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**Global trends in research related to sleeve gastrectomy: A bibliometric and visualized study**

Barqawi A *et al.* Research trends in sleeve gastrectomy

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**Abstract**

BACKGROUND

One of the most popular bariatric procedures is sleeve gastrectomy, and it has become significantly more common in recent years.

AIM

To evaluate the research activity in sleeve gastrectomy over the last two decades, and to visualize the hot spots and emerging trends in this type of bariatric surgery using bibliometric methods.

METHODS

The Scopus database was used to search for publications related to sleeve gastrectomy. The retrieved publications were reviewed in terms of year of publication, type of study, country of origin, institutions, journals, and citation patterns by using descriptive analysis. Collaboration network and term co-occurrence analysis were visualized by using VOSviewer software.

RESULTS

The search strategy yielded a total of 6508 publications on sleeve gastrectomy from 2001 to 2020. As regards the document type, the majority were articles (*n* = 5230; 80.36%), followed by reviews (*n* = 544; 8.36%). The top three countries are the United States, with 1983 publications (30.47%), followed by France (600; 9.22%) and Italy (417; 6.71%). The most cited publication was published in 2012 by Schauer *et al* in the *New England Journal of Medicine* (*n* = 1435 citations). This publication found that weight loss was greater in the sleeve gastrectomy group than in the medical therapy group. Furthermore, this study demonstrated that 12 mo of medical therapy plus bariatric surgery greatly improved glycemic regulation in obese patients with uncontrolled type 2 diabetes compared with medical therapy alone. The focus of the current literature on sleeve gastrectomy was directed toward several themes such as morbidity and potential complications, the complexity of the procedure and different surgical approaches, and diabetes and body mass index in correlation to sleeve gastrectomy.

CONCLUSION

The number of sleeve gastrectomy publications has gradually grown over the last 20 years. This bibliometric analysis could help researchers better understand the knowledge base and research frontiers surrounding sleeve gastrectomy. In addition, future studies may focus on emerging research hotspots.

**Key Words:** Sleeve gastrectomy; Bibliometric; Scopus; VOSviewer; Bariatric surgery

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**Core Tip:** One of the most popular bariatric procedures is sleeve gastrectomy, and it has become significantly more common in recent years. Therefore, this study intends to evaluate the research activity in sleeve gastrectomy over the last two decades and quantitatively estimate the hot spots and emerging trends in this type of bariatric surgery with bibliometric methods and enable researchers to identify new areas for potential development. The current literature on sleeve gastrectomy was directed toward several themes such as morbidity and potential complications, the complexity of the procedure and different surgical approaches, and diabetes mellitus and body mass index in correlation with sleeve gastrectomy.

**INTRODUCTION**

Bariatric surgery has been trending since the twentieth century as hundreds of articles discussed different surgical approaches in the prospect of feasibility, complication rate, and long-term outcomes[[1](#_ENREF_1)]. Bariatric surgery is a broad term that does entail different surgical approaches, including open and laparoscopic surgery. In 2018, 696191 surgical and endoluminal procedures were performed under the umbrella of bariatric surgery[[2](#_ENREF_2)]. Most of the procedures were surgical approaches rather than endoluminal, such as sleeve gastrectomy (SG), one anastomosis gastric bypass (OAGB), and Roux-en-Y gastric bypass (RYGB). Sleeve gastrectomy remains the most popular procedure worldwide, with thousands of articles and reviews debating its benefits, complications, and long-term outcomes[[3-10](#_ENREF_3)]. The reasons behind sleeve gastrectomy being a trending topic over the last twenty years are that sleeve gastrectomy is technically less demanding, the learning curve is shorter than other surgical approaches, and it is purely physiological as no anastomosis or bypass is required. The previously mentioned facts support sleeve gastrectomy as it should be associated with less nutritional deficiency and low short-term complications[[11-13](#_ENREF_11)].

The volume of scientific evidence related to sleeve gastrectomy is enormous, and the annually published article curve is steeply growing[[14](#_ENREF_14),[15](#_ENREF_15)]. Still, it is poorly correlated and not connected to a simple algorithm or graph to explain the pattern and to display the topics that still demand more scientific input so researchers can work on them. Bibliometric analysis revealed that surgical activity and scientific publications in bariatric surgery is a rapidly developing research field[[14-18](#_ENREF_14)]. However, a quantitative analysis of sleeve gastrectomy has not yet been conducted. Therefore, this study intends to evaluate the research activity in sleeve gastrectomy over the last two decades and quantitatively estimate the hot spots and emerging trends in this type of bariatric surgery with bibliometric methods and enable researchers to identify new areas for potential development.

**MATERIALS AND METHODS**

***Sources of the Data***

We downloaded and extracted the publications from the Scopus database. All data were acquired on January 9, 2021. Despite the fact that there are many databases available for worldwide research evaluation, the current study selected the Scopus database because it included rich information such as country distribution and citation analysis. It has been widely used in the field of bibliometric studies[[19-22](#_ENREF_19)].

***Search strategy***

The published papers were searched in the recent twenty years (from 2001 to 2020). We used the keyword “Sleeve gastrectomy” or "Gastric Sleeve" in the title and/or abstracts because we are concerned with sleeve gastrectomy per se rather than related terminology. The search strategy was as follows: (TITLE-ABS ("Sleeve gastrectomy") OR TITLE-ABS ("Gastric Sleeve")) AND PUBYEAR > 2000 AND PUBYEAR < 2021.

***Bibliometric Analysis***

In this analysis, descriptive statistics are primarily used. Scopus's intrinsic role categorized and analyzed research trends and publication features, such as the distribution of countries, organizations, journals, and citation pattern areas. Besides, the top 20 most cited articles were also listed.

***Statistical analysis***

The Visualization of Similarity viewer (VOSviewer 1.6.16) software[[23](#_ENREF_23)] was used to create collaboration network maps regarding the cooccurrences of all terms in the title and abstract to determine the hotspots related to sleeve gastrectomy research. The visualization of international collaboration to identify the most prominent countries visualizing their relationships was also accomplished using VOSviewer. The data are compared over three 20-year time spans to see how the term used has evolved over time.

**RESULTS**

***Volume and types of publications***

The search strategy yielded a total of 6,508 publications on sleeve gastrectomy from 2001 to 2020. As regards the document type, the majority were articles (*n* = 5230; 80.36%), followed by reviews (*n* = 544; 8.36%), letters (*n* = 250; 3.84%), editorials (*n* = 172; 2.64%). Other document types such as notes, conferences, papers, or errata amounted to 312 (4.79%) publications. The growth track over the last 20 years (Figure 1) has seen two stages: the first (2001–2010), which had a very slow development period, and the second (2011–2020), which had a very fast development period. The average publication output increased from 46.2 publications per year in the initial period to 604.6 publications per year in the development period. Furthermore, the number of publication outputs during the development period increased from 205 publications in 2011 to 1,176 publications in 2020.

***Top prolific countries***

The contributions from each country were counted. The top ten most profitable countries for sleeve gastrectomy are listed in Table 1, along with the total number of publications for each region. Researchers from the United States of America reported about 1983 publications (30.5%) of the science material relating to sleeve gastrectomy over the last 20 years, resulting in the highest pool of evidence about sleeve gastrectomy. France (*n* = 600, 9.2%) and Italy (*n* = 417, 6.4%) are the next two countries. Figure 2 illustrates a network mapping of international research collaboration between countries with a minimum research output of 10 documents on sleeve gastrectomy. The United States and France are the countries with the most active research and collaboration.

***Top prolific institutions***

Table 2 shows each institution's contribution to the top ten most profitable institutions for sleeve gastrectomy research. The United States and France share six out of the ten most productive institutions for sleeve gastrectomy. The top institution is *Cleveland Clinic Foundation* with a total of 130 publications (2%). The second and third institutions were France-based as both *Inserm institution* and *AP-HP Assistance Publique - Hopitaux de Paris* shared 125 (3.4%) published articles.

***Top prolific journals***

Concerning the individual journals, *Obesity Surgery* published the largest number of sleeve gastrectomy publications (*n* = 1744, 27%). This is followed by *Surgery for Obesity and Related Diseases* (*n* = 1040, 16%). Both journals share the major output of research and articles related to sleeve gastrectomy. Surgical endoscopy is the third on the list with 304 (4.7%) published articles. Table 3 lists the top ten most productive journals for sleeve gastrectomy research.

***Top-cited publications***

The top 20 most cited papers on sleeve gastrectomy are summarized in Table 4. The top 20 most cited articles had citations ranging from 556 to 1435[[1](#_ENREF_1),[24-42](#_ENREF_24)]. The top-cited article is bariatric surgery *vs* intensive medical therapy in obese patients with diabetes, published in 2012 in the *New England Journal of Medicine* with 1435 citations. The second top-cited article is Bariatric surgery *vs* intensive medical therapy for diabetes - 3-Year outcomes, which was published in 2014 in the *New England Journal of Medicine* with 983 citations. The third and fourth top-cited publications were published in *Obesity Surgery* in 2013 and 2015 with 1751 total citations per both documents, retrospectively. A Cochrane review was published in 2014 with total 806 citations discussing surgery for weight loss in adults, which was written by Colquitt JL*.*

***Sleeve gastrectomy research themes, frequent topics, and trends***

The visualization of the most frequently found terms in the title and abstracts of the collected documents (a minimum of 50 times) resulted in three major colored clusters (red, green, and blue), which reflect the three research topics as the highest research priority topics (Figure 3). Cluster number 1 (red color) included terms related to morbidity and potential complications topics such as conversion, leak, and fistula; Cluster number 2 (blue color) included terms related to the complexity of the procedure and different surgical approach topics such laparoscopy; and Cluster number 3 (green color) included terms related to diabetes and BMI in correlation to sleeve gastrectomy. Figure 4 shows an overlay visualization in which the VOSviewer was used to add colors to the terms according to the year of publication. Blue terms emerged first, followed by yellow terms later. Most sleeve gastrectomy research centered on terms relating to morbidity and surgical complications before 2016, namely, in the early stages of research in this field. The current trends presented the terms associated with surgical techniques and the correlation of sleeve gastrectomy to diabetes mellitus and body mass index.

**DISCUSSION**

This bibliometric analysis presents a comprehensive overview of the growth of the scientific literature regarding sleeve gastrectomy researchin the recent twenty years. Sleeve gastrectomy is one of the most common bariatric procedures and one of the most researched[[14](#_ENREF_14),[15](#_ENREF_15),[17](#_ENREF_17),[18](#_ENREF_18),[43-46](#_ENREF_43)]. The global patterns of published papers in sleeve gastrectomy research showed statistically continued growth over time. While the number of publications increased gradually, the year-over-year percentage of publications increased noticeably in the last two years. Thus, sleeve gastrectomy-related research has recently shown considerable growth, which can be recognized by researchers’ contributions globally. To evaluate the research contributions at the global level, total research publication output in the field of sleeve gastrectomy has been applied as an indicator for scientific research production. In accordance with the observed increase of research regarding morbidity and surgical complications in general[[47-53](#_ENREF_47)], our results demonstrated a continued increase of sleeve gastrectomy literature since 2001. This progress was particularly prominent since 2010, which coincided with the shift in focusing on developing tools for surgical techniques[[54-57](#_ENREF_54)] and the correlation of sleeve gastrectomy with diabetes mellitus and body mass index[[58-67](#_ENREF_58)].

In the current study, the United States has the highest publication rate in research production with sleeve gastrectomy, which matches what has also been found in other therapeutic approaches to obesity treatment[[14](#_ENREF_14),[15](#_ENREF_15),[18](#_ENREF_18),[43-46](#_ENREF_43)]. France was ranked as the second in the number of publications in the field of sleeve gastrectomy, followed by Italy. This can be attributed to the development of countries’ scientific systems and the number of researchers[[68](#_ENREF_68)] or due to the high prevalence of overweight and obesityin these countries[[69](#_ENREF_69),[70](#_ENREF_70)].

According to Angrisani *et al*[[1](#_ENREF_1)] the United States had the largest number of bariatric procedures and the United States is the leading country globally. In addition, according to a review of bariatric practice in the United States, laparoscopic sleeve gastrectomy has become the most commonly performed bariatric procedure[[71](#_ENREF_71)]. According to data from Europe, France currently has the highest rate of bariatric surgery[[72](#_ENREF_72)]. Despite the comparatively low prevalence rates of 3.1% and 1.2% for grade II and III obesity, respectively, in France in comparison to other European countries, this may be clarified by a favorable policy contextual and unrestricted access to bariatric surgery in France[[73](#_ENREF_73)]. France's current distinction in comparison to other European countries is the current and increasing preference for laparoscopic sleeve gastrectomy over other procedures[[73](#_ENREF_73)].

The current findings are in accord with a previous bibliometric study indicating that the United States were the most productive country in research related to the microbiome related to irritable bowel syndrome[[74](#_ENREF_74)]. These findings seem to be in agreement with other bibliometric research that found the United States and France were the leading scientific countries on Chagas cardiomyopathy[[75](#_ENREF_75)]. On the other hand, as revealed by previous bibliometric studies[[76-80](#_ENREF_76)], the United States took the first international collaborative articles position. The importance of international collaboration was not only focusing on advancing knowledge and strengthening research capacity[[81](#_ENREF_81)]; it also might increase citation rates and improve research quality[[82](#_ENREF_82), [83](#_ENREF_83)].

The most cited publication was published in 2012 by Schauer *et al*[[42](#_ENREF_42)] in the *New England Journal of Medicine* (*n* = 1435 citations). This publication found that weight loss was greater in the sleeve gastrectomy group than in the medical therapy group. Furthermore, this study demonstrated that 12 mo of medical therapy plus bariatric surgery greatly improved glycemic regulation in obese patients with uncontrolled type 2 diabetes compared with medical therapy alone[[42](#_ENREF_42)]. The second most cited publication (*n* = 983 citations) was published in 2014 in the *New England Journal of Medicine* by Schauer *et al*[[41](#_ENREF_41)], it presented the outcomes 3 years obese patients with uncontrolled type 2 diabetes were randomly assigned to undergo either intensive medical therapy alone or intensive medical therapy plus sleeve gastrectomy or Roux-en-Y gastric bypass. This study proved that 3 years of medical therapy plus bariatric surgery greatly improved glycemic regulation in obese patients with uncontrolled type 2 diabetes compared to medical therapy alone[[41](#_ENREF_41)]. Finally, the third paper (*n* = 902 citations), published in 2013 in *Obesity Surgery* by Buchwald and Oien[[25](#_ENREF_25)], found that the most commonly performed bariatric procedures were Roux-en-Y gastric bypass and sleeve gastrectomy.

The major limitation of this study is related to the database used to collect publications related to sleeve gastrectomy. However, the Scopus database does not represent all scientific journals. However, it is the largest database of peer-reviewed scientific journals[[84](#_ENREF_84)]. Another limitation is that certain articles' titles and abstracts did not include the term "sleeve gastrectomy" or related expressions, so not all articles regarding sleeve gastrectomy might be considered. Furthermore, the majority of publications were published and indexed in 2020, but since new journal issues are still being released and indexed, therefore, the amount of scientific research productivity this year could be higher.

**CONCLUSION**

The number of sleeve gastrectomy publications has gradually grown over the last 20 years. The current study's findings were biased in favor of high-income countries. In this domain, the United States and France had a significant impact. The current literature on sleeve gastrectomy was directed toward several themes such as morbidity and potential complications, the complexity of the procedure and different surgical approaches, and diabetes mellitus and body mass index in correlation with sleeve gastrectomy. This bibliometric analysis could help researchers better understand the knowledge base and research frontiers surrounding sleeve gastrectomy. In addition, future studies may focus on emerging research hotspots.

**ARTICLE HIGHLIGHTS**

***Research background***

Sleeve gastrectomy has grown in popularity among laparoscopic surgeons who do bariatric surgery and has shown to be an effective way of obtaining significant weight loss in a short period of time.

***Research motivation***

The amount of scientific evidence relating to sleeve gastrectomy is massive, and the annually published article curve is sharply increasing. It is still weakly correlated and unconnected to a simple algorithm or graph to describe the pattern and highlight the issues that require more scientific input so that researchers may work on them.

***Research objectives***

The goal of this study is to use bibliometric approaches to assess the research activity in sleeve gastrectomy over the last two decades and to visualize the hot areas and developing trends in this type of bariatric surgery.

***Research methods***

On January 9, 2021, we performed a literature search utilizing the Scopus database to gather papers from 2001 to 2020 for this retrospective research. Bibliometric characteristics such as publication output, countries, institutions, journals, citation frequency, and research hotspots were evaluated by using Excel 2013 and VOSviewer.

***Research results***

Over the previous 20 years, the number of publications on sleeve gastrectomy has progressively increased. The outcomes of the current study were skewed in favor of high-income nations. The United States and France have a big effect in this sector.

***Research conclusions***

The present literature on sleeve gastrectomy focused on numerous issues, including morbidity and possible complications, the procedure's complexity and various surgical methods, and diabetes mellitus and body mass index in connection to sleeve gastrectomy.

***Research perspectives***

This bibliometric study may aid researchers in better understanding the current state of knowledge and research horizons in the field of sleeve gastrectomy.

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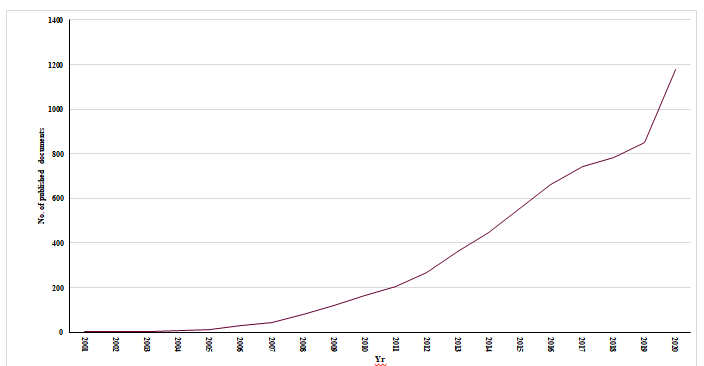
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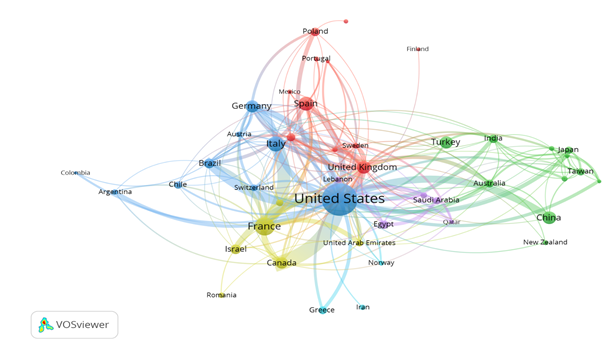
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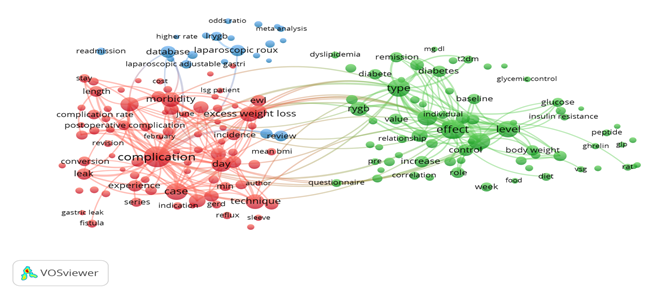
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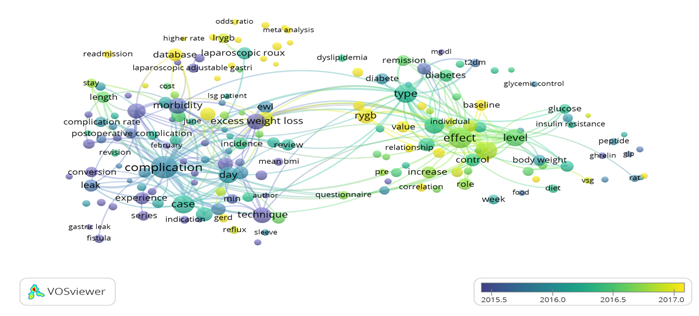
**Figure 1 Number of publications on sleeve gastrectomy per year (2001-2020).**

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**Figure 2 Network visualization map of research collaboration between the top 45 active countries.** Each country has a contribution of 20 documents at least.



**Figure 3 Network visualization map of the most frequent terms in the title and abstracts of the retrieved literature.** Of the 72684 terms, 305 terms have occurred at least 100 times. The network visualization term map for sleeve gastrectomy research undertaken globally over the 20 years.



**Figure 4 Distribution of terms according to the mean frequency of appearance; terms in blue appeared earlier than those in yellow-colored terms appeared later.**

**Table 1 Top 10 most productive countries in sleeve gastrectomy research**

|  |  |  |  |
| --- | --- | --- | --- |
| **Ranking** | **Country** | **Number of publications** | **%** |
| 1st | United States | 1983 | 30.47 |
| 2nd | France | 600 | 9.22 |
| 3rd | Italy | 417 | 6.41 |
| 4th | Spain | 356 | 5.47 |
| 5th | United Kingdom | 316 | 4.86 |
| 6th | China | 297 | 4.56 |
| 7th | Germany | 281 | 4.32 |
| 8th | Turkey | 272 | 4.18 |
| 9th | Canada | 243 | 3.73 |
| 10th | Israel | 190 | 2.92 |

**Table 2 Top 10 most productive institutions in sleeve gastrectomy research**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ranking** | **Institute** | **Country** | **Number of publications** | **%** |
| 1st | *Cleveland Clinic Foundation* | United States | 130 | 2.00 |
| 2nd | *Inserm* | France | 118 | 1.81 |
| 3rd | *AP-HP Assistance Publique - Hopitaux de Paris* | France | 107 | 1.64 |
| 4th | *Università degli Studi di Roma La Sapienza* | Italy | 93 | 1.43 |
| 5th | *Tel Aviv University* | Israel | 84 | 1.29 |
| 6th | *University of Michigan, Ann Arbor* | United States | 82 | 1.26 |
| 7th | *Harvard Medical School* | United States | 81 | 1.24 |
| 8th | *Università degli Studi di Napoli Federico II* | Italy | 70 | 1.08 |
| 9th | *Centre Hospitalier Universitaire de Nice, Hôpital l'Archet* | France | 68 | 1.04 |
| 10th | *Hôpital du Sacré-Cœur-de-Montréal* | Canada | 65 | 1.00 |

**Table 3 Top 10 most productive journals in sleeve gastrectomy research**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ranking** | **Journal** | **Number of publications** | **%** | **IFa** |
| 1st | *Obesity Surgery* | 1744 | 26.80 | 3.412 |
| 2nd | *Surgery for Obesity and Related Diseases* | 1040 | 15.98 | 3.812 |
| 3rd | *Surgical Endoscopy* | 304 | 4.67 | 3.149 |
| 4th | *Bariatric Surgical Practice and Patient Care* | 85 | 1.31 | 0.391 |
| 5th | *Journal of Laparoendoscopic and Advanced Surgical Techniques* | 75 | 1.15 | 1.310 |
| 6th | *Surgical Laparoscopy Endoscopy and Percutaneous Techniques* | 61 | 0.94 | 1.382 |
| 7th | *International Journal of Surgery* | 57 | 0.88 | 3.352 |
| 8th | *Annals of Surgery* | 56 | 0.86 | 10.130 |
| 9th | *Journal of Gastrointestinal Surgery* | 54 | 0.83 | 2.573 |
| 10th | *International Journal of Surgery Case Reports* | 53 | 0.81 | NA |

aImpact factors based on Journal Citation Reports 2019 from Clarivate Analytics. IF: Impact factors; NA: Not available.

**Table 4 Top-cited papers from 2001 to 2020 in sleeve gastrectomy research, based on the number of citations in Scopus**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Ranking** | **Authors** | **Title** | **Year** | **Source title** | **Cited by** |
| 1st | Schauer *et al*[[42](#_ENREF_42)] | “Bariatric surgery versus intensive medical therapy in obese patients with diabetes” | 2012 | *New England Journal of Medicine* | 1435 |
| 2nd | Schauer *et al*[[41](#_ENREF_41)] | “Bariatric surgery versus intensive medical therapy for diabetes – 3 yr outcomes” | 2014 | *New England Journal of Medicine* | 983 |
| 3rd | Buchwald and Oien[[25](#_ENREF_25)] | “Metabolic/bariatric surgery worldwide 2011” | 2013 | *Obesity Surgery* | 902 |
| 4th | Angrisani *et al*[[1](#_ENREF_1)] | “Bariatric Surgery Worldwide 2013” | 2015 | *Obesity Surgery* | 849 |
| 5th | Schauer *et al*[[40](#_ENREF_40)] | “Bariatric surgery versus intensive medical therapy for diabetes – 5 yr outcomes” | 2017 | *New England Journal of Medicine* | 845 |
| 6th | Colquitt *et al*[[27](#_ENREF_27)] | “Surgery for weight loss in adults” | 2014 | *Cochrane Database of Systematic Reviews* | 806 |
| 7th | Chang *et al*[[26](#_ENREF_26)] | “The effectiveness and risks of bariatric surgery an updated systematic review and meta-analysis, 2003-2012” | 2014 | *JAMA Surgery* | 768 |
| 8th | Buchwald and Oien[[24](#_ENREF_24)] | “Metabolic/bariatric surgery worldwide 2008” | 2009 | *Obesity Surgery* | 635 |
| 9th | Mechanick *et al*[[34](#_ENREF_34)] | “Clinical practice guidelines for the perioperative nutritional, metabolic, and nonsurgical support of the bariatric surgery patient-2013 update: Cosponsored by American association of clinical endocrinologists, the obesity society, and American society for metabolic and bariatric surgery” | 2013 | *Obesity* | 634 |
| 10th | Picot *et al*[[36](#_ENREF_36)] | “The clinical effectiveness and cost-effectiveness of bariatric (weight loss) surgery for obesity: A systematic review and economic evaluation” | 2009 | *Health Technology Assessment* | 616 |
| 11th | Karamanakos *et al*[[33](#_ENREF_33)] | “Weight loss, appetite suppression, and changes in fasting and postprandial ghrelin and peptide-yy levels after roux-en-y gastric bypass and sleeve gastrectomy a prospective, double blind study” | 2008 | *Annals of Surgery* | 596 |
| 12th | Regan *et al*[[37](#_ENREF_37)] | “Early Experience with Two-Stage Laparoscopic Roux-en-Y Gastric Bypass as an Alternative in the Super-Super Obese Patient” | 2003 | *Obesity Surgery* | 592 |
| 13th | Rosenthal *et al*[[38](#_ENREF_38)] | “International sleeve gastrectomy expert panel consensus statement: Best practice guidelines based on experience of > 12,000 cases” | 2012 | *Surgery for Obesity and Related Diseases* | 556 |
| 14th | Ryan *et al*[[39](#_ENREF_39)] | FXR is a molecular target for the effects of vertical sleeve gastrectomy” | 2014 | *Nature* | 545 |
| 15th | Himpens *et al*[[30](#_ENREF_30)] | “A prospective randomized study between laparoscopic gastric banding and laparoscopic isolated sleeve gastrectomy: Results after 1 and 3 years” | 2006 | *Obesity Surgery* | 500 |
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