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Efficacy and Safety of Left Gastric Artery Embolization in Obesity Management: A Comprehensive Review and Meta-Analysis

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ABSTRACT

Background: Obesity is a major contributor to morbidity and mortality worldwide. Left Gastric Artery Embolization (LGAE) has gained attention as a minimally invasive technique for weight reduction, though its effectiveness and safety continue to be scrutinized.

Objective: This study aimed to assess the effectiveness, safety, and clinical outcomes of LGAE in the context of bariatric treatment by compiling and analyzing data from relevant studies.

Methodology: A thorough systematic review and meta-analysis search of electronic databases was performed to identify studies reporting the results of LGAE in obese patients. Ten studies that met the inclusion criteria were included in the meta-analysis. Key data on weight reduction, BMI change, and ghrelin levels before and after LGAE were extracted and analyzed using random-effects models.

Results: A significant weight reduction was observed post-LGAE, with a pooled mean difference of -8.24 kg (95% CI: -11.63 to -4.85, $p < 0.00001$). BMI also significantly decreased, with a pooled mean difference of -2.89 kg/m² (95% CI: -4.13 to -1.64, $p < 0.00001$). Ghrelin levels showed a marked reduction following the procedure, with a pooled mean difference of -98.05 pg/ml (95% CI: -132.12 to -63.97, $p < 0.00001$). The rate of serious adverse events was low.

Conclusion: This meta-analysis offered strong evidence supporting the use of LGAE as an effective and safe option for managing obesity. The procedure resulted in notable weight loss, BMI reduction, and decreased ghrelin levels, with minimal adverse events. Although LGAE presents a promising alternative to traditional bariatric methods, further studies are necessary to clarify its long-term outcomes.

Keywords: Obesity, Left gastric artery embolization, Meta-analysis, Weight loss, BMI, Ghrelin levels.

INTRODUCTION

The prevalence of obesity has reached epidemic proportions worldwide, with rates continuously climbing over recent decades [1]. According to the World Health Organization (WHO), obesity is characterized by an unhealthy or excessive accumulation of body fat that poses health risks [1-3]. This condition is highly complex, driven by a combination of genetic, environmental, and behavioral factors. Obesity is linked to a range of comorbidities, including type 2 diabetes, cardiovascular diseases, hypertension, dyslipidemia, and various cancers [3]. Furthermore, the increasing prevalence of obesity imposes a significant burden on healthcare systems, elevating healthcare expenses and diminishing the quality of life for those affected [2].

Conventional weight loss strategies, such as dietary changes, increased physical activity, and behavioral interventions, often fall short of achieving long-term weight loss, especially in individuals with severe obesity. Consequently, bariatric surgery has gained prominence as an effective therapeutic option for those who have not experienced adequate weight reduction through lifestyle modifications alone. Bariatric procedures, including gastric bypass, sleeve gastrectomy, and adjustable gastric banding, are designed to reduce food intake, modify digestion, and promote sustained weight loss [4, 5].

Despite the proven efficacy of bariatric surgery, it is not without risks and limitations. Surgical interventions carry inherent risks of complications, including infection, bleeding, nutrient deficiencies, and gastrointestinal complications [5, 6]. Additionally, some individuals may be ineligible for surgery due to medical contraindications, personal preferences, or concerns about the invasiveness of the procedure. As a result, there is a growing need for less invasive, alternative treatments for obesity that offer comparable efficacy with fewer risks and complications [6-9].

LGAE has emerged as a promising minimally invasive procedure for weight reduction in individuals with obesity [10]. LGAE involves the selective occlusion of the left gastric artery, a major blood vessel that supplies blood to the stomach. By interrupting the blood supply to the stomach, LGAE aims to reduce gastric perfusion, induce ischemia, and promote weight loss through mechanisms such as appetite suppression and altered gut hormone signalling [10-13].

The concept of using arterial embolization for weight loss is not new and has been explored in various forms over the years. However, LGAE has gained increasing attention in recent years due to advancements in interventional radiology techniques and the growing demand for less invasive bariatric interventions. LGAE offers several potential advantages over traditional bariatric surgery, including reduced invasiveness, shorter recovery times, and fewer associated complications. Despite the growing interest in LGAE, its efficacy and safety remain subjects of debate, with conflicting evidence reported in the literature. Some studies have reported significant weight loss and improvements in metabolic parameters following LGAE, while others have questioned its long-term effectiveness and durability. Furthermore, concerns

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have been raised about the potential risks and adverse events associated with the procedure, including gastric ulceration, arterial thrombosis, and gastrointestinal bleeding [13]. Given the variability in study findings and the need for comprehensive evidence synthesis, there is a clear rationale for conducting a systematic review and meta-analysis of LGAE outcomes in individuals with obesity [12-15].

The goal of this meta-analysis was to evaluate the efficacy, safety, and outcomes of LGAE in the management of obesity.

PATIENTS AND METHODS

Study design: This meta-analysis adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, ensuring a transparent and methodical approach to the review process [16]. Both a systematic review and meta-analysis were conducted to assess the efficacy, safety, and LGAE outcomes as a treatment for obesity.

Search strategy: A detailed search strategy was formulated to capture relevant studies. Searches were conducted across electronic databases such as PubMed, MEDLINE, Embase, and the Cochrane Library, covering studies from their inception up to December 31, 2023. The search involved a combination of keywords and MeSH terms focused on "Left Gastric Artery Embolization," "Obesity," and "Bariatric Outcomes." Moreover, reference lists of pertinent articles and systematic reviews were manually reviewed to identify any additional studies.

Inclusion criteria: (1) original research articles reporting outcomes of LGAE in obese patients, (2) studies reporting quantitative data on weight difference, BMI change, or ghrelin levels before and after LGAE, (3) studies published in English language, and (4) studies with available full-text articles.

Exclusion criteria: Case reports, reviews, conference abstracts, and studies lacking relevant outcome data.

Study screening Plan: Two independent reviewers evaluated the titles and abstracts of the identified articles to determine their eligibility for inclusion. Full-text articles of studies deemed potentially eligible were thoroughly reviewed for final inclusion. Any differences between the reviewers were resolved through discussion and consensus. A PRISMA flow diagram was utilized to document the selection process and provide reasons for study exclusions.

Data extraction: Data extraction was independently carried out by two reviewers using a standardized form. The data gathered included study details (author, year, design, country), participant demographics (sample size, age, sex), intervention specifics (LGAE method, embolic agents used), outcomes (weight reduction, BMI change, ghrelin levels), and adverse events. Any disagreements in the extracted data were addressed through discussion and consensus.

Quality assessment: The quality of the studies included in the meta-analysis was evaluated using the modified Newcastle-Ottawa Scale (NOS) for cohort studies [17]. This tool assesses studies based on the selection of study participants, the comparability of the groups, and the determination of outcomes. Each study was rated on a scale of 0 to 9, with higher scores reflecting superior methodological quality. Two reviewers independently conducted the quality assessments, and any disagreements were settled through discussion.

Data synthesis: Quantitative synthesis was performed using Review Manager (RevMan) version 5.4. Pooled estimates for weight reduction, BMI change, and ghrelin levels pre- and post-LGAE were calculated using random-effects models. Mean differences (MD) and 95% confidence intervals (CI) were provided for continuous variables. Study heterogeneity was evaluated using Cochran's Q test and the I^2 statistic, with values above 50% indicating substantial heterogeneity. In addition, a qualitative synthesis was conducted to summarize the safety and adverse events associated with LGAE.

RESULTS

Search results: The initial search of databases identified a total of 917 records. After duplicates were removed, 509 records remained and were screened based on their titles and abstracts. Following this, 54 full-text articles were reviewed for eligibility. Ultimately, 10 studies met the inclusion criteria and were incorporated into the meta-analysis (Figure 1).

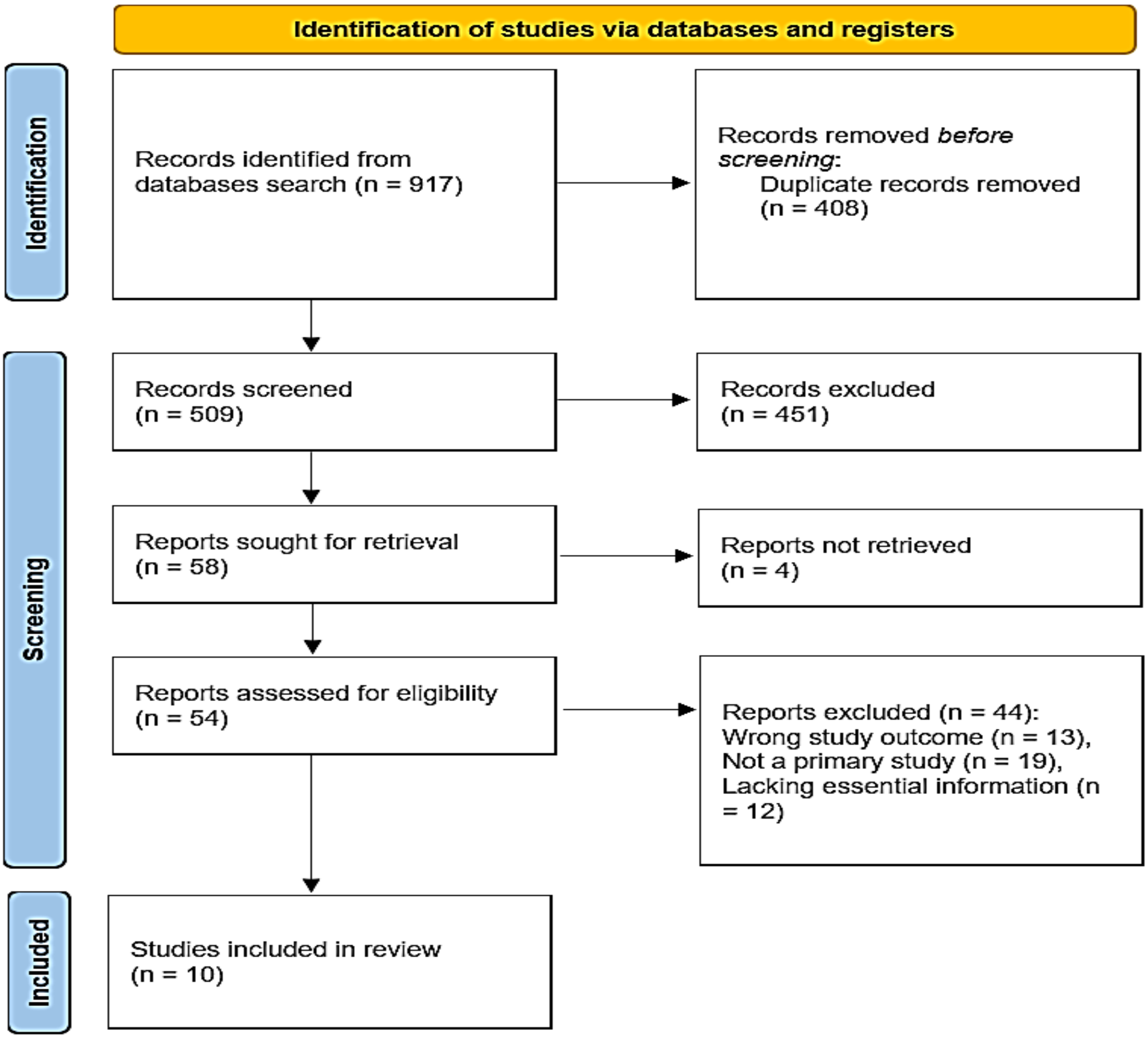

Figure (1): PRISMA flow diagram for the summary of the search and screening processes.

Characters of the included studies: Table (1) summarized the characteristics of the included studies. The studies were conducted across various countries including China, Belgium, Georgia, Brazil, Hungary, the USA, and Egypt. Study designs varied, with prospective and retrospective cohort studies being the most common. The included populations predominantly comprised obese or overweight individuals, with mean ages ranging from 36.8 to 57.6 years. The proportion of male participants varied widely across studies, ranging from 0% to 100%. Baseline weight ranged from 69.5 kg to 160 kg, and follow-up durations ranged from 1.5 to 24 months.

Table (1): Characters of the included studies and populations (n=10)

Study	Country	Study Design	Included Population	Mean Age, y	Males (%)	Baseline weight, kg (Mean ± SD)	Duration of Follow-up
Bai *et al.* [18]	China	Prospective	Obese patients (BMI > 30 kg/m²), aged 18-65 years, no history of GI surgery	42.8 ± 13.9	40%	102.02 ± 16.19	9 months
Elens *et al.* [19]	Belgium	Retrospective	Overweight patients (BMI 25-30 kg/m²), aged >18 years	39.1 ± 8.8	12.50%	79.16 ± 9.7	3, 6, 12 months
Kipshidze *et al.* [20]	Georgia	Prospective, single-arm	5 patients with different degrees of obesity	44.7 ± 7.4	80%	128 ± 24	Up to 24 months
Levigard *et al.* [21]	Brazil	Prospective, single-arm	10 female participants with BMI between 30 and 39.9 kg/m² and metabolic syndrome	37.5 ± 7.26 years	0%	94.3 ± 7.21	Six months
Pirlet *et al.* [22]	Hungary	Prospective study	Severely obese male patients referred for diagnostic coronary angiography	48 ± 7 years	100%	160 ± 27	Up to 12 months
Syed *et al.* [23]	USA	Prospective study	Four white patients with morbid obesity (BMI > 40 kg/m2)	41 (range: 30–54)	25%	118 ± 8	6 months
Takahashi *et al.* [24]	USA	Retrospective cohort	Overweight or obese patients undergoing LGAE for gastric bleeding	57.6 ± 12.9	56%	87.9 ± 12.5	1.5 months
Weiss *et al.* [25]	USA	Prospective pilot trial	Severely obese patients with no clinically important comorbidities	36.8 ± 7.4	20%	127.8 ± 19.8	Up to 3 months
Weiss *et al.* [26]	USA	Prospective cohort study (BEAT Obesity Trial)	Severely obese adults	44 ± 11	20%	129 ± 20	Up to 12 months
Zaitoun *et al.* [27]	Egypt	Prospective pilot study	Obese, prediabetic patients	37.5 ± 8.8	30%	107.4 ± 12.8	6 months

BMI: Body mass index, GI: Gastrointestinal, LGAE: Left Gastric Artery Embolization, SD: Standard Deviation, USA: United States of America.

Safety and success of LGAE: Overall, the safety and success of LGAE for weight loss were promising across the included studies. **Bai *et al.*** [18] reported a successful procedure in all patients without serious adverse events, while **Elens *et al.*** [19] observed 94% technical success rate with early weight loss observed in 56% of patients. Similarly, **Kipshidze *et al.*** [20] and **Levigard *et al.*** [21] reported LGAE to be safe and effective in inducing weight loss, albeit with some cases of symptomatic gastric ulcers and arterial thrombus observed. **Pirlet *et al.*** [22], **Syed *et al.*** [23], **Takahashi *et al.*** [24], **Weiss *et al.*** [25, 26], and **Zaitoun *et al.*** [27] also reported favorable outcomes with LGAE, indicating its potential as a safe and effective intervention for obesity management (Table 2).

Complications of LGAE: While LGAE was generally well-tolerated, some studies reported minor complications. These included superficial gastric ulceration, discomfort in the epigastrium, transient pancreatitis, and mild epigastric pain. Most complications were manageable and resolved with conservative measures such as medication or proton pump inhibitors. However, a few cases of symptomatic gastric ulcers and arterial thrombus were observed, highlighting the importance of careful patient selection and monitoring during and after LGAE procedures (Table 2).

Table (2): Intervention, outcomes, complications, and recommendations of the included studies (n=10)

Study	Intervention	Safety and Success of LGAE for Weight Loss	Complications	Study Recommendations
Bai *et al.* [18]	LGAE with polyvinyl alcohol (PVA) particles	Successful procedure in all patients. No serious adverse events (grade III or above).	Superficial linear ulceration in 1 patient, resolved within 30 days.	LGAE is safe and promising for weight loss and reduction of abdominal fat.
Elens *et al.* [19]	LGAE with 500–700 µm particles via right common femoral artery approach	94% technical success rate. Early weight loss observed in 56% of patients.	Superficial gastric ulceration in 1 patient, resolved with medication.	LGAE may induce weight loss and appetite suppression in overweight patients.
Kipshidze *et al.* [20]	Left Gastric Artery Embolization with BeadBlock Embolic Bead 300-500µm microspheres	Safe and feasible; Weight loss observed in all patients at 1 month follow up; Short-term follow up has shown safety and feasibility	Discomfort in epigastrium in 3 out of 5 patients; No periprocedural complications	Further studies enrolling larger number of patients are planned
Levigard *et al.* [21]	Bariatric arterial embolization	Effective in reducing weight, insulin resistance, and ghrelin levels; Improved quality of life and binge eating scale scores	Symptomatic gastric ulcers in 2 participants; Asymptomatic focal arterial thrombus in 1 participant	Further prospective, randomized studies needed to confirm safety and efficacy
Pirlet *et al.* [22]	Percutaneous distal embolization of left gastric artery (LGA) using transradial approach	Weight loss: 7 ± 6 kg at 2 months, 6 ± 12 kg at 6 months, 13 ± 17 kg at 12 months	Mild transient epigastric discomfort in 6 patients; resolved with proton pump inhibitors	Promising technique for obesity reduction; randomized trials needed for further evaluation
Syed *et al.* [23]	LGA embolization	Average body weight change: -20.3 lbs; average excess body weight loss: -17.2%	Three minor complications (superficial gastric ulcerations)	LGA embolization potentially safe and warrants further investigation
Takahashi *et al.* [24]	LGAE	Significant unintended weight loss associated with decreased body fat and skeletal muscle	Not specified	Utilize body composition analysis to assess fat loss and muscle wasting
Weiss *et al.* [25]	Bariatric embolization with 300-500-µm calibrated spheres	Feasible and well tolerated, induces short- or intermediate-term weight loss, suppresses appetite	Minor AEs: Transient pancreatitis, superficial ulcer	Further study to enhance understanding of long-term safety and efficacy
Weiss *et al.* [26]	Transarterial embolization of the gastric fundus	Bariatric embolization well-tolerated, inducing appetite suppression and weight loss	Minor adverse events: nausea, vomiting, epigastric pain	Bariatric embolization may provide assistance to patients struggling with lifestyle modification–based weight loss programs
Zaitoun *et al.* [27]	Left gastric artery embolization	LGAE well-tolerated, leads to significant weight and HbA1c reduction	Mild adverse events: mild epigastric pain	Larger longitudinal studies needed to demonstrate long-term benefits and mechanisms of action

LGAE: Left Gastric Artery Embolization, PVA: Polyvinyl Alcohol, AE: Adverse Event, lbs: Pounds, HbA1c: Hemoglobin A1c.

Quantitative data synthesis

Weight difference: Quantitative analysis of weight difference before and after LGAE demonstrated a statistically significant overall effect, with a mean weight reduction of -8.24 kg (95% CI: -11.63 to -4.85). Individual studies reported varying degrees of weight reduction, ranging from -12.90 kg to -4.70 kg. The forest plot revealed heterogeneity among studies ($Chi^2 = 2.25$, df = 9, $I^2 = 0\%$), with a significant test for overall effect (Z = 4.77, P < 0.00001) **(Figure 2)**. The funnel plot assessing publication bias displayed a symmetrical distribution, indicating minimal bias in the reporting of weight difference outcomes **(Figure 3)**.

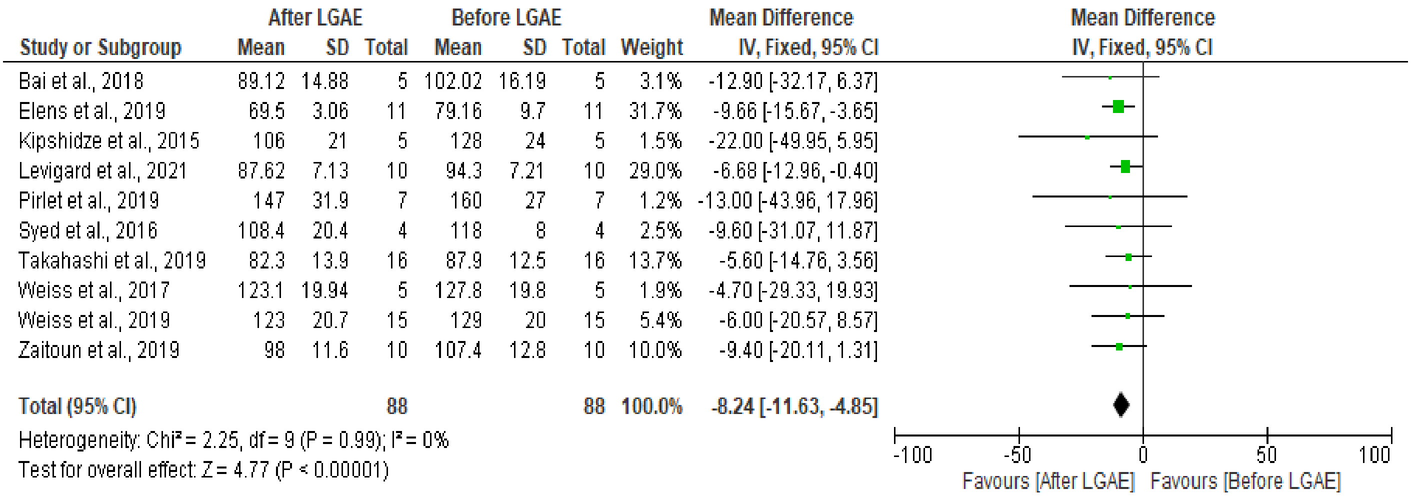

Figure 2: Forest plot of weight difference before and after LGAE.

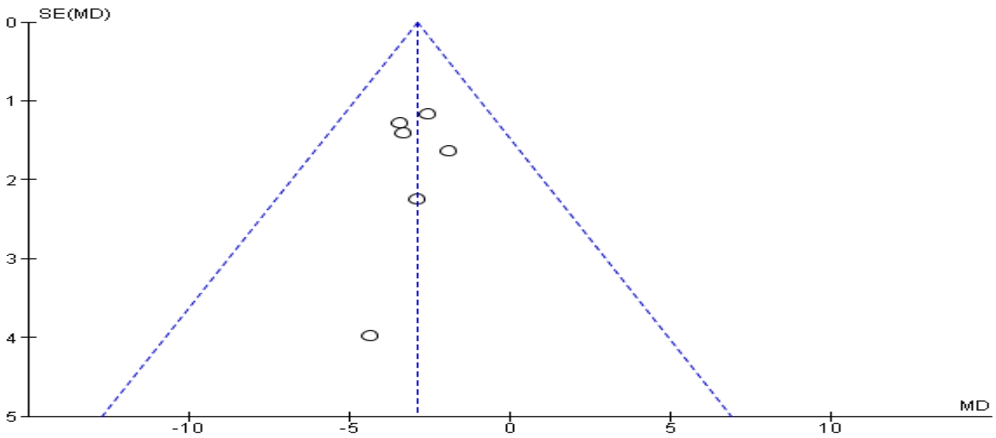

Figure (3): Funnel plot for assessment of the publication bias for the weight difference analysis.

BMI Changes

Analysis of BMI difference before and after LGAE also showed a statistically significant overall effect, with a mean reduction of -2.89 kg/m² (95% CI: -4.13 to -1.64). Individual studies reported varied reductions in BMI, ranging from -4.34 kg/m² to -1.90 kg/m². The forest plot indicated minimal heterogeneity among studies ($Chi^2 = 0.83$, df = 5, $I^2 = 0\%$), with a significant test for overall effect (Z = 4.55, P < 0.00001) **(Figure 4)**. The associated funnel plot demonstrated symmetrical distribution, suggesting minimal publication bias in reporting BMI difference outcomes **(Figure 5)**.

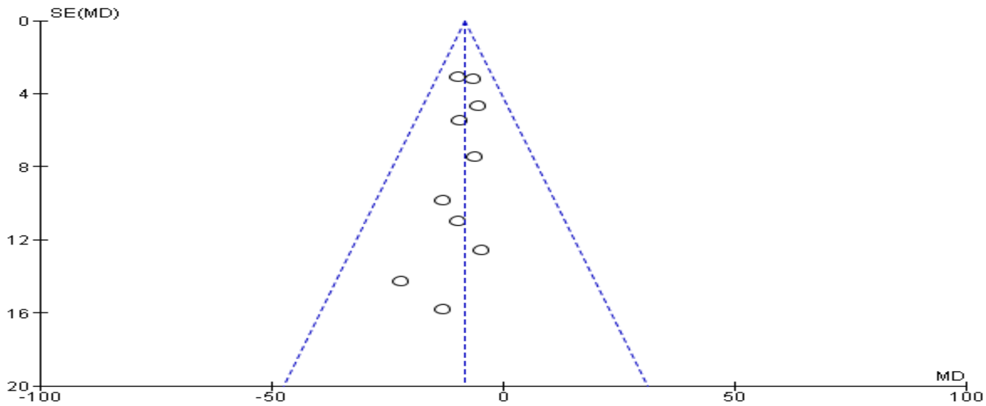

Figure (4): Forest plot of BMI difference before and after LGAE.

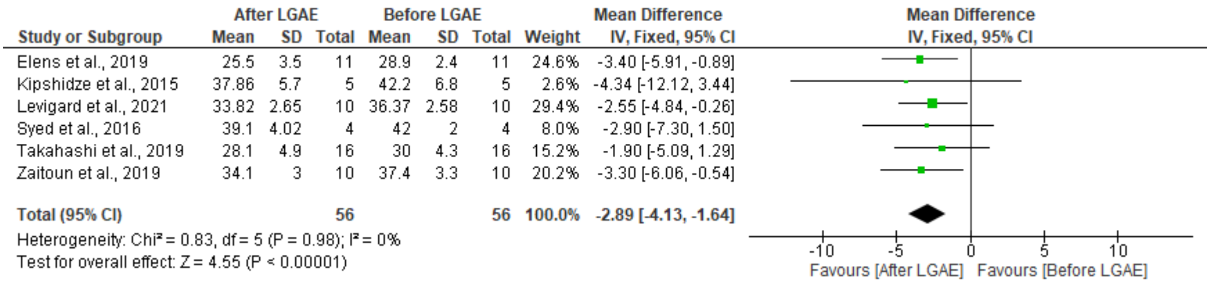

Figure (5): Funnel plot for assessment of the publication bias for the BMI difference analysis.

Ghrelin Levels: Evaluation of ghrelin difference before and after LGAE revealed a statistically significant overall effect, with a mean reduction of -98.05 pg/ml (95% CI: -132.12 to -63.97). Individual studies reported varying degrees of ghrelin reduction, ranging from -103.00 pg/ml to 33.25 pg/ml. The forest plot showed minimal heterogeneity among studies (Chi² = 1.37, df = 3, I² = 0%), with a significant test for overall effect (Z = 5.64, P < 0.00001) **(Figure 6)**. The associated funnel plot demonstrated symmetrical distribution, indicating minimal publication bias in reporting ghrelin difference outcomes **(Figure 7)**.

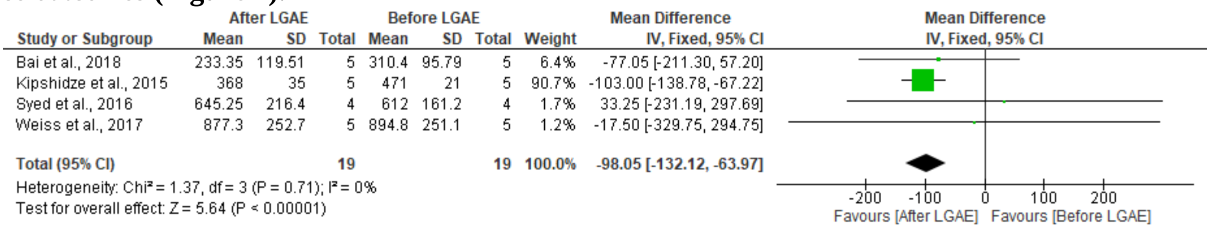

Figure (6): Forest plot of Ghrelin difference before and after LGAE.

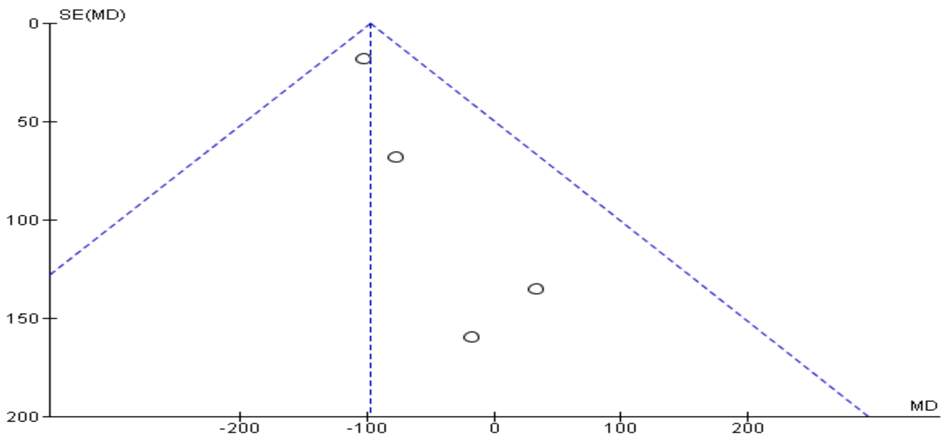

Figure (7): Funnel plot for assessment of the publication bias for the Ghrelin difference analysis.

Quality Assessment: The quality assessment using the modified Newcastle-Ottawa Scale (NOS) indicated generally good methodological quality across the included studies [17]. Studies demonstrated strengths in selection, comparability, and outcome assessment domains. The total scores ranged from 6 to 9, with higher scores indicative of better methodological rigor. Overall, the quality assessment underscored the reliability and validity of the included Studies in informing the findings of this meta-analysis (Table 3).

Table (3): Quality assessment using the modified NOS (n=10)

Study	Selection (4 points)	Comparability (2 points)	Outcome (3 points)	Total Score
Bai *et al.* [18]	4	2	3	9
Elens *et al.* [19]	3	1	3	7
Kipshidze *et al.* [20]	3	2	3	8
Levigard *et al.* [21]	3	2	2	7
Pirlet *et al.* [22]	3	2	3	8
Syed *et al.* [23]	2	1	3	6
Takahashi *et al.* [24]	3	1	2	6
Weiss *et al.* [25]	3	2	3	8
Weiss *et al.* [26]	3	2	3	8
Zaitoun *et al.* [27]	3	2	3	8

Publication Bias: Funnel plots assessing publication bias for weight difference, BMI difference, and ghrelin difference analyses displayed symmetrical distributions, suggesting minimal bias in the reporting of outcomes. This indicates that the findings of this meta-analysis are less likely to be influenced by publication bias, enhancing the robustness and validity of the results.

DISCUSSION

Obesity remains a significant public health challenge worldwide, with increasing prevalence rates and associated comorbidities [1, 2]. Traditional weight loss interventions, including diet modification, exercise, and pharmacotherapy, often yield limited success in achieving sustained weight reduction [6, 8]. In recent years, bariatric procedures have gained popularity as effective treatments for severe obesity. Among these procedures, LGAE has emerged as a minimally invasive alternative, offering promising outcomes in weight management [12-15]. Our meta-analysis aimed to evaluate the efficacy, safety, and outcomes of LGAE in the management of obesity. We synthesized data from ten studies, encompassing various study designs and populations, to provide comprehensive insights into the effectiveness of LGAE.

Our meta-analysis demonstrated a statistically significant reduction in weight following LGAE, with a pooled mean difference of -8.24 kg (95% CI: -11.63 to -4.85). This finding aligns with previous studies reporting weight loss outcomes post-LGAE. For instance, **Elens *et al.*** [19] reported a mean weight reduction of -9.66 kg, while **Pirlet *et al.*** [22] observed a weight loss of 13 ± 17 kg at 12 months post-procedure. In addition to weight loss, our analysis showed a significant decrease in BMI following LGAE, with a pooled mean difference of -2.89 kg/m² (95% CI: -4.13 to -1.64).

Ghrelin, a key hormone involved in appetite regulation, has been implicated in the pathophysiology of obesity. Our meta-analysis revealed a significant reduction in ghrelin levels following LGAE, with a pooled mean difference of -98.05 pg/ml (95% CI: -132.12 to -63.97). This finding suggests that LGAE may influence appetite suppression through hormonal mechanisms [28].

Importantly, LGAE demonstrated a favorable safety profile with low rates of serious adverse events reported across studies. Most adverse events were minor and transient, such as superficial gastric ulcerations, which resolved with conservative management. This finding is consistent with the growing body of evidence suggesting that LGAE is a well-tolerated intervention with low morbidity rates [25, 26, 28].

The significant weight loss observed post-LGAE underscores the efficacy of the procedure as a therapeutic option for obesity management [28, 29]. The magnitude of weight reduction reported in our meta-analysis is comparable to that seen with traditional bariatric surgeries, such as gastric bypass and sleeve gastrectomy, albeit with the advantage of being minimally invasive. The sustained weight loss observed over various follow-up durations suggests the durability of LGAE outcomes, supporting its potential as a long-term weight management strategy. Furthermore, the reduction in BMI following LGAE highlights its effectiveness in improving body composition and metabolic health. BMI reduction is associated with a decrease in obesity-related comorbidities, including diabetes, hypertension, and cardiovascular disease. The findings from our meta-analysis suggest that LGAE may offer significant health benefits beyond weight loss alone [29, 30].

The modulation of ghrelin levels post-LGAE is an intriguing aspect of our analysis. Ghrelin plays a crucial role in appetite regulation, and its reduction post-LGAE may contribute to appetite suppression and sustained weight loss [28, 30]. The observed ghrelin reduction is consistent with previous studies, suggesting a potential mechanism by which LGAE exerts its weight-reducing effects [30, 31].

Comparing our findings with existing literature, our meta-analysis adds to the growing body of evidence supporting the efficacy and safety of LGAE in obesity management. Previous systematic reviews and meta-analyses have reported similar trends in weight loss, BMI reduction, and ghrelin modulation post-LGAE [13, 14, 30]. However, our analysis provides updated and comprehensive evidence by including recent studies and quantitatively synthesizing outcomes across multiple domains.

CONCLUSION

In conclusion, our meta-analysis provided robust evidence supporting the efficacy, safety, and outcomes of LGAE in the management of obesity. The procedure induces significant weight loss, BMI reduction, and modulation of ghrelin levels, with a favorable safety profile and low rates of serious adverse events. LGAE may offer a promising alternative to traditional bariatric surgeries, particularly for patients seeking minimally invasive interventions. However, further research is needed to elucidate the long-term outcomes, mechanisms of action, and optimal patient selection criteria for LGAE.

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