



Sleeve gastrectomy and hypertension: a systematic review of long-term outcomes

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Abstract

Introduction Bariatric surgery has been shown to be a safe and durable intervention for patients struggling with obesity and metabolic syndrome, including hypertension. Buchwald et al. reported hypertension resolution rates in 67.1% and improvement in 78.5% following aggregate bariatric surgery. The laparoscopic sleeve gastrectomy (LSG) is becoming increasingly utilized as a primary bariatric surgery, but lacks long-term outcome data. There are a growing number of studies reporting outcome data beyond 5 years.

Objective This study aims to systematically evaluate the efficacy of laparoscopic sleeve gastrectomy on hypertension amongst obese patients.

Materials and methods A comprehensive literature search was conducted through Medline, Embase, Scopus, Web of Science, Dare, Cochrane library, and HTA database. The search terms used were broad: sleeve gastrectomy AND hypertension OR blood pressure. Adult patients undergoing LSG with follow-up hypertension outcome results of at least 5 years were included. Revisional surgeries were excluded. Two independent reviewers were used.

Results Fourteen studies were included in this systematic review, which included 3550 subjects in total. Mean age was 41.1 ± 10.7 years. Mean pre-operative BMI and weight were 47.7 ± 8.83 kg/m² and 272.8 ± 48.4 lb, respectively. Pre-operative prevalence of hypertension was 36.5% (range 6.7–91%) which dropped to 14.79% (range 0–33.3%) at approximately 5-year follow-up. Hypertension resolved in 62.17% (range 0–100%) of patients and improved in 35.7% (range 13.3–76.9%) at a mean of 5.35 years of follow-up.

Conclusion From this systematic review, LSG is an effective intervention for bariatric patients with hypertension. In addition to the observed reduction in the incidence of hypertension, it is likely that LSG may lead to additional health system benefits such as cost savings due to reductions in antihypertensive medications. Further prospective studies should include estimates of cost savings associated with reductions in chronic antihypertensive medication usage.

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Graphical abstract

Sleeve Gastrectomy and Hypertension: A Systematic Review of Long-Term Outcomes



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Obesity and hypertension have a well-established relationship. Research in the area is ongoing; however, a number of mechanisms have been proposed and help to further explain the relationship [1]. The mechanisms, as outlined by Kotsis et al., include indirect effects of adipocytes on the kidneys via increased free fatty acids (FFA) and angiotensinogen, as well as direct upregulation of the renin-angiotensin system (RAS). In addition, the pro-inflammatory effects of adipocytes via cytokine and interleukin release, thromboxane A-2, and a decreased insulin sensitivity lead to endothelial dysfunction, increased arterial stiffness, and ultimately to hypertension. These effects are suspected to decrease with weight loss, thus resulting in improvement and/or resolution in obesity-related hypertension.

Laparoscopic sleeve gastrectomy (LSG) was initially used as the first part of a staged bariatric procedure, the duodenal switch. In the year 2000, it began gaining popularity as a stand-alone procedure [2]. Such profound results with regards to weight loss were noted following the first portion of the procedure and as such patients and surgeons alike elected to forego the second portion. As noted by Nguyen et al. in their 2016 review [3], LSG surpassed the Roux-En-Y-Gastric Bypass (RYGB) as the most commonly performed bariatric procedure in 2012.

Bariatric surgery has been shown to be a safe and durable intervention for patients struggling with severe obesity

and the metabolic syndrome, including hypertension. Buchwald et al. reported hypertension resolution rates in 67.1% and improvement in 78.5% following aggregate bariatric surgery [4]. Currently, the LSG is gaining popularity and being increasingly utilized as a primary procedure for weight loss in obese and morbidly obese patients, but it lacks comparable long-term outcome data to gastric bypass. There are a growing number of studies demonstrating reporting outcome data beyond 5 years.

This review aims to further delineate the effects of LSG on more long-term outcomes of hypertension in obese patients undergoing bariatric surgery at a minimum of 5-year follow-up.

Materials and methods

A comprehensive literature search was conducted through Medline, Embase, Scopus, Web of Science, Dare, Cochrane library, and HTA database. Registered clinical trials were also searched, along with Google for other types of grey literatures. In addition, the reference lists of all included studies were examined to identify any relevant publications. IRB approval and informed consent were not required for this retrospective review.

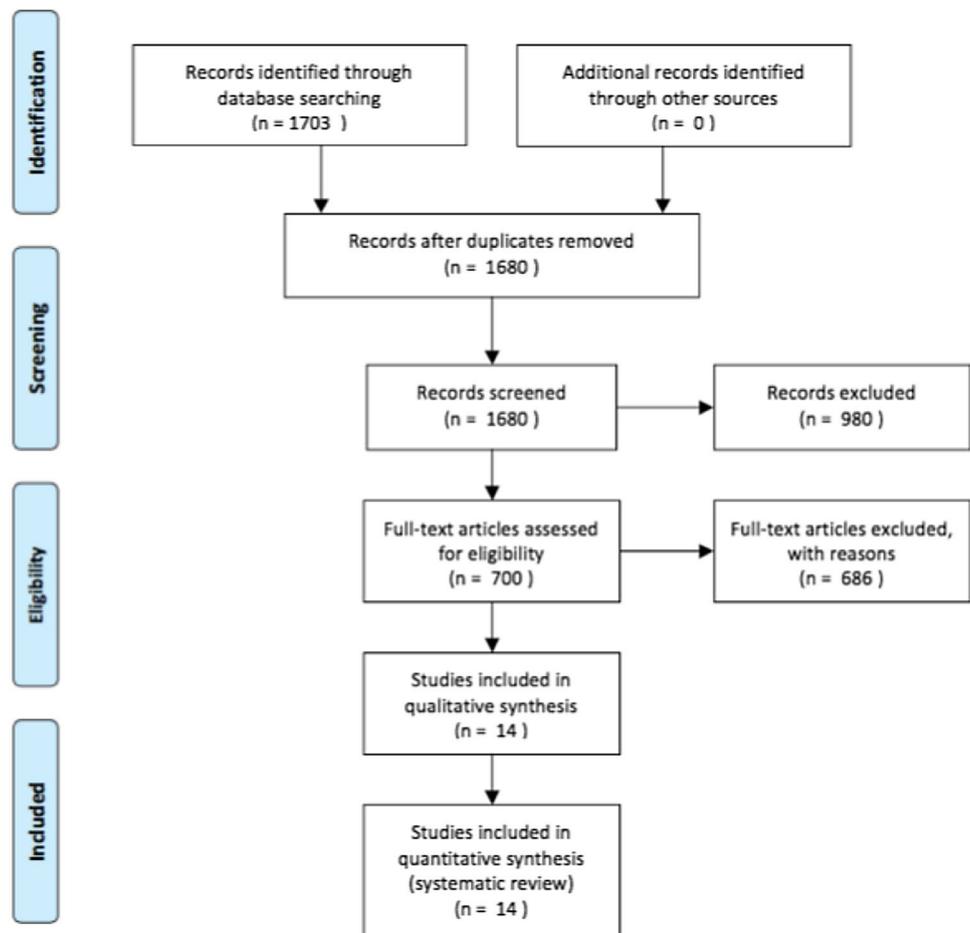
The search terms used were “sleeve gastrectomy” and “hypertension” or “blood pressure.” All human randomized controlled trials, non-randomized comparison studies, case series, and those published in languages other than English from 1946 to October 2015 were considered for inclusion. Adult patients over the age of 18 with pre-existing hypertension who underwent a LSG, and with follow-up of at least 5 years with recorded hypertension outcomes were included. Revisional surgeries were excluded from this review. Case reports, expert’s opinions and reviews were also excluded.

Hypertension was not a homogenous outcome variable in the studies, as some reported this as blood pressure greater than 140/90 mmHg [5–7], others as greater than 135/85 mmHg [8] and greater than 120/80 mmHg [9]. In addition, some definitions of hypertension were made regardless of medication use. To that effect, there was also not a uniform definition of “improved” hypertension as some reported this as off antihypertensive medications [10] and others did not give specific information. Similarly, the definition of “resolved” hypertension was also not reported the same across studies. In fact, many studies did not provide definitions at all [11–18].

As described in Fig. 1, a total of 1703 citations were reviewed, first by title, by abstract, and then by full article review to determine eligibility for inclusion into this review. Two independent reviewers were used to identify eligible papers. Fourteen studies were included in the analysis, for a total of 3550 patients. Data were then extracted from each paper. Specifically, demographic data such as age, percentage of female patients, BMI, pre/post-operative average weight, pre/post-operative BMI, and pre/post-operative rates of hypertension were extracted. Other data included were average excess weight loss (EWL, %) and rates of improvement and/or resolution of hypertension at 5-year follow-up.

Due to the heterogeneity of the data with a retrospective systematic review, lack of randomized-controlled trials, control groups, and standard definition of hypertension, we were not able to conduct a meta-analysis. For the purposes of this review, averages of the means and percentages were used to determine the effectiveness of LSG on reducing rates of hypertension.

Fig. 1 PRISMA flow diagram of papers reviewed and included in this systematic review



Results

Our initial search returned 1703 results. After eliminating duplicate results, 1680 titles remained. Another 980 were eliminated during the process of title and abstract screening. The remaining 700 abstracts were reviewed and 686 were eliminated for failure to meet the inclusion criteria. This resulted in 14 studies that were included in our systematic review (Fig. 1). Two of the studies were prospective cohort studies, whereas the other 12 were retrospective reviews.

Fourteen studies were included in this systematic review, which included 3550 subjects in total. The mean age was

41.1 ± 10.7 years (Table 1). Mean pre-operative BMI and weight were 47.7 ± 8.83 kg/m² and 272.8 ± 48.4 lb, respectively (Table 1).

None of the studies reported specific data on patients with pre-existing hypertension as it relates to blood pressure values, number and type of antihypertensive medications, or other variables (Table 2).

The pre-operative prevalence of hypertension was 36.5% (range 6.7–91%), which dropped to 14.79% (range 0–33.3%) at approximately 5-year follow-up. Hypertension resolved in 62.17% (range 0–100%) of patients and improved in 35.7% (range 13.3–76.9%) at a mean of 5.35-year follow-up.

Table 1 Baseline characteristics within included studies for systematic review

Investigator (year)	Patients (n), HTN (n)	Mean age (year)	Gender (% female)	Mean BMI (kg/m ²)	Surgery	Pre-op HTN (%)	Definition of HTN	FU period (year)
Alexandrou (2016)	19, 2	39.4	89.5	48.2	Robotic LSG	10.5	Not reported	5
Aminian (2016)	154, 140	52.3	67	46.9	LSG	91	BP > 140/90 regardless of medication use	6
Casella (2015)	148, 67	43.9	67.6	45.8	LSG	45.2	BP > 140/90 regardless of medication use	7
Gadiot (2016)	277, 93	42	76.2	57	LSG	33.6	Not reported	5
Golomb (2015)	443, 113	44.5	61.5	42.6	LSG	25.6	BP > 140/90 or medication use	5
Jammu and Sharma (2015)	339, 90	23	45.4	45	LSG	26.5	Not reported	7
Kehagias (2011)	208, 14	34.3	74.5	43.2	LSG	6.7	Not reported	5
Lemanu (2014)	55, 31	46.9	81.8	50.7	LSG	56.4	Not reported	5
Neagoe (2016)	101, 45	42	76.2	44.5	LSG	60.4	Not reported	5
Nocca (2016)	1050, 348	42.7	72.9	44.6	LSG	33.1	Not reported	5
Rawlins (2012)	270, 43	44	–	65	LSG	15.9	BP > 120/80 resolution off medication	5
Ruiz Tovar (2015)	54, 15	44.1	80	46.9	LSG	30	BP > 135/85 resolution off medication, improvement decreased medication use	5
Saleh (2016)	204, 103	–	70.1	50.9	LSG	50.2	BP > 140/90 resolution off medication	5
Zacariah (2013)	228, 61	34.7	62.6	37.4	LSG	26.8	Not reported	5
Total	3550, 1165	41.1 ± 10.7	71.6 ± 11.4	47.7 ± 6.73	–	36.5		5.36

Table 2 Laparoscopic sleeve gastrectomy results—systematic review

Investigator (year)	Incidence of hypertension (%)	Hypertension outcomes (%)		Post-op mean BMI (kg/m ²)
		Resolved	Improved	
Alexandrou (2016)	10.5	0	–	–
Aminian (2016)	91	80	–	–
Casella (2015)	45.2	59.7	38.8	30.2
Gadiot (2016)	33.6	52.9	47.1	–
Golomb (2015)	25.6	45.5	54.5	32.3
Jammu and Sharma (2015)	26.5	46.7	–	–
Kehagias (2011)	6.7	100	–	32
Lemanu (2014)	56.4	41.9	19.4	39.8
Neagoie (2016)	60.4	73.3	–	–
Nocca (2016)	33.1	19.2	76.9	–
Rawlins (2012)	15.9	95	–	–
Ruiz Tovar (2015)	30	66.7	13.3	29.5
Saleh (2016)	50.2	74	–	–
Zacariah (2013)	26.8	100	–	27.9
Total	36.5	62.2	37.5	32 ± 4.9

Post-operatively, EWL was found to be $60\% \pm 21.8\%$. The average post-operative BMI was determined to be 32 ± 4.86 kg/m². Mean follow-up time was 5.36 years. On average, 85% of patients were followed to completion of the study, and 15% were lost to follow up.

Papers were reviewed according to the Newcastle-Ottawa Grading system, and all papers received a grade of either “Good” or “Fair” based on the three domains of the selection of the study group, comparability of groups, and the ascertainment of exposure/outcome.

Discussion

In contrast to literature analyzing the effects of LSG on weight loss and type II diabetes mellitus, there is a paucity of literature on hypertension outcomes following bariatric surgery. Furthermore, hypertension has only been reported as a secondary outcome with no patient-specific data up to this point.

As described by Kotsis et al., there are numerous proposed mechanisms for development of obesity-related hypertension [2]. Specifically, the effects of adipocytes on increased FFA and angiotensinogen, as well as stimulation of the RAS cause an increase in salt and water retention by the kidney, thereby leading to increased blood pressure. With weight loss and decrease in adipocytes, it follows that the physiologic changes observed with obesity-related hypertension would be reversed.

The results of this study demonstrate that LSG is an effective method to decrease rates of hypertension in the obese and morbidly obese patient populations. On average, EWL was 60%. BMI decreased by approximately 15 kg/m²

post-LSG versus pre-LSG. This reduction in BMI was associated with a decrease in prevalence of hypertension from 36.5 to 14.8% at an average of 5.36 years of follow-up. This was a 62.2% resolution rate in those with hypertension, and in those who remained hypertensive following LSG, there was improvement noted in 35.7% of patients.

The study containing the largest proportion of patients was that of Nocca et al. [15]. Their study was a retrospective review of a prospectively maintained database, and included a total of 1050 patients who underwent LSG between January 2005 and June 2013 at a single centre in France. Three hundred and nine patients out of the 1050 had pre-existing hypertension, which accounted for 33% of patients. At the 5-year mark, there were 144 patients available and eligible for follow-up who were at least 5-year post-LSG. Of the 46.6% of hypertensive patients who followed up, there was a 19.2% resolution of hypertension, while 76.9% of patients had improvement in the degree of hypertension. Unfortunately, the authors did not provide a definition as to what, specifically, they used to define hypertension, nor did they define improvement or resolution of the same.

The only study that was prospective in nature was performed by Ruiz-Tovar et al. in Spain [8]. This was a small study of 54 patients between October 2007 and February 2010, in which 15 (30%) had pre-existing hypertension. There was minimal loss to follow up, with a follow-up rate of 94%. Resolution of hypertension, defined as blood pressure < 135/85 mmHg on no antihypertensive medications, was observed in 10 patients, and improvement in another 2. This study did not report number of antihypertensive medications nor specific blood pressure values.

As mentioned, the lack of data reported on hypertensive patients, absence of a standardized definition of

hypertension, resolution and improvement of hypertension, as well as heterogeneity in data reporting made meta-analysis unfeasible (Table 2). As such, a limited systematic review was performed.

Limitations

This study was limited by a few factors. First, there are relatively few studies that have researched the specific effects of LSG on hypertension. The majority of studies comment on hypertension as a secondary outcome, thereby limiting the data available for analysis of this patient population. In the future, it would be beneficial to carry out studies specifically aimed at analyzing patients undergoing LSG with pre-existing hypertension to more fully analyze outcomes.

Second, although there were a total of 3550 patients included in the systematic review, there were only 1165 patients who had hypertension pre-operatively. The relatively small sample size limits the ability to generalize data to all patients with pre-existing hypertension prior to LSG. In addition, our outcomes were calculated based on aggregate data from all studies, not with weighted averages. This may have had an effect on outcome percentages. Further research must be done into specific patient characteristics that affect outcomes of LSG on hypertension.

Third, studies reviewed were mostly retrospective in nature. Retrospective reviews are limited by the data available on file, and as such may be at risk for recall bias or subject to confounding as not all variables can be accounted for. In addition, retrospective reviews are inferior in the level of evidence provided as compared to prospective studies. In order to further delineate the effects of LSG on hypertension outcomes, future studies should aim to be prospective in nature to be able to mitigate confounding variables.

Finally, hypertension was defined differently, and occasionally not at all, by each study. In some, it was defined as a blood pressure > 140/90 mmHg, others as > 135/85 mmHg, as well as variance in whether this was with or without pharmacologic management. Given the significant heterogeneity in the data, lack of randomized controlled trials, and the majority of included studies being retrospective cohort studies, a meta-analysis could not be performed.

Conclusion

The aim of this systematic review was to determine the long-term outcomes of LSG on rates of hypertension after 5 years of follow-up. We found that the pre-operative prevalence of hypertension was 36.5%, while post-operatively it dropped to 14.8%. Resolution of hypertension was seen in 62.2% of patients, while another 35.71% of patients had improvement in hypertension.

From this systematic review, LSG appears to be an effective intervention for bariatric patients with hypertension. In addition to the observed reduction in the incidence of hypertension, it is likely that LSG may lead to additional health system benefits such as cost savings due to reductions in antihypertensive medications and treatment of hypertensive sequelae. It is important that further prospective studies should be performed, and should include estimates of cost savings associated with reductions in chronic antihypertensive medication usage.

Compliance with ethical standards

Disclosures Drs. Graham, Switzer, Reso, Armstrong, Church, Mitchell, Debru, and Gill have no conflicts of interest or financial ties to disclose.

References

1. Kotsis V, Stabouli S, Papakatsika S, Rizos Z, Parati G (2010) Mechanisms of obesity-induced hypertension. *Hypertens Res* 33:386–393
2. Deitel M, Gagner M, Erickson A, Crosby R (2011) Third international summit: current status of sleeve gastrectomy. *Surg Obes Relat Dis* 7:749–759.
3. Nguyen NT, Vu S, Kim E et al (2016) *Surg Endosc* 30:2723. <https://doi.org/10.1007/s00464-015-4535-9>
4. Buchwald H, Avidor Y, Braunwald E, Jensen MD, Pories W, Fahrenbach K, Schoelles K (2004) Bariatric surgery: a systematic review and meta-analysis. *JAMA* 292(14):1724–37
5. Aminian A, Brethauer SA, Andalib A, Puchai S, MacKey J, Rodriguez J, Rogula T, Kroh M, Schauer PR (2016) Can sleeve gastrectomy “cure” diabetes? Long-term metabolic effects of sleeve gastrectomy in patients with type 2 diabetes. *Ann Surg* 264(4):674–681
6. Casella G, Soricelli E, Giannotti D, Collalti M, Maselli R, Genco A, Redler A, Basso N (2016) Long-term results after laparoscopic sleeve gastrectomy in a large monocentric series. *Surg Obes Relat Dis* 12(4):757–762
7. Saleh M, Cheruvu MS, Moorthy K, Ahmed AR (2016) Laparoscopic sleeve gastrectomy using a synthetic bioabsorbable staple line reinforcement material: post-operative complications and 6 year outcomes. *Ann Med Surg* 10:83–87
8. Ruiz-Tovar J, Martinez R, Bonete JM, Rico JM, Zubiaga L, Diez M, Llaverro C, Obelche G (2016) Long-term weight and metabolic effects of laparoscopic sleeve gastrectomy calibrated with a 50-Fr bougie. *Obes Surg* 26(1):32–37
9. Rawlins L, Rawlins MP, Brown CC, Schumacher DL (2013) Sleeve gastrectomy: 5-year outcomes of a single institution. *Surg Obes Relat Dis* 9(1):21–25
10. Golomb I, Ben David M, Glass A, Kolitz T, Keidar A (2015) Long-term metabolic effects of laparoscopic sleeve gastrectomy. *JAMA Surg* 150(11):1051–1057
11. Gadiot R, Biter U, Van Mil S, Zengerink H, Mannaerts G (2017) Long-term results of laparoscopic sleeve gastrectomy for morbid obesity: 5 to 8-year results. *Obes Surg* 27(1):59–63
12. Jammu GS, Sharma R (2016) A 7-year clinical audit of 1107 cases comparing sleeve gastrectomy, roux-en-y gastric bypass, and mini-gastric bypass, to determine an effective and safe bariatric and metabolic procedure. *Obes Surg* 26(5):926–932

13. Kehagias I, Spyropoulos C, Karamanakos S, Kalfarentzos F (2013) Efficacy of sleeve gastrectomy as sole procedure in patients with clinically severe obesity ($BMI \leq 50 \text{ kg/m}^2$). *Surg Obes Relat Dis* 9(3):363–369
14. Neagoie RM, Muresan M, Bancu S, Balmos I, Baisan V, Voidazan S, Sala D (2017) Results of laparoscopic sleeve gastrectomy-5-year follow-up study in an eastern European emerging bariatric center. *Obes Surg* 27(4):983–989
15. Nocca D, Loureiro M, Skalli EM, Nedelcu M, Jaussent A, Deloze M, Lefebvre P, Fabre JM (2016) Five-year results of laparoscopic sleeve gastrectomy for the treatment of severe obesity. *Surg Endosc* 31:3251–3257
16. Orfanos S, Alexandrou A, Mpaili E, Vailas M, Diamantis T, Sxizas D, Liakakos T (2016) Robotic sleeve gastrectomy for morbid obesity: report of a 5 year experience. *Int J Med Robot* 12(2):283–287
17. Zachariah SK, Chang PC, Ooi ASE, Hsin MC, Wat JY, Huang CK (2013) Laparoscopic sleeve gastrectomy for morbid obesity: 5 years experience from an Asian center of excellence. *Obes Surg* 23(7):939–946
18. Lemanu DP, Singh PP, Rahman H, Hill AG, Babor R, MacCormick AD (2015) Five-year results after laparoscopic sleeve gastrectomy: a prospective study. *Surg Obes Relat Dis* 11(3):518–524