} For instance, earlier reports investigated the effectiveness of weight loss after bariatric surgery in achieving optimal glycemic control.^{9–19} According to these studies, bariatric procedures could be effective therapeutic interventions in morbidly obese patients with diabetes. However, a few other studies reported bariatric surgery may not necessarily correlate with optimal glycemic control.^{20,21}

The health benefits of bariatric procedures in diabetes patients are well documented in several international studies. It has been reported that laparoscopic sleeve gastrectomy (LSG) in diabetic patients with obesity may be effective in achieving optimal glycemic control.^{14–19} Other studies reported that LSG and Roux-en-Y gastric bypass (RYGB) lead to similar improvements in plasma glucose homeostasis, insulin sensitivity, and beta-cell function in non-diabetic obese people.^{12,13}

Despite the fact that bariatric surgery confirmed improved patient clinical outcome by reducing the risk of potential weight-related health problems, our understanding of the health benefits of bariatric surgery in Saudi Arabia has not yet been documented, specifically in diabetic patients. Two studies in Saudi Arabia focused only on weight reduction and one on a surgical option, which is sleeve gastrectomy.^{22,23} Another study compared weight reduction, complications, and quality of life in patients who underwent one of three surgical procedures – LSG, RYGB, and laparoscopic adjustable gastric banding.²⁴ No evidence is available on the impact of the bariatric surgery on glycemic control status (i.e., hemoglobin A1c [HbA1c]) in the Saudi population.

Recently, Ahmed et al, in a study conducted at King Abdulaziz Medical City in Riyadh, reported a hospital readmission rate of 8% and an emergency department visit rate of 14% in obese Saudi patients who underwent bariatric surgery.²⁵ According to this study, LSG was associated with fewer hospital readmissions or emergency department visits as compared to RYGB.

To date, the effectiveness of bariatric surgery has not been assessed in Saudi Arabia to obtain optimal glycemic control. Such studies on the Saudi Arabian population would be of international interest. The hypotheses of the study are the following: there is a statistically significant reduction in the HbA1c over a 1-year period after surgery among patients with diabetes. The study aimed to 1) assess whether bariatric surgery improves HbA1c in obese patients and 2) identify its associated factors in Saudi Arabia.

Patients and methods

The authors retrospectively studied 318 patients with obesity class 1 or higher BMI (≥ 30 kg/m²), who underwent either bariatric surgery LSG or RYGB at King Abdulaziz Medical City in Riyadh, Saudi Arabia, between January 1, 2001 and March 31, 2017. The study was approved by the Institutional Review Board at King Abdullah International Medical Research Center, Riyadh, Saudi Arabia (RC17/138/R). Patient consent to review their medical records was not required by the Institutional Review Board at King Abdullah International Medical Research Center. This study involves the use of existing information with no patient-related care responsibilities. No identifier was used, and the privacy and confidentiality of patients were completely protected.

Data for this study were retrieved from the collected medical records. The baseline and clinical characteristics included information such as age, sex, BMI (kg/m²), diabetes (Yes/No), asthma (Yes/No), obstructive sleep apnea (Yes/No), and procedure type (LSG/RYGB). The authors evaluated surgery outcomes in the study population. Available BMI and/or HbA1c readings were reviewed for patients who had visited our center and these measurements were only considered if they occurred within a period of 12 months after the surgery. In the case of multiple readings, the most recent reading was selected and recorded. Differences between the preoperative visit and postoperative visit were calculated for each reading of BMI, and HbA1c. Percent reduction was calculated for BMI and HbA1c using the formula (postoperative – preoperative)/preoperative $\times 100\%$. Also, for the purpose of the analysis, BMI reduction was classified into three groups: reduction of 9 kg/m² or less, reduction between 10 and 14 kg/m², and reduction of >14 kg/m². As per the criteria of the American Diabetes Association, the authors used HbA1c $\leq 6.5\%$ as the definition of achieving optimal HbA1c.

Statistical analyses

Statistical analyses were performed using SAS V 9.4 (SAS Institute, Cary, NC, USA). Categorical patient characteristics were expressed as frequency and percent, while continual patient characteristics were expressed as mean and SD. Paired sample *t*-tests were used to test differences in HbA1c in the whole sample (N=318). Furthermore, paired sample *t*-tests were used to assess the differences in HbA1c before and after the surgery, separately, and in the diabetic group and non-diabetic group. The effects of visit (pre- and postoperative) on HbA1c were also assessed. We assessed the impact of diabetes, BMI reduction, and visit on lowering HbA1c

after the surgery, controlling the patient characteristics. A multivariate mixed-effects model was used to identify the interaction terms that were associated with lowering HbA1c. The following interaction terms were examined: (diabetes $\times$ visit), (diabetes $\times$ BMI reduction), and (procedure type $\times$ visit). Moreover, multiple comparisons were performed using the Tukey for significant interactions terms.

Results

The sample included 318 obese subjects who underwent surgical weight loss intervention (LSG or RYGB) during the study period. The baseline characteristics of the sample with obesity are shown in Table 1. The mean age was 34.7 years with an SD of 11.7 years, and the age ranged between 13 and 64 years. The mean of baseline BMI was 46.8 kg/m² with an SD of 7.7 kg/m², and the BMI ranged between 32.7 and 83 kg/m². The mean HbA1c at baseline was 6.7 with an SD of 2.1, and HbA1c ranged between 2.5 and 14. The majority of patients (67.6%) were females, and 88.4% underwent LSG. Of the sample, 18.4% had diabetes, 13.9% had asthma, and 7.9% had obstructive sleep apnea.

Paired sample *t*-test showed significant reduction in HbA1c in the whole sample (N=318) from pre- to postoperative (6.74 $\pm$ 2.1 preoperative vs. 5.83 $\pm$ 0.9 postoperative, $P=0.001$). This analysis was stratified further by the diabetic status: we noted significantly greater reduction in HbA1c from pre- to postoperative (8.5 $\pm$ 2.4 preoperative vs. 6.3 $\pm$ 1.0 postoperative, $P=0.001$) in the diabetes group and slight but significant reduction in HbA1c (5.7 $\pm$ 0.7 preoperative vs.

5.4 $\pm$ 0.5 postoperative, $P=0.001$) in the non-diabetic group. This resulted in a reduction of 25.9% in the diabetic group and 5.3% in non-diabetic group. The individual changes in HbA1c after surgery can be found in Figure 1A. The waterfall plot shows that the procedure was associated with greater HbA1c reduction in patients with diabetes than in those without diabetes. Postoperatively, the HbA1c target of 6.5% or below was met in 62.5% of the diabetic group and 97.1% of the non-diabetic group.

Analysis with the multivariate mixed model showed that there were insignificant differences in HbA1c by demographic characteristics: age and sex. The model demonstrated significant diabetes by visits interaction effects ($P=0.001$). According to Tukey multiple comparisons, diabetic patients had significantly higher HbA1c than non-diabetic patients at the baseline, whereas diabetic patients had insignificantly higher HbA1c than non-diabetic patients following the surgical procedure (Figure 1B).

We found significant interaction effects between diabetes by BMI reduction (10–14 kg/m² [$P=0.012$] and >14 kg/m² [$P=0.003$]) on HbA1c. In those who had minimal reduction in BMI (0–9 kg/m²), we observed significantly higher HbA1c levels in diabetic patients than in non-diabetic patients. In those who had greater reduction in BMI (10–14 and >14 kg/m²), we observed insignificant differences in HbA1c levels in diabetic patients than in non-diabetic patients (Figure 1C).

Results of the mixed-effects model analysis presented in Table 2 indicate significant interaction effects between procedure type-by-visit ($P=0.018$) on HbA1c. There was significant difference in HbA1c within the LSG and RYGB groups between baseline and following the surgical procedure, while there was insignificant difference between the LSG and RYGB groups in the HbA1c preoperatively and postoperatively (Figure 1D).

Discussion

The literature describing the clinical outcomes of surgical weight loss interventions in Saudi Arabia is limited, particularly regarding the HbA1c parameter. In this study, we retrospectively gathered data on patients with obesity class I or higher (BMI ≥ 30 kg/m²) who underwent LSG and RYGB at King Abdulaziz Medical City in Riyadh, Saudi Arabia, between January 1, 2001 and March 31, 2017. The surgical weight loss interventions appear to have had a large effect on the HbA1c parameter within a short term, that is, a period of 12 months after the surgery.

In a period of 12 months postoperatively, the HbA1c target of 6.5% or below was met in 62.5% of the diabetic

Table 1 Patient characteristics (N=318)

Characteristics	Levels	n	%
Sex	Female	215	67.6
	Male	103	32.4
Bariatric procedure	RYGB	37	11.6
	LSG	281	88.4
Diabetes	No	258	81.6
	Yes	58	18.4
Asthma	No	272	86.1
	Yes	44	13.9
Obstructive sleep apnea	No	291	92.1
	Yes	25	7.9
BMI reduction, kg/m ²	0–9	113	43.0
	10–14	68	25.9
	>14	82	31.1
	Mean		$\pm$ SD
Age (13–64), years		34.7	11.7
Baseline BMI (32.7–83.1), kg/m ²		46.8	7.7
Baseline HbA1c (2.5–14), %		6.7	2.1

Abbreviations: BMI, body mass index. LSG, laparoscopic sleeve gastrectomy; HbA1c, hemoglobin A1c; RYGB, Roux-en-Y gastric bypass.

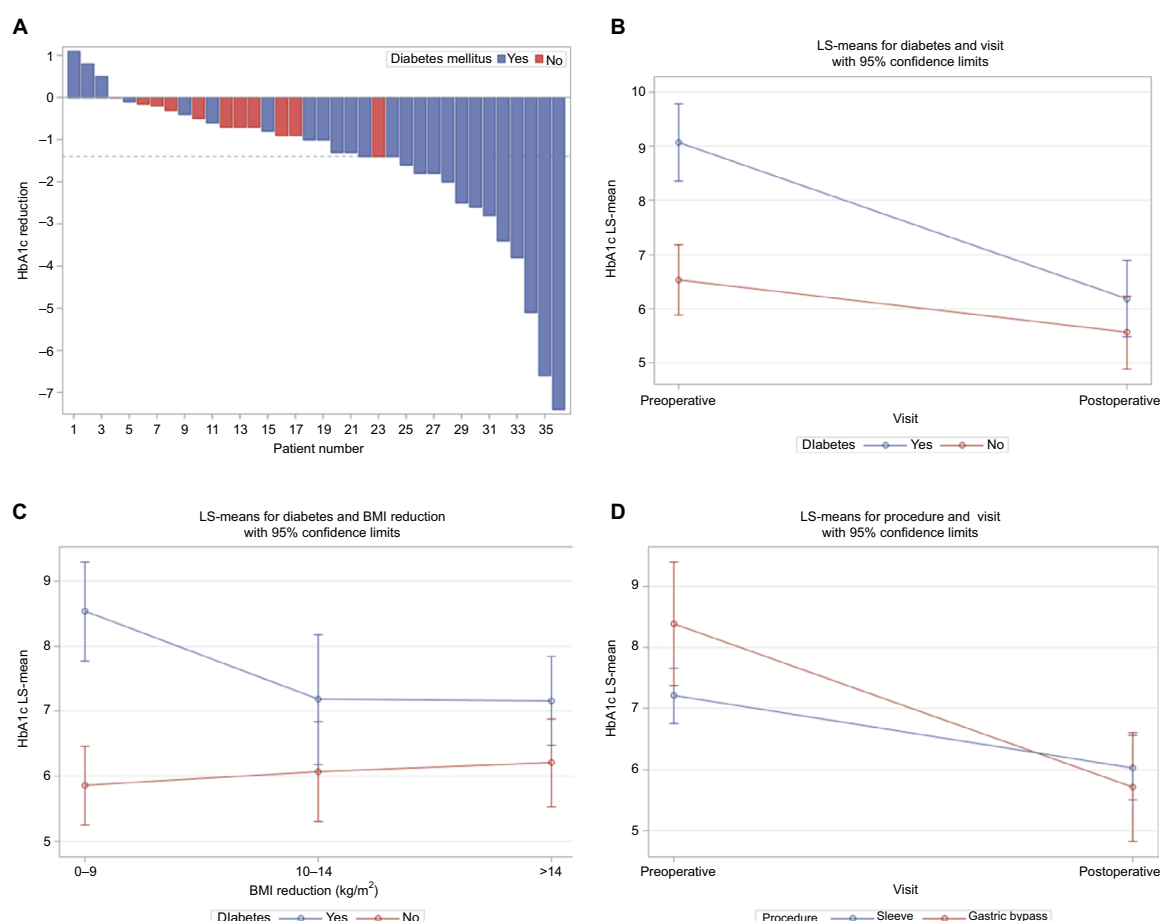


Figure 1 Changes in HbA1c by visit, diabetes status, body mass index (kg/m²) reduction, and procedure type after bariatric surgery.

Notes: (A) We observed significantly greater reduction in HbA1c in patients with diabetes than those without diabetes. (B) Diabetic patients had significantly higher HbA1c than non-diabetic patients at the baseline, whereas diabetic patients had insignificantly higher HbA1c than non-diabetic patients following the surgical procedure. (C) In those who had greater reduction in BMI (10–14 and >14 kg/m²), we observed insignificant differences in HbA1c levels between diabetic patients and non-diabetic patients. (D) There was a significant difference in HbA1c within the LSG and RYGB groups between baseline and following the surgical procedure, while there was insignificant difference between the LSG and RYGB groups in the HbA1c preoperatively and postoperatively.

Abbreviations: BMI, body mass index; HbA1c, hemoglobin A1c; LS-means, least squares-means.

Table 2 Factors associated with the change in HbA1c using mixed-effects model

	B	SE	t-value	P-value
Intercept	6.343	0.651	9.740	0.001
Main effects				
Age	0.013	0.010	1.300	0.206
Female	-0.194	0.240	-0.810	0.426
LSG	-1.181	0.486	-2.430	0.022*
Diabetes	3.628	0.406	8.940	0.001*
Asthma	-0.390	0.305	-1.280	0.212
Obstructive sleep apnea	0.697	0.410	1.700	0.100
Postoperative visit	-1.717	0.598	-2.870	0.008*
BMI reduction 10–14 kg/m ²	0.210	0.329	0.640	0.528
BMI reduction >14 kg/m ²	0.349	0.333	1.050	0.304
Interaction effects				
Diabetes × postoperative visit	-1.911	0.393	-4.860	0.001*
Diabetes × BMI reduction 10–14 kg/m ²	-1.560	0.580	-2.690	0.012*
Diabetes × BMI reduction >14 kg/m ²	-1.717	0.528	-3.250	0.003*
LSG × postoperative visit	1.497	0.596	2.510	0.018*

Note: *Significant at $\alpha=0.05$.

Abbreviations: BMI, body mass index; HbA1c, hemoglobin A1c; LSG, laparoscopic sleeve gastrectomy; SE, standard error.

patients and 97.1% of the non-diabetic patients. This can be compared with patients who were on HbA1c target of 6.5% or below at baseline or prior to the procedure: 25.71% of the diabetic patients and 91.8% of the non-diabetic patients. Similar findings are found in reports from various international regions and with different follow-up periods, where they have shown rapid improvement in glycemic control after bariatric surgery.^{9–19} Thus, our data provide strong evidence for the effectiveness of bariatric surgery in improving HbA1c in a Saudi sample of patients in whom optimal HbA1c has not been investigated. Future research studies are needed to assess the effectiveness of weight reduction in treating obese patients with other comorbidities.

The uniqueness of the current study is that we were able to link the reduction in HbA1c to the diabetic status and to the reduction in BMI. For instance, at baseline, we noted significantly higher HbA1c in diabetic patients than in non-diabetic patients, whereas postoperatively, insignificant

differences were noted between diabetes patients and non-diabetes patients. The reduction in HbA1c levels in our study can be explained by diabetes and the greater reduction in BMI. Among those who had minimal reduction in BMI (0–9 kg/m²), we observed significantly higher HbA1c levels in diabetic patients than in non-diabetic patients, whereas among those who had a large reduction in BMI (10–14 kg/m²) and (>14 kg/m²), we observed insignificant differences in HbA1c levels in diabetic patients than in non-diabetic patients. These findings were similar to a number of previous international reports,^{26–29} in which weight reduction led to a significant improvement of glycemic control in diabetic patients who underwent bariatric surgery.

Although we noted significant reduction in HbA1c within the LSG and RYGB groups between preoperative and postoperative periods, in agreement with our analysis results,^{30,31} both LSG and RYGB had a similar effect on the reduction of HbA1c levels postoperatively. LSG seems to be a promising weight loss procedure in our center, as 88.4% of our patients underwent this procedure. A long-term longitudinal study is needed to compare and evaluate the effectiveness of these procedures in achieving early optimal glycemic control after surgery.

The current study was limited by its nature, that is, retrospective chart review, as not all data were available during the 12-month period after surgery. We did not retrieve data on the types and dose of insulin prescribed to diabetes patients. Data were collected only preoperatively and postoperatively, rather than by using multiple records: baseline, 3, 6, and 12 months. Despite these limitations, the study findings represent preliminary highlights of the clinical outcomes of bariatric surgery on achieving optimal glycemic control in Saudi Arabia, as none of the studies have evaluated metabolic comorbidities in this population.

Conclusion

A significant reduction in HbA1c levels at postoperative was noted in diabetic patients. The study suggests that reduction in HbA1c levels could be modified by BMI, wherein greater reduction in BMI leads to greater reduction in HbA1c levels. Large longitudinal studies on the long-term clinical outcomes of the surgical weight loss interventions are warranted, specifically assessing remission of other comorbidities that are related to obesity.

Acknowledgment

We would like to thank King Abdullah International Medical Research Center, Riyadh, Saudi Arabia, for approving the study.

Disclosure

The authors report no conflicts of interest in this work.

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