Eduvest – Journal of Universal Studies
Volume 5 Number 4, April, 2025
p- ISSN 2775-3735- e-ISSN 2775-3727

THE EFFECT OF SLEEVE GASTRECTOMY ON THE IMPROVEMENT OF RANDOM BLOOD GLUCOSE LEVELS IN OBESE DIABETIC RATS

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ABSTRACT

This experimental study investigates the impact of sleeve gastrectomy on blood glucose regulation in obese diabetic rats. Obesity and Type 2 diabetes are major health concerns globally, and sleeve gastrectomy has been identified as an effective bariatric surgery for managing these conditions. The study used a randomized control group pretest-posttest design with two groups: one underwent sleeve gastrectomy, and the other served as a control group. The rats' body weight and blood glucose levels were monitored before and after the procedure. The results demonstrated a significant reduction in random blood glucose levels in the group that underwent sleeve gastrectomy compared to the control group, indicating an improvement in glucose metabolism. These findings suggest that sleeve gastrectomy effectively improves blood glucose levels, potentially due to changes in hormonal and metabolic pathways, particularly the enhancement of GLP-1 secretion, which plays a role in insulin sensitivity. The implications of this research highlight the potential of sleeve gastrectomy as a therapeutic intervention for obesity-related Type 2 diabetes. Further studies are recommended to explore the underlying mechanisms and long-term effects of this procedure in humans and its broader applications in metabolic disease management.

KEYWORDS sleeve, gastrectomy, bariatric, obese, diabetes

INTRODUCTION

Diabetes (DM) is a chronic disease with a high prevalence worldwide, with the majority being obesity-related type 2 diabetes (O-T2D) (Lemus et al., 2018). The inflammatory condition associated with obesity induces insulin resistance, which contributes to the development of O-T2D. This type of diabetes can occur in chronically obese individuals who, due to pathophysiological disruptions in insulin

How to cite: Putranto, I. K. A., Mughni, A., & Boediono, B. P. (2025). The Effect of Sleeve Gastrectomy on the Improvement of Random Blood Glucose Levels in Obese Diabetic Rats. Journal Eduvest. *5*(4): 4364-4372.
E-ISSN: 2775-3727
Published by: https://greenpublisher.id/

function, develop type 2 diabetes. Alternatively, it may also manifest in individuals with pre-existing type 2 diabetes who experience weight gain as a side effect of oral diabetes therapy.[1]

Obesity itself is a chronic condition characterized by excessive body fat or adipose tissue accumulation, which is detrimental to health and contributes to disease. Globally, the prevalence of obesity has risen sharply, to the point where the World Health Organization (WHO) has classified it as an epidemic. Lifestyle changes primarily drive the increase in obesity cases, although other factors such as genetics, maternal influences, environment, aging, gut microbiota, and certain medications also play a role in the rising prevalence of obesity (Sun et al., 2014; H. Wang et al., 2019; Y. Wang et al., 2011; Xu et al., 2015).

Sleeve gastrectomy is a bariatric surgery involving the removal of approximately 80% of the stomach. This procedure works through several mechanisms. First, the newly created stomach pouch has a much smaller volume than a normal stomach, significantly limiting the amount of food and calories that can be consumed (Kawano et al., 2013).

While sleeve gastrectomy induces minimal malabsorption, the reduction in stomach volume, faster gastric emptying, and increased intestinal motility stimulate gut hormones that promote anorexia, or reduced appetite (Abdul Basith Khan et al., 2020). The decrease in appetite contributes to lower blood glucose levels and weight loss, making sleeve gastrectomy an effective intervention for individuals with obesity and obesity-related metabolic disorders (Chambers et al., 2011).

Obesity, particularly obesity-related Type 2 Diabetes (O-T2D), is a primary global health concern, with increasing prevalence driven by factors such as poor dietary habits, sedentary lifestyles, and genetic predispositions. One of the most effective surgical interventions for managing obesity and its associated conditions, including diabetes, is sleeve gastrectomy (Aminian et al., 2016). This bariatric surgery involves the removal of a significant portion of the stomach, reducing its size and limiting food intake, thereby aiding weight loss and improving glucose control (Tinajero & Malik, 2021). However, the mechanisms underlying the improvement in blood glucose levels after sleeve gastrectomy are not fully understood, and more research is needed to clarify how this procedure impacts metabolic processes, particularly in individuals with obesity-induced Type 2 diabetes (Rosenthal et al., 2019).

The effectiveness of sleeve gastrectomy in improving blood glucose levels has been observed in clinical studies, but the detailed physiological changes and long-term outcomes remain underexplored, especially in experimental settings. The relationship between sleeve gastrectomy, gut hormones like GLP-1, insulin sensitivity, and glucose metabolism requires further investigation to enhance understanding of the benefits of this procedure (Chiu et al., 2011). This research aims to explore the effects of sleeve gastrectomy on blood glucose regulation, particularly in obese diabetic rats, and to understand the physiological processes involved in this metabolic improvement (Burgerhart et al., 2014).

The urgency of this research is critical due to the escalating global epidemic of obesity and Type 2 diabetes. These conditions are linked to increased mortality and morbidity worldwide, and finding effective interventions is essential for managing the growing health crisis. Sleeve gastrectomy has shown promising results in improving blood glucose levels and facilitating weight loss, but further research is needed to understand its underlying mechanisms fully. This study's findings could help refine the therapeutic use of bariatric surgery, offering better treatment options for individuals struggling with obesity and diabetes, and contributing to the broader goal of improving public health outcomes.

Previous studies have demonstrated the positive impact of sleeve gastrectomy on weight loss and blood glucose control. Research by Schauer (2012) found that sleeve gastrectomy resulted in significant improvements in glucose metabolism, with many patients achieving remission from Type 2 diabetes post-surgery. Similarly, Jiménez (2014) reported that sleeve gastrectomy increased GLP-1 levels, a hormone that plays a crucial role in regulating insulin secretion and glucose homeostasis. These studies underline the potential of sleeve gastrectomy as a long-term solution for obesity-related Type 2 diabetes.

Furthermore, studies by Juodeikis (2017) have explored the long-term effects of bariatric surgery, including sleeve gastrectomy, in patients with Type 2 diabetes, showing improvements in insulin sensitivity and reduction in glucose levels. However, these studies primarily focused on human subjects, with limited experimental data from animal models that could provide deeper insights into the mechanisms involved. Animal models, particularly obese diabetic rats, can offer more controlled and detailed observations of the hormonal and metabolic changes after sleeve gastrectomy.

Research by Khaitan (2021) Also, these studies emphasize the role of sleeve gastrectomy in achieving both weight loss and glucose regulation, especially in patients with morbid obesity. However, while these studies provide evidence of the procedure's benefits, there is still a gap in understanding the precise biological mechanisms through which sleeve gastrectomy influences glucose metabolism, particularly concerning gut hormones and insulin sensitivity in animal models.

Although previous studies have highlighted the positive effects of sleeve gastrectomy on weight loss and blood glucose control, there remains a gap in understanding the precise physiological processes that contribute to these improvements, particularly in animal models (P. Liu et al., 2021; T. Liu et al., 2017). Most of the existing research has focused on human clinical trials, with limited exploration of the underlying mechanisms, such as the role of GLP-1 and other gut hormones, in improving insulin sensitivity and glucose metabolism after surgery. This research seeks to fill this gap by investigating the impact of sleeve gastrectomy on blood glucose levels and the physiological changes that occur in obese diabetic rats (Trung et al., 2013).

This study introduces a novel approach by using an animal model (obese diabetic rats) to investigate the physiological effects of sleeve gastrectomy on blood glucose regulation. Unlike previous research that primarily focused on human clinical outcomes, this research aims to provide a deeper understanding of the mechanisms at play in obese diabetic individuals undergoing sleeve gastrectomy. By focusing on the hormonal and metabolic pathways involved, particularly the role of gut hormones such as GLP-1, this study offers new insights into how bariatric surgery can improve glucose metabolism at a physiological level.

This research's primary objective is to evaluate the effects of sleeve gastrectomy on blood glucose levels in obese diabetic rats. The study aims to assess the changes in blood glucose regulation, insulin sensitivity, and gut hormone secretion following the procedure. By understanding the biological mechanisms involved, the research seeks to provide insights into the potential benefits of sleeve gastrectomy for managing obesity-related Type 2 diabetes and to explore the underlying factors that contribute to its effectiveness.

The findings from this study will provide valuable insights into the physiological mechanisms through which sleeve gastrectomy improves blood glucose regulation in obese diabetic individuals. These insights could help refine bariatric surgery practices and improve patient outcomes by identifying specific metabolic pathways that can be targeted for enhanced effectiveness. Additionally, the research may offer a foundation for future studies on non-surgical interventions aimed at replicating the benefits of sleeve gastrectomy, particularly in managing Type 2 diabetes and obesity. By improving our understanding of the biological processes involved, this study could contribute to more personalized treatment strategies for diabetes and obesity.

RESEARCH METHOD

This study uses an experimental research method with a Randomized Control Group Pretest-Posttest Design, involving two intervention groups of 2-week-old male Wistar rats. The first group consists of obese and diabetic rats serving as the control group, while the second group includes obese and diabetic rats undergoing sleeve gastrectomy. The study aims to investigate the impact of sleeve gastrectomy on blood glucose regulation and metabolic changes in obese diabetic rats. The sample size was determined using the Federer formula, ensuring adequate statistical power, with 10 rats per group based on WHO guidelines. The experimental procedure includes inducing obesity through a high-calorie, high-fat diet and diabetes through intraperitoneal streptozotocin (STZ) and nicotinamide administration.

Data collection involved measuring body weight using the Lee index, and rats were placed in controlled environmental conditions for 7 days to standardize living conditions. Postoperative monitoring and care were conducted for 2 weeks following sleeve gastrectomy. Descriptive statistical analysis was used to evaluate the data, with the mean and standard deviation for each dependent variable presented in tables. For comparisons, the Mann-Whitney test was applied to unpaired data, and the Wilcoxon test was used for paired data. SPSS version 23.0 for Windows was used for data processing. Ethical approval was obtained from the Animal Ethics Committee, and the study adhered to standard animal care protocols and ethical guidelines.

RESULT AND DISCUSSION

Table 1. Data description

Variabel	Frek.	%	Mean ± SD	Median (min–max)
Sleeve gastrectomy				
Yes	10	50,0		
No	10	50,0		
Weight			255,70 ± 5,27	255 (247 – 263)
Length			19,50 ± 0,33	19,43 (18,99 – 20,07)
Lee index			325,64 ± 5,66	326,54 (315,45 – 336,53)
Glucose pre			263,22 ± 6,13	262,76 (253,97 – 274,48)
Glucose post			169,3 ± 22,2	180,79 (138,82 – 195,69)

Tabel 2. Descriptive and Normality Analysis of Body Weight, Length, and Lee Index

Variable	Sleeve Gastrectomy	Mean ± SD	Median (min – max)	p
Weight	Yes	256,50 ± 5,26	256 (248 – 263)	0,563*
	No	254,90 ± 5,45	255 (247 – 263)	0,775*
Length	Yes	19,50 ± 0,34	19,42 (18,99 – 20,07)	0,735*
	No	19,49 ± 0,33	19,44 (18,99 – 19,93)	0,532*
Lee Index	Yes	325,84 ± 5,92	326,54 (319,13 – 336,53)	0,344*
	No	325,44 ± 5,69	326,57 (315,45 – 333,93)	0,756*

* Normal (p > 0,05)

The normality test results, conducted using the Shapiro-Wilk test, showed that the data were normally distributed. Therefore, further comparisons were made using the Independent t-test to assess differences between groups.

Table 3. Differences in Body Weight, Length, and Lee Index Based on Sleeve Gastrectomy

Variabel	Sleeve Gastrectomy	Mean ± SD	p
Weight	Yes	256,50 ± 5,26	0,512
	No	254,90 ± 5,45	
Lenght	Yes	19,50 ± 0,34	0,911
	No	19,49 ± 0,33	
Lee Index	Yes	325,84 ± 5,92	0,878
	No	325,44 ± 5,69	

The Independent t-test results for body weight, length, and Lee index based on sleeve gastrectomy intervention showed a p-value > 0.05. This indicates no statistically significant differences between the groups for these variables.

Table 4. Descriptive and Normality Analysis of Glucose Levels

Glucose	Sleeve Gastrectomy	Mean ± SD	Median (min–max)	$p^{£}$
Pre	Yes	260,63 ± 5,39	261,09 (253,97 – 272,80)	0,155*
	No	265,82 ± 5,93	264,65 (256,07 – 274,48)	0,790*
Post	Yes	149,97 ± 13,38	147,74 (138,82 – 186,27)	<0,001
	No	188,62 ± 5,57	188,04 (180,39 – 195,69)	0,449*

Glucose	Sleeve Gastrectomy	Mean ± SD	Median (min–max)	p£
Diff.	Yes	-110,7 ± 12,97	-114,49 (-124,18 – (-76,49))	0,001
	No	-77,19 ± 1,09	-77,20 (-78,79 – (-75,67))	0,414*

The Shapiro-Wilk normality test indicated that pre-glucose levels were normally distributed; therefore, an Independent t-test was used for unpaired comparisons of pre-glucose levels. However, post-glucose levels and glucose differences were not normally distributed, so the Mann-Whitney test was used for unpaired comparisons in these cases. Additionally, the difference in glucose levels within the sleeve gastrectomy group was not normally distributed, prompting the use of the Wilcoxon test for paired comparisons. Conversely, the non-sleeve gastrectomy group showed normal distribution in glucose differences, so the Paired t-test was applied for paired comparisons in this group.

Table 5. Table of glucose differences

Glukosa	Sleeve Gastrectomy		p
	Yes	No	
Pre	260,63 ± 5,39	265,82 ± 5,93	0,055§
Post	149,97 ± 13,38	188,62 ± 5,57	<0,001‡*
p	0,005†*	<0,001¶*	
Diff.	-110,7 ± 12,97	-77,19 ± 1,09	0,001‡*

The paired comparison test results between pre-glucose and post-glucose levels in the sleeve gastrectomy group showed a p-value of 0.005 ($p < 0.05$), indicating a statistically significant difference. In the non-sleeve gastrectomy group, the p-value was <0.001 ($p < 0.05$), also indicating a significant difference.

In the unpaired comparison between the sleeve gastrectomy and non-sleeve gastrectomy groups, the pre-glucose levels had a p-value of 0.055 ($p > 0.05$), suggesting no significant difference. However, the p-value was <0.001 ($p < 0.05$) for post-glucose levels, indicating a significant difference. Furthermore, the difference in glucose levels between the groups yielded a p-value of 0.010 ($p < 0.05$), confirming a statistically significant difference.

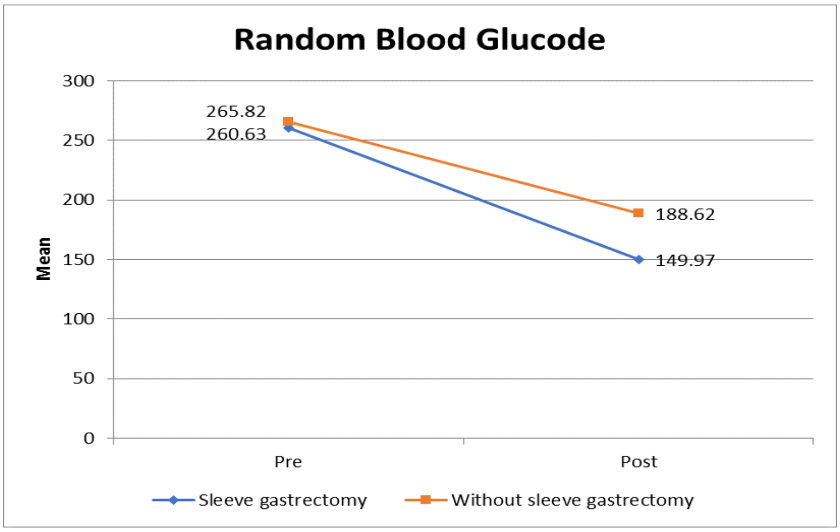

Figure 1. Research Data

The research data indicates a significant reduction in blood glucose levels in both groups, with a p-value of <0.05, showing statistical significance. The P1 group, which underwent the sleeve gastrectomy procedure, demonstrated a significant reduction in blood glucose levels. This suggests that the sleeve gastrectomy group achieved better blood glucose control than the other group.

Sleeve gastrectomy, particularly procedures like sleeve gastrectomy, significantly impact food intake, nutrient absorption, and blood glucose levels, contributing to obesity management. By reducing stomach size, gastrectomy limits food intake, leading to decreased caloric consumption. This alteration also accelerates gastric emptying, resulting in faster nutrient delivery to the small intestine, which can enhance the release of hormones such as GLP-1. Elevated GLP-1 levels improve insulin secretion and glucose metabolism, aiding blood glucose regulation.

The rapid exposure of nutrients to the small intestine post-gastrectomy stimulates an increased release of GLP-1 from intestinal cells. This surge in GLP-1 can enhance insulin secretion and improve blood glucose control, which is particularly beneficial for individuals with type 2 diabetes. In fact, the rise in GLP-1 after gastrectomy is one of the mechanisms believed to contribute to the improvement in blood glucose levels observed in many patients who undergo the procedure, especially in bariatric surgeries aimed at weight loss.

Glucagon-like peptide-1 (GLP-1) is a hormone that plays a significant role in blood glucose regulation by enhancing insulin secretion in response to food intake, especially after a meal. When blood glucose levels are high, GLP-1 is released from the intestines and signals the pancreas to release insulin, which helps lower blood sugar levels by facilitating glucose uptake in cells. Additionally, GLP-1 inhibits the release of glucagon, another hormone that raises blood glucose levels, thereby reducing the liver's glucose production. By slowing gastric emptying, GLP-1 also extends the time glucose takes to enter the bloodstream, helping to prevent sudden spikes in blood sugar. Together, these actions make GLP-1 a valuable target in treatments for type 2 diabetes, as enhancing or mimicking its effects can significantly improve blood glucose control in patients.

CONCLUSION

Sleeve gastrectomy has a significant effect on improving random blood glucose levels in obese diabetic rats. By reducing stomach volume, this procedure limits food intake, accelerates gastric emptying, and enhances the release of gut hormones such as GLP-1, improving insulin sensitivity and aiding in blood glucose regulation. The study findings reveal that sleeve gastrectomy leads to a notable reduction in blood glucose levels within the intervention group and demonstrates a more substantial impact compared to non-surgical interventions. These results indicate that sleeve gastrectomy may be an effective intervention for managing blood glucose levels in obesity-related type 2 diabetes, highlighting its potential as a therapeutic approach for metabolic control in similar clinical conditions.

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