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ORIGINAL ARTICLE

Incidence of Kidney Stones After Bariatric Surgeries: Comparing Roux-en-Y Gastric Bypass and Sleeve Gastrectomy

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Abstract

Introduction/Purpose The two most common procedures performed to treat obesity are Roux-En-Y gastric bypass (RNYGB) and laparoscopic sleeve gastrectomy (LSG). Due to changes in enteric absorption, bariatric surgery increases rates of nephrolithiasis. As population-based data are limited, we aimed to compare the incidence of kidney stones after RNYGB and LSG.

Materials and Methods We queried Explorys (Cleveland, OH), a database that aggregated data from 26 healthcare systems. We identified patients who were newly diagnosed with nephrolithiasis 3, 6, and 12 months after their RNYGB or LSG. Additionally, a multivariate analysis was conducted to investigate the association of nephrolithiasis with RNYGB as compared to LSG. This analysis adjusted for other risk factors, including age above 65, male gender, Caucasian race, diabetes mellitus, hypertension, primary hyperparathyroidism, gout, and obesity.

Results From 1999 to 2019, there were 11,480 patients who underwent RNYGB and 22,770 patients who underwent LSG. The incidence of nephrolithiasis in the RNYGB cohort at all three time points was higher than in the LSG cohort (3 months, 7.1% vs. 2.4%; 6 months, 6.6% vs. 2.0%; 1 year, 5.8% vs. 1.4%; $P<0.001$). After the multivariate analysis, it was found that, though both RNYGB and LSG were independently associated with the development of nephrolithiasis, the risk of nephrolithiasis was higher in those who underwent RNYGB compared to those who underwent LSG (OR 1.594, 95% CI 1.494 to 1.701, $P<0.001$).

Conclusion RNYGB is associated with a higher risk of nephrolithiasis when compared to LSG.

Keywords Bariatric surgery · Nephrolithiasis · Roux-en-Y · Laparoscopic sleeve gastrectomy

Key Points
- RNYGB is associated with a higher risk of nephrolithiasis when compared to LSG.
- LSG may be preferred in those who have a predisposition for nephrolithiasis.
- Further studies may indicate need for prophylactic measures for high-risk groups.

Introduction

The worldwide prevalence of obesity has been on the rise since 1980, irrespective of geographic location, socioeconomic status, age, or sex.[1] In the USA, this has led to an increase in laparoscopic bariatric procedures.[2] The two most common bariatric surgical procedures performed are the Roux-en-Y

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gastric bypass (RNYGB) and laparoscopic sleeve gastrectomy (LSG).[3] Though these procedures have led to profound positive effects on weight and metabolic comorbidities, they have also, as with any intervention, been associated with risks and post-procedural complications.[4]

LSG, initially described in 1988, involves resection of a portion of the stomach, typically approximating 90% of the total volume.[5] This operation resulted in an average excessive weight loss of 57.4% after 5 years.[6] The RNYGB procedure involves creation of a gastroenterostomy and an enteroenterostomy, which allows bypass of a large portion of the stomach, as well as the duodenum.[7]

Major categories of common late complications associated with RNYGB are wound-related (hernias), nutritional (iron deficiency, hypokalemia), and gastrointestinal (cholelithiasis, nausea and vomiting, ulcer, or stricture formation).[8] LSG can result in late complications of stricture, gastroesophageal reflux disease, and nutritional deficiencies, as well.[9]

LSG and RNYGB differ in some of their effects on nutrient absorption, as evidenced by similar rates of post-operative iron deficiency anemia, but differing rates of post-operative vitamin B12 deficiency.[10] Additionally, RNYGB, but not LSG, resulted in a significant loss of bone mass in rats, thought to be due, at least in part, to effects on vitamin D and calcium absorption.[11] In RNYGB, it is known that changes in enteric absorption can lead to hyperoxaluria, a known risk factor for calcium oxalate stones.[12] Though we know that after bariatric surgery, there is an increase in incidence of nephrolithiasis, it is unclear if LSG affects oxalate in a similar manner to RNYGB.[13] A recent study has demonstrated a higher rate of nephrolithiasis in those who underwent RNYGB, as compared to LSG.[14] Given that this study was performed at a single institution, population-based data regarding post-op bariatric nephrolithiasis remains limited. This information has important clinical implications, as nephrolithiasis not only increases the risk of urinary tract infection and may require invasive procedures to remove the stones; it also increases the risk of chronic kidney disease.[15]

In this study, we aimed to compare the incidence of kidney stones at different post-operative time points in RNYGB and LSG on a national level. In addition, we utilized a multivariate analysis to examine the association between the two procedures and the incidence of nephrolithiasis while correcting for other known risk factors.

Methods

Database

Explorys, Inc. (Cleveland, OH) is a commercial, cloud-based database that pools de-identified data from 26 integrated healthcare systems across the 50 states. Since 1999, this has resulted in the collection of data from over 64 million unique records.[16] As presented in previous papers, de-identified data is collected from contributing hospitals' electronic medical records, as well as billing and laboratory records.[17] Cohorts can then be created using standardized methods, with diagnoses being identified by the presence or absence of Systematized Nomenclature of Medicine–Clinical Terms (SNOMED-CT). Further subcategorization of the cohorts based on demographics can also be obtained. Previous studies have demonstrated the validity of this database's use to investigate associations in a variety of medical specialties, as well as pharmacosurveillance.[18–21] Further description of the process by which data for Explorys is collected and categorized is presented in previous papers.[17]

Explorys is compliant with the Health Insurance Portability and Accountability Act (HIPAA). Therefore, research utilizing this database alone was determined to be exempt from review by an institutional review board.

Patient Selection

We utilized the Explorys search function to query data collected between 1999 and November 2019. Two cohorts of non-deceased patients, identified using SNOMED-CT, were created. The two cohorts were made up of patients, all over the age of 18, who underwent "laparoscopic sleeve gastrectomy" or underwent "Roux-en-Y gastrojejunostomy." Within those cohorts, using the "first ever diagnosis" tool in Explorys, we identified patients who had a new diagnosis of a "kidney stone" after 3, 6, and 12 months post-RNYGB or LSG.

Independent of the initial analysis, a multivariate analysis was then conducted using the "fast search" feature. All entries were for patients that were active within the last 3 years and excluded those less than 18. Variables included were the following potential confounding risk factors: age greater than 65, Caucasian race, male gender, diabetes mellitus, benign hypertension, primary hyperparathyroidism, gout, obesity, Roux-en-Y gastrojejunostomy, and laparoscopic sleeve gastrectomy. The outcome of interest was nephrolithiasis.

Statistical Analysis

At 3 months post-operatively, characteristics of the cohort were obtained, including gender, race, and age group. The demographics of the cohorts were compared using an N-1 chi squared test for proportions. Additionally, for each post-operative time point, the incidence of nephrolithiasis was calculated by dividing patients with new diagnoses nephrolithiasis by the total number of patients who underwent the procedure, either LSG or RNYGB. The incidence was then compared between the two cohorts to calculate relative risks (RR) and 95% confidence intervals (CI), calculated as described by Altman in 1991.[22] The relative risks at the three time points were compared via their confidence intervals to evaluate for significant difference.

Next, we performed a univariate analysis to compare RNYGB and LSG with regard to nephrolithiasis, as well as with previously listed risk factors for nephrolithiasis. A separate multivariate analysis utilizing logistic regression was conducted using nephrolithiasis as the dependent variable, corrected for these risk factors, which all demonstrated an association with the development of kidney stones. Odds ratios and 95% confidence intervals were calculated for each of the variables. *P* values were also obtained.

Results

From 1999 to 2019, there were 11,480 patients identified who underwent RNYGB and 22,770 patients identified who underwent LSG. Baseline characteristics of patients at 3 months post-operatively are outlined in Table 1. As demonstrated, the majority of patients were female. In terms of age, the majority of patients were between 18 and 65, and, with respect to race, the majority of patients were Caucasian.

Nephrolithiasis at least 3 months after undergoing bariatric surgery occurred in 810 patients in the RNYGB group and 540 in the LSG group (RR = 2.9; 95% CI 2.67 to 3.31). After 6 months post-operatively, nephrolithiasis occurred in 760 patients in the RNYGB group and 460 in the LSG group (RR = 3.3; 95% CI 2.93 to 3.67). After 1-year post-bariatric surgery, the incidence of nephrolithiasis was 670 patients in the RNYGB group and 320 patients in the LSG group (RR = 4.1; 95% CI 3.64 to 4.74). The incidence of nephrolithiasis in the RNYGB cohort, as measured by incident diagnoses after the specified time point, was higher than in the LSG cohort at all three time points ($P < 0.001$) (Fig. 1).

In the initial analysis, diagnoses of diabetes, gout, hyperparathyroidism, and IBD were more common in the group who had previously undergone RNYGB (Table 2). However, male gender and age below 65, as well as diagnoses of essential hypertension or obesity, were all less common in those who underwent RNYGB. There was no significant difference in race (Caucasian vs. non-Caucasian) between the two groups. Finally, nephrolithiasis occurred less frequently in those who underwent LSG, as compared to RNYGB (odds ratio 0.32, $P < 0.00001$).

The raw results of the multivariate logistic regression analysis can be seen in Supplemental Table 1. Age above 65, male gender, Caucasian race, diabetes, hypertension, primary hyperparathyroidism, gout, obesity, RNYGB, and LSG were all independent risk factors for the development of nephrolithiasis (Table 3). The risk of nephrolithiasis was higher in those who underwent RNYGB compared to those who underwent LSG (OR 1.594, 95% CI 1.494 to 1.701, $P < 0.001$).

Discussion

Our study showed that the risk of nephrolithiasis is significantly higher in those who underwent RNYGB, as compared to LSG. On a national level, this increased risk appears to be sustained at different time points after the procedures. This risk remains significantly elevated when other potential risk factors are corrected for in a multivariate analysis.

Previously, hyperoxaluria, a risk factor for calcium oxalate stones, was described in patients with extensive ileal resection, thought to be a result of fat malabsorption leading to decreased calcium-binding capacity and increased oxalate absorption.[23] The suggested etiology for an increased rate of nephrolithiasis in patients who underwent RNYGB is related to hyperoxaluria as a result of changes in enteric absorption.[12] This is attributed to fat malabsorption, as evidenced by increased fecal fat excretion, related to passage through the common channel, the portion of the bowel distal to the

Table 1 Demographic comparison of those with nephrolithiasis after RNYGB or LSG at 3 months to those who underwent LSG or RNYGB without any diagnosis of nephrolithiasis

Demographics	RNYGB without nephrolithiasis	RNYGB and nephrolithiasis	LSG without nephrolithiasis	LSG and nephrolithiasis
Age				
18–65	77%	65%	88%	83%
> 65	23%	35%	15%	17%
Gender				
Male	19%	25%	21%	31%
Female	81%	75%	79%	69%
Race				
Caucasians	83%	91%	75%	83%
African Americans	13%	7%	17%	11%
Hispanic/Latino	1%	1%	2%	NA
Asians	1%	NA	0%	NA

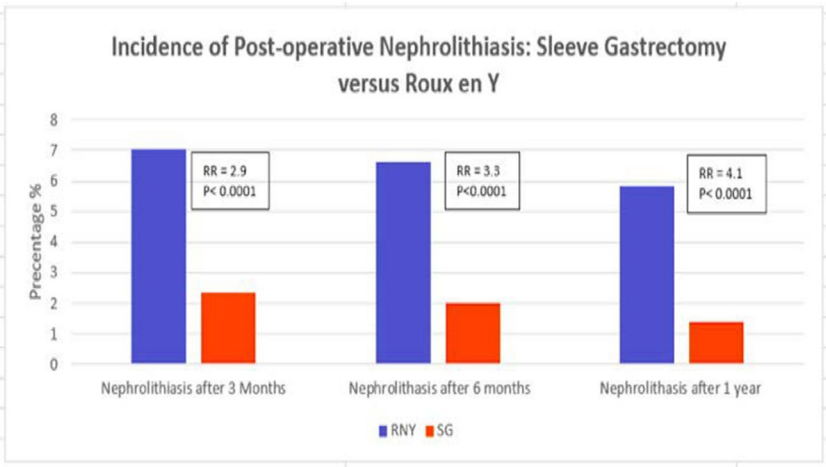

Fig. 1 Incidence of post-operative nephrolithiasis: LSG vs. RNYGB

Table 2 Univariate analysis comparing RNYGB and LSG

	LSG		RNYGB		Odds Ratio (LSG to RNYGB)	*P* value
	Yes	No	Yes	No		
Age < 65	620	130	9150	3000	1.56	*P* < 0.00001
Male gender	220	530	2270	9870	1.8	*P* < 0.00001
Caucasian race	640	90	10,050	1490	1.05	*P* = 0.65
Diabetes mellitus	10,960	23,390	4600	8710	0.89	*P* < 0.00001
Gout	1130	33,500	550	11,860	0.73	*P* < 0.00001
Hyperparathyroidism	970	34,160	480	12,040	0.71	*P* < 0.00001
Essential hypertension	19,200	14,470	7280	6450	1.18	*P* < 0.00001
IBD	190	34,340	180	12,060	0.37	*P* < 0.00001
Obesity	32,200	1950	9030	4880	8.92	*P* < 0.00001
Nephrolithiasis	750	33,000	840	11,680	0.32	*P* < 0.00001

Table 3 Multivariate analysis results with nephrolithiasis as dependent variable

	P value	OR	95% CI	
			Lower	Upper
Age > 65	< 0.0001	1.208	1.201	1.214
Male	< 0.0001	1.278	1.272	1.284
Caucasian	< 0.0001	2.711	2.694	2.729
DM	< 0.0001	1.782	1.771	1.792
HTN	< 0.0001	1.517	1.507	1.527
P-hyperparathyroidism	< 0.0001	3.513	3.418	3.61
Gout	< 0.0001	2.072	2.053	2.091
Obesity	< 0.0001	1.816	1.805	1.826
RYG	< 0.0001	2.058	1.964	2.156
LSG	< 0.0001	1.29	1.236	1.346

enteroenteric anastomosis.[24] This, in turn, leads to increased excretion of urinary oxalate, as evidenced by one analysis of post-RNYGB patients with nephrolithiasis where 17 out of 31 patients were noted to have hyperoxaluria.[12] However, given the vastly different resultant anatomy between the two procedures, it does not necessarily follow that LSG would lead to a similar change in enteric absorption. The length of the digestive tract remains unchanged in LSG and, thus, may lead to less fat malabsorption. A retrospective study at one institution concluded that RNYGB led to a significantly higher incidence (8.12%) of nephrolithiasis, as compared to LSG (3.68%).[14] This study reported a mean time to stone formation of 1.4 years for RNYGB and 0.6 years for LSG.[14] In our study, the higher rate of nephrolithiasis in RNYGB was confirmed on a population level, with higher rates of nephrolithiasis at 3, 6, and 12 months post-operatively, as compared to LSG, though LSG was also noted to be independently associated with nephrolithiasis.

A higher rate of nephrolithiasis has several implications. First, the risks of bariatric procedures should be fully understood by patients and surgeons prior to the operation. In addition, having this information may allow for post-operative interventions in those at particular high risk. This can include risk factor modification, hydration, dietary changes, or a lower threshold to seek care if symptoms potentially consistent with nephrolithiasis

arise. Prevention of nephrolithiasis is desirable for multiple reasons. This includes the fact that, as previously mentioned, nephrolithiasis also puts patients at a significantly higher risk for chronic kidney disease. One study reported that the risk was increased 50 to 67%.[15] This is especially notable in this population, as obesity is also an independent risk factor for chronic kidney disease.[25]

Limitations of the study include the presence of potential confounding variables. Despite our effort to correct for several of the known risk factors for nephrolithiasis via a multivariate analysis, other unknown variables remain a threat to internal validity. In addition, incident diagnoses are counted cumulatively at 3, 6, and 12 months. Thus, the risk of nephrolithiasis over time is difficult to interpret.

The Explorys database does have specific limitations, as well. The creation of the two cohorts, as well as the determination of whether the patient had a new diagnosis of a kidney stone or not, was based on SNOMED-CT in the electronic health record, which may not always be accurately recorded. The multivariate analysis is also limited by this factor. In the multivariate analysis, we are also unable to look at relative time of diagnosis, as the "first ever diagnosis" tool is not available in the "fast search" tool required for the data for a multivariate analysis. Similarly, the diagnosis of obesity was not coded for all patients undergoing these bariatric procedures. This is likely a reflection of inadequate documentation or resolution of obesity postoperatively. Specific quantification of BMI was not available within the constraints of the database, either.

In addition, there is no way to verify that the data reflect the SNOMED-CT coding and represent true diagnoses of the patient due to the de-identified nature of the data. Similarly, there is no way to validate that "first ever" diagnoses are truly accurate. Finally, patients who underwent surgery at an institution within the Explorys network, but sought care for nephrolithiasis at a facility outside the network, would likely be missed by this analysis, and those who sought care at multiple different institutions may be counted multiple times.

Conclusion

Both RNYGB and LSG are independently associated with increased risk of nephrolithiasis. However, RNYGB is associated with increased risk as compared to LSG. Both patients and providers should be fully informed regarding the risks of each surgical technique in order to guide decision making, monitor for symptoms post-operatively, and, potentially, take preventative measures to limit complications. LSG may be a preferred operation in those who have other risk factors for kidney stones. Given the results of this study, interventions such as hydration and dietary changes should be considered for routine post-RNYGB care, while taking into account the phases of gut adaptability at different time points.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11605-023-05849-9.

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Data Availability All data is available in body of manuscript, as well as the supplementary material.

Declarations

Ethical Approval As this study utilized a de-identified database, the study was considered exempt from the need for IRB approval at University Hospitals.

Conflict of Interest The authors declare no competing interests.

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