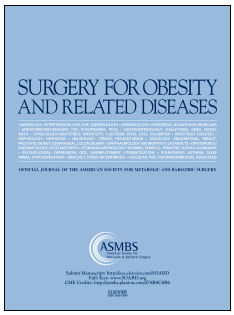
Journal Pre-proof



Revision surgery after sleeve gastrectomy: a nationwide study with 10 years of follow-up

Andrea Lazzati, MD, PhD, Stéphane Bechet, MSc, Saadeddinne Jouma, MD, L. Paolino, MD, Camille Jung, Md PhD

PII: S1550-7289(20)30302-6

DOI: https://doi.org/10.1016/j.soard.2020.05.021

Reference: SOARD 4180

To appear in: *Surgery for Obesity and Related Diseases*

Received Date: 24 February 2020

Revised Date: 24 April 2020

Accepted Date: 16 May 2020

Please cite this article as: Lazzati A, Bechet S, Jouma S, Paolino L, Jung C, Revision surgery after sleeve gastrectomy: a nationwide study with 10 years of follow-up, *Surgery for Obesity and Related Diseases* (2020), doi: https://doi.org/10.1016/j.soard.2020.05.021.

TITLE:

REVISION SURGERY AFTER SLEEVE GASTRECTOMY: A NATIONWIDE STUDY WITH 10 YEARS OF FOLLOW-UP

Authors:

Lazzati Andrea, MD, PhD

Department of Digestive Surgery, Centre Hospitalier Intercommunal de Créteil, Créteil, France.

Bechet Stéphane, MSc

ACTIV, Association Clinique et Thérapeutique Infantile du Val-de-Marne, Saint Maur-des-Fossés, France.

Jouma Saadeddinne, MD

Department of Digestive Surgery, Centre Hospitalier Intercommunal de Créteil, Créteil, France.

Paolino L , MD

Department of Digestive Surgery, Centre Hospitalier Intercommunal de Créteil, Créteil, France.

Jung Camille, Md PhD

Clinical Research Center, Centre Hospitalier Intercommunal de Créteil, Créteil, France.

Department of Pediatrics, Centre Hospitalier Intercommunal de Créteil, Créteil, France.

Key-Words: bariatric surgery, sleeve gastrectomy, revisional surgery, conversion, obesity

Corresponding author: Andrea LAZZATI

andrea.lazzati@chicreteil.fr; fax number +33145175156; phone number +33145175000

Department of Digestive Surgery, Centre Hospitalier Intercommunal de Créteil, Créteil, France.

Short title: Revisional rate after sleeve gastrectomy on a nationwide basis: an analysis on 220,000 patients .

Abstract

Setting

Sleeve gastrectomy is the most common bariatric procedure worldwide. Several studies report good short- and midterm results. However, recent studies report alarming long-term outcomes, in particular about the revision rate. These data are issued from monocentric studies from high-volume centers whose generalizability may be questioned. Our study is based on a national claims database comprehensive of all bariatric procedures performed on a 10 years period.

Objectives

The aim of this study is the assessment of the revisional rate after sleeve gastrectomy, the analysis of most common reasons for surgical conversion and early complications.

Methods

The French PMSI database was used to identify all patients who underwent sleeve gastrectomy between 2008 and 2018. Codes for diagnoses and procedures were used to describe the reason for and the morbidity of revision surgeries. Multivariate Cox proportional hazard regression analysis was performed to compare the risk of having a revision procedure.

Results

During the analyzed period, 224,718 sleeve gastrectomies were performed. The rate of revision surgery after sleeve gastrectomy was 4.7%, 7.5% and 12.2%, at 5, 7 and 10 years post-procedure, respectively. A history of gastric banding was associated with a higher risk of revision (HR 2.81, 95% confidence interval (CI) 2.66–2.95, $p < 0.001$). The most common revision procedure was gastric bypass (75.2%), followed by re-sleeve (18.7%). The main

reason for revision surgery was: persistence of obesity (87.0%) and gastroesophageal reflux disease (5.2%). After revision surgery, we observed the following complications: 5.1% gastric leak, 18% bleeding and a reoperation rate of 6.4%.

Conclusions

This study suggests that a large number of patients who initially underwent a sleeve gastrectomy will undergo a revisional surgery. This information should be considered in the initial choice of the bariatric procedure, and patients should be informed of the mid- and long-term risks.

Introduction

Sleeve gastrectomy has recently become the most common bariatric procedure worldwide [1]. Several randomized trials report good short- and midterm weight loss results (comparable to Roux-en-Y gastric bypass [RYGB]) [2, 3]. Nevertheless, two major long-term results, weight regain and rate of revisions, are poorly known.

In a recent meta-analysis, Clapp et al. [4] reported a revision rate after sleeve gastrectomy of about 28% at 7 years, with a great variability among the series that ranged from 14% to 37%. The most common reason for revision is the persistence of obesity (some studies reported as insufficient weight loss or weight regain). Gastroesophageal reflux disease (GERD) is reported as the second cause of revision for 9–40% of patients [5, 6]. The revision rate of sleeve gastrectomy seems lower compared to adjustable gastric banding; it has been previously reported that about 40% of gastric bandings are removed at 7 years, and that most of patients will receive another bariatric procedure [7].

The issue of revision surgery is of capital importance in bariatric surgery. In fact, the assessment of long-term performances of a given procedure should help surgeons to better select their patients and customize the choice of the best surgical procedure. The aim of this study was to assess the revision rate after sleeve gastrectomy on a nationwide basis using a national claims database.

Methods

This observational descriptive study examined revision surgery after sleeve gastrectomy performed in patients with obesity. Data were extracted from the *Programme De Médicalisation des Systèmes d'Information* (PMSI) database, which collects information on hospital discharge and is used as a billing tool for hospital activity, irrespective of academic

affiliation or ownership (public, private for-profit and private non-profit). Given that discharge reports are mandatory and constitute the basis for hospital funding, this database is comprehensive for all reimbursed surgical interventions in the country. The collected data comprise patient demographics (age, gender, zip code, entry and release dates), primary and associated diagnoses based on the International Classification of Disease, 10th edition (ICD-10) and therapeutic procedures based on the Common Classification of Medical Acts (*Classification Commune des Actes Médicaux*, CCAM, 11th edition), which is a national standardized classification of medical procedures [8] .

Each patient is assigned a unique identifier, which remains unchanged over time. Thus, one can link consecutive hospital stays at different hospitals. The individual information is anonymous and publicly available, and thus patient consent is not required. Nevertheless this data are submitted to the authorization from the National Commission on Informatics and Liberty (CNIL) which was obtained in February, 2017 (n=1947391*).*

We included all patients who underwent sleeve gastrectomy in France in the period from 1 January 2007 to 31 December 2018. We included any adult patient between 18 and 65 years of age. Patients were identified in the database through the CCAM codes for sleeve gastrectomy (HFMA010, HFMC006, HFFA011 and HFFC018).

The primary outcome of this study was the revision rate after sleeve gastrectomy. The secondary outcome was the morbidity and mortality rate stratified by revision procedure (gastric banding, sleeve gastrectomy, gastric bypass or biliopancreatic derivation). A revision bariatric procedure is defined as a bariatric intervention performed after another bariatric operation irrespective of the medical indication. We also included patients that had an adjustable gastric banding before the sleeve gastrectomy. In the case of multiple sleeves in the same patient, we only considered the first for computing the revision rate. Given that the data

set is comprehensive for all hospitals in the country, revision procedures could be assessed even if the initial sleeve gastrectomy and revision procedure were performed in different hospitals.

In order to assess a history of banding prior to the sleeve gastrectomy, data from 2007 were only used to identify band removal.

Morbidity was assessed using the ICD-10 codes for complications and the CCAM codes for reintervention (see appendix 1 for full algorithms). We could assess surgical reoperation in the case of complication(s) that occurred in the days following the bariatric procedure, but not if the reoperation took place the same day as the bariatric surgery.

Demographic data included age and gender. Age was grouped into five categories. The body mass index (BMI) is not reported in the dataset as a continuous variable; rather, it is stratified into four categories through the ICD-10 codes "E66x" (obesity with a BMI from 30 to 40 kg/m^2, from 40 to 50 kg/m^2, > 50 kg/m^2 and BMI unspecified).

Comorbidities were assessed using the Charlson comorbidity index, specifically the version of Quan and colleagues [9] . The final score was the categorized into three groups (0, 1–2 and ≥ 3). Obstructive sleep apnea syndrome (OSAS), which is not part of the Charlson index, was included as a separate covariate. OSAS and comorbidities included in the Charlson index are chronic diseases, and so they were identified using an inpatient lookback period. In other words, comorbidities were assessed for the index hospitalization as well as by using all the longitudinal patient information prior to the index hospitalization. This approach has been shown to improve the explanatory power of the model, in particular for readmissions [10] .

The presence of any difference in baseline characteristics between the groups of patients who did or did not undergo a revision surgery after sleeve gastrectomy was tested by univariate logistic regression.

The main outcome was assessed through a survival analysis using the Kaplan-Meier method, with two-sided 95% confidence intervals (CIs) of hazard ratios (HRs). A Cox proportional hazard model was used to test univariate and multivariate associations with revision surgery.

All analyses were performed using R version 3.6.1. (R Foundation for Statistical Computing, Vienna, Austria). Data are reported according to the REporting of studies Conducted using Observational Routinely-collected Data (RECORD) statement [11] .

RESULTS

During the study period, 2007–2018 inclusive, 232,691 patients received a sleeve gastrectomy. A total of 7,973 (3.4%) patients were excluded from analysis: 3,605 patients (1.5%) for age beyond the limits (18–65 years), 2,705 (1.2%) for missing data on BMI or sex, 1,681 (0.7%) patients who received the operation in 2007 and 201 patients (0.1%) for ambiguous coding of the surgical procedure. Hence, a total of 224,718 patients were included in the study.

The baseline patient characteristics are reported in Table 1. With a median follow-up of 42.6 months (interquartile range (IQR) 22.4–67.6), 8,051 (3.6%) patients had a sleeve gastrectomy followed by at least one revision procedure. Compared to patients who did not undergo a reoperation, patients who experienced a revision surgery presented a higher prevalence of the female sex (84.7% versus 79.6%, $p < 0.001$), a BMI > 50 kg/m^2 (18.2% versus 10.3%, $p < 0.001$), a more common history of previous gastric banding (24.6%, versus 10.0% $p < 0.001$) and type-2 diabetes (T2D) was almost 2-times more frequent (9.7% versus 5.0%, $p<0.001$).

REVISION RATE

The Kaplan-Meier analysis of revision surgery after sleeve gastrectomy is reported in Figure 1. After 5, 7 and 10 years from the initial sleeve gastrectomy, the rate of patients who

received another bariatric procedure was 4.7, 7.5 and 12.2%, respectively. In patients with a history of gastric banding prior to the sleeve gastrectomy, the revision rate was 9.9, 14.4 and 20.7%, respectively (Figure 2). In total, for hospitals (n=189) performing at least 50 sleeves per year on average, the revisional rate goes from 0% to 40% (Figure 3).The most common revision procedure after sleeve gastrectomy was gastric bypass (75.2%), followed by another sleeve ('re-sleeve', 18.7%), biliopancreatic diversion (5.3%) and adjustable gastric banding (0.9%). The statistically significant coefficients from the Cox proportional-hazards model are reported in Table 2. Covariates associated with an increased risk of revision surgery are BMI > 50 kg/m^2 (HR 2.70, 95% CI 2.52–2.89, $p < 0.001$), history of gastric banding (HR 2.81, 95% CI 2.66–2.95, $p < 0.001$) and T2D (HR 2.02, 95% CI 1.86–2.18, $p < 0.001$). Some factors reduced the probability of revision, including liver disease and the occurrence of a malignancy.

REASONS FOR REVISION

Principal diagnoses during the hospital stay for revision surgery are reported in Table 3, according to the revision procedure. The code for obesity (E66x) was the most common (87.0%), followed by the codes for GERD (K21x, 5.2%) and the codes K31x (3.6%), which include, among others, fistula (K316, 1.3%) and gastric stenosis (K312, 1.2%). The GERD code was more common in the case of gastric bypass compared to 're-sleeve' (6.4% versus 0.7%). In the same table, we also report the overall frequency of any code that is considered a principal and secondary diagnosis. Finally, we observed that GERD was reported for 15.3% of patients.

MORBIDITY

Table 4 describes the 90-day morbidity for revision surgery. The codes for fistula or peritonitis were found in 6.3% of hospital stays, while intestinal bleeding was found for 1.8% of the patients. Approximately 2.1% of patients was admitted to the intensive care unit (ICU)

stay for a median time of 10 days (3–28.5). Overall, 6.4% of the patients required a reoperation for complications, and 3.2% had an endoscopic procedure. Mortality at 90 days after revision surgery was 0.1%.

DISCUSSION

This study provided the revision rate after sleeve gastrectomy on a nationwide basis for more than 200,000 patients. At 10 years after the initial sleeve gastrectomy, 12.2% of patients had undergone another bariatric procedure. This rate seems lower than previously reported. In their meta-analysis, Clapp et al. [(4)] reported a pooled revision rate of 19.9% at 7 years; they noted that in studies with a follow-up rate higher than 50%, this rate is estimated at 29.4%. Similarly, in a recent systematic review by Guan and colleagues [(12)] , the rate of revision surgery after sleeve gastrectomy was reported at 22.6% for the studies with at least 10 years of follow-up. These results are from a small group of selected studies (n = 9) from a minority of bariatric centers. For example, in France we accounted for more than 400 hospitals that have performed sleeve gastrectomy for more than 7 years, but only one has published long-term results. The representativeness of this result on a national basis may be questionable.

In order to overcome this bias, administrative data may be useful and provide a wider representation of hospital performance. For instance, the New York Statewide Planning and Research Cooperative System (SPARCS) database collects data from all hospitals in the State of New York. Using this source, Tsui et al. [(13)] reported 341 revisions for 8,389 sleeves, for a revision rate of 6.2% and 15.3% at 5 and 8 years, respectively. This result is closer to our findings.

We also assessed factors associated with a higher probability of revision, and the three most influential were history of gastric banding, super-obesity (BMI > 50 kg/m^2) and T2D. Given that sleeve gastrectomy may be planned as the first part of a two-step strategy in patients with

super-obesity, the impact of BMI should be interpreted with caution. On the contrary, in patients with a previous gastric banding or a history of T2D, the risk of revision after a gastric sleeve is more than 2-times higher. We think that this information should be seriously considered when proposing a sleeve gastrectomy in this type of patients.

Considering the cause of revision, we found that the most common principal diagnosis for revision surgery was obesity (87.0%), followed by GERD (5.2%). Nevertheless, when considering any available diagnosis (principal and associated), GERD was found in 15.3% of patients. This rate is close to what was previously reported in the series of Antonopulos (17%, n = 144) and Landreaneau (19%, n = 89) [14, 15] . In order to identify a single specific medical cause for revision, we think that ICD-10 codes should be interpreted with caution, mainly because the reason for conversion may be multifactorial. In the study from Boru et al. (n = 30), GERD and weight regain together accounted for 10% of revisions after sleeve gastrectomy [16] . Finally, we also found gastric fistula (1.3%) and gastric stenosis (1.2%) as reasons for revision, although they were more uncommonly reported.

Morbidity from revision surgery has been reported at a higher rate than primary procedures [17] . Major complications are reported in several studies at more than 10% (14, 16, 18–20), with a reoperation rate from 2.7% (5) to 13% [18] in recent studies. Our study confirmed that revision procedures are associated with an important complication rate. Some of these complications may be extremely severe because we noted a median ICU stay of 10 days. Despite this alarming frequency of major complications, mortality remained low and comparable to mortality from primary procedures [17, 21] .

This study has several limitations. First, it was not possible to assess reoperation for complications that occurred the same day of the bariatric procedure; hence, it is likely that the reoperation rate was underestimated. Second, the number of patients with a previous history

of adjustable gastric banding is probably underestimated because we kept only 1 year of 'wash-out' for identifying band removal. This bias especially concerns patients who had their sleeve gastrectomy in 2008, because the rate of previous adjustable gastric banding was lower than for 2009 (12.1% versus 17.3%), while patients who underwent the operation in 2010 had a similar rate (15.3%). This study was descriptive and not interventional, and thus the main outcome (revision rate after gastrectomy) is not associated with adjustable gastric banding. However, we consider this bias to be minor. Finally, although our data did not represent a sample from a larger population it did represent the entire bariatric population from one nation. Thus, generalization of these results to other countries should be performed with caution. In fact, several factors independent of the intrinsic quality of the procedure may play an important role in the overall revision rate. For instance, a reimbursement by the national health system or the availability of centers that perform bariatric surgery could encourage revisional surgery.

Conclusions

In conclusion, this descriptive study found that during a 10-year period, approximately 1 out of 8 patients who initially underwent a sleeve gastrectomy had a revision bariatric procedure, mainly due to the persistence of excessive weight or GERD. We also identified factors that could double the rate of revision (e.g. history of gastric banding, T2D and super-obesity). Compared to adjustable gastric banding, which has been progressively replaced by sleeve gastrectomy, revision surgeries are 4–5-times less frequent. This finding suggests that this procedure could be more efficient in the long-term for obesity treatment.

Disclosure of all conflicts of interest

Authors declare no conflict of interest concerning the present study

225 KEYWORDS

Sleeve gastrectomy, Bariatric surgery, Revisional surgery, Long-term results, Gastroesophageal reflux disease

Figure 1. Cumulative incidence of revision surgery after sleeve gastrectomy

Figure 2. Cumulative incidence of revision surgery after sleeve gastrectomy by history of adjustable gastric banding.

Figure 3. Cumulative incidence of revision surgery after sleeve gastrectomy by hospital (n=189).

REFERENCES

(1) L. Angrisani *et al.*, "IFSO Worldwide Survey 2016: Primary, endoluminal, and revisional procedures," *Obes. Surg.*, vol. 28, no. 12, pp. 3783–3794, 2018.

(2) O. Reges *et al.*, "Association of bariatric surgery using laparoscopic Banding, Roux-en-Y gastric bypass, or laparoscopic sleeve gastrectomy vs usual care obesity management with all-cause mortality," *JAMA*, vol. 319, no. 3, p. 279, 2018.

(3) R. Peterli *et al.*, "Effect of laparoscopic sleeve gastrectomy vs laparoscopic roux-en-y gastric bypass on weight loss in patients with morbid obesity: the SM-BOSS randomized clinical trial," *JAMA*, vol. 319, no. 3, p. 255, 2018.

(4) B. Clapp, M. Wynn, C. Martyn, C. Foster, M. O'Dell, and A. Tyroch, "Long term (7 or more years) outcomes of the sleeve gastrectomy: a meta-analysis," *Surg. Obes. Relat. Dis.*, vol. 14, no. 6, pp. 741–747, 2018.

(5) T. Poghosyan *et al.*, "Conversion of sleeve gastrectomy to one anastomosis gastric bypass for weight loss failure," *Obes. Surg.*, vol. 29, no. 8, pp. 2436–2441, 2019.

(6) P. Noel, M. Nedelcu, I. Eddbali, T. Manos, and M. Gagner, "What are the long-term results 8 years after sleeve gastrectomy?," *Surg. Obes. Relat. Dis.*, vol. 13, no. 7, pp. 1110–1115, 2017.

(7) A. Lazzati *et al.*, "Reduction in early mortality outcomes after bariatric surgery in France between 2007 and 2012: A nationwide study of 133,000 obese patients," *Surg. (United States)*, vol. 159, no. 2, 2016.

(8) G. Moulis, M. Lapeyre-Mestre, A. Palmaro, G. Pugnet, J. L. Montastruc, and L. Sailler,

"French health insurance databases: what interest for medical research?," *Rev. Med. Interne*, vol. 36, no. 6, pp. 411–417, 2015.

(9) H. Quan *et al.*, "Updating and validating the Charlson Comorbidity Index and score for risk adjustment in hospital discharge abstracts using data from 6 countries," *Am. J. Epidemiol.*, vol. 173, no. 6, pp. 676–682, 2011.

(10) D. B. Preen, C. D. A. J. Holman, K. Spilsbury, J. B. Semmens, and K. J. Brameld, "Length of comorbidity lookback period affected regression model performance of administrative health data," *J. Clin. Epidemiol.*, vol. 59, no. 9, pp. 940–946, 2006.

(11) E. I. Benchimol *et al.*, "The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement," *PLoS Med.*, vol. 12, no. 10, 2015.

(12) B. Guan, T. H. Chong, J. Peng, Y. Chen, C. Wang, and J. Yang, "Mid-long-term revisional surgery after sleeve gastrectomy: a systematic review and meta-analysis," *Obes. Surg.*, vol. 29, no. 6, pp. 1965–1975, 2019.

(13) S. T. Tsui *et al.*, "Association of revisions or conversions after sleeve gastrectomy with annual bariatric center procedural volume in the state of New York," *Surg. Endosc.*, 2019, https://doi.org/10.1007/s00464-019-07068-3.

(14) C. Antonopulos *et al.*, "Comparison of Repeat sleeve gastrectomy and roux-en-y gastric bypass in case of weight loss failure after sleeve gastrectomy," *Obes. Surg.*, vol. 29, pp.3919–3927, 2019.

(15) J. P. Landreneau *et al.*, "Conversion of sleeve gastrectomy to Roux-en-Y gastric bypass," *Obes. Surg.*, vol. 28, no. 12, pp. 3843–3850, 2018.

(16) C. E. Boru, F. Greco, P. Giustacchini, M. Raffaelli, and G. Silecchia, “Short-term outcomes of sleeve gastrectomy conversion to R-Y gastric bypass: multi-center retrospective study,” *Langenbeck’s Arch. Surg.*, vol. 403, no. 4, pp. 473–479, 2018.

(17) D. Gero *et al.*, “Defining global benchmarks in bariatric surgery,” *Ann. Surg.*, vol. 270, no. 5, p. 1, 2019.

(18) N. Nevo, S. Abu-Abeid, G. Lahat, J. Klausner, and S. M. Eldar, “Converting a sleeve gastrectomy to a gastric bypass for weight loss failure—is it worth it?,” *Obes. Surg.*, vol. 28, no. 2, pp. 364–368, 2018.

(19) H. Yilmaz, I. Ece, and M. Sahin, “Revisional surgery after failed laparoscopic sleeve gastrectomy: retrospective analysis of causes, results, and technical considerations,” *Obes. Surg.*, vol. 27, no. 11, pp. 2855–2860, 2017.

(20) T. Poghosyan *et al.*, “Conversion of sleeve gastrectomy to Roux-en-Y gastric bypass: an audit of 34 patients.,” *Surg. Obes. Relat. Dis.*, vol. 12, no. 9, pp. 1646–1651, Nov. 2016.

(21) A. Lazzati *et al.*, “Natural history of adjustable gastric banding,” *Ann. Surg.*, vol. 265, no. 3, pp. 439–445, 2017.

Table 1. Baseline patient characteristics

Covariate	Overall (n = 224,718)	No revision (n = 216,667)	Revision (n = 8,051)	p value
Sex, female, n (%)	179,234 (79.8)	172,412 (79.6)	6,822 (84.7)	< 0.001
BMI, kg/m^2, n (%)				
30–40	76,230 (33.9)	74,223 (34.3)	2,007 (24.9)	< 0.001
40–50	122,651 (54.6)	118,332 (54.6)	4,319 (53.7)	
> 50	23,718 (10.6)	22,251 (10.3)	1,467 (18.2)	
Not specified	2,107 (0.9)	1,850 (0.9)	257 (3.2)	
History of Adjustable Gastric Banding, n (%)	23,546 (10.5)	21,569 (10.0)	1,977 (24.6)	< 0.001
OSAS, n (%)	68,696 (30.6)	66,554 (30.7)	2,142 (26.6)	< 0.001
Charlson Index, n (%)				
0	178,737 (79.5)	172,395 (79.6)	6,342 (78.8)	< 0.001
1	17,757 (7.9)	16,927 (7.8)	830 (10.3)	
2	21,236 (9.5)	20,614 (9.5)	622 (7.7)	
> 2	6,988 (3.1)	6,731 (3.1)	257 (3.2)	
Charlson comorbidities, n (%)				
Myocardial infarction	2,347 (1.0)	2,278 (1.1)	69 (0.9)	0.103
Congestive heart failure	1,764 (0.8)	1,694 (0.8)	70 (0.9)	0.418
Peripheral vascular disease	1,547 (0.7)	1,479 (0.7)	68 (0.8)	0.097
Cerebrovascular disease	2,278 (1.0)	2,190 (1.0)	88 (1.1)	0.505
Dementia	70 (0.0)	68 (0.0)	2 (0.0)	0.996
Chronic pulmonary disease	18,877 (8.4)	18,045 (8.3)	832 (10.3)	< 0.001
Rheumatologic disease	1,275 (0.6)	1,230 (0.6)	45 (0.6)	0.978
Peptic ulcer disease	4,674 (2.1)	4,503 (2.1)	171 (2.1)	0.809
Diabetes without chronic complications	7,771 (3.5)	7,222 (3.3)	549 (6.8)	< 0.001
Diabetes with chronic complications	3,852 (1.7)	3,628 (1.7)	224 (2.8)	< 0.001
Overall Diabetes	11,623 (5.2)	10,850 (5.0)	773 (9.6)	< 0.001
Renal disease	1,546 (0.7)	1,497 (0.7)	49 (0.6)	0.419
Hemiplegia or paraplegia	947 (0.4)	910 (0.4)	37 (0.5)	0.652
Any malignancy, including leukaemia and lymphoma	3,488 (1.6)	3,396 (1.6)	92 (1.1)	0.003
Mild liver disease	21,361 (9.5)	20,727 (9.6)	634 (7.9)	< 0.001
Moderate or severe liver disease	427 (0.2)	410 (0.2)	17 (0.2)	0.754
Overall liver disease	21,788 (9.7)	21,137 (9.8)	651 (8.1)	< 0.001
Metastatic solid tumour	507 (0.2)	495 (0.2)	12 (0.1)	0.175
AIDS/HIV	608 (0.3)	588 (0.3)	20 (0.2)	0.779

Abbreviations: BMI, body mass index; OSAS, obstructive sleep apnoea syndrome.

Diabetes with and without chronic complications and liver disease (mild or moderate/severe) are mutually exclusive.

Table 2. Multivariate analysis: most significant coefficients.

Covariate	Hazard Ratio	P value
Sex, female	1.35 (1.27–1.44)	< 0.001
BMI, 40–50 kg/m^2	1.46 (1.38–1.54)	< 0.001
BMI, > 50 kg/m^2	2.70 (2.52–2.89)	< 0.001
History of adjustable gastric banding	2.81 (2.66–2.95)	< 0.001
Overall diabetes	2.02 (1.86–2.18)	< 0.001
OSAS	0.80 (0.76–0.85)	< 0.001
Any malignancy, including leukaemia and lymphoma	0.70 (0.56–0.87)	< 0.01
Overall liver disease	0.83 (0.77–0.90)	< 0.001

Abbreviations: BMI, body mass index; OSAS, obstructive sleep apnoea syndrome

Table 3. Principal and associated diagnosis for revision surgeries (principal diagnoses are stratified by the revision procedure).

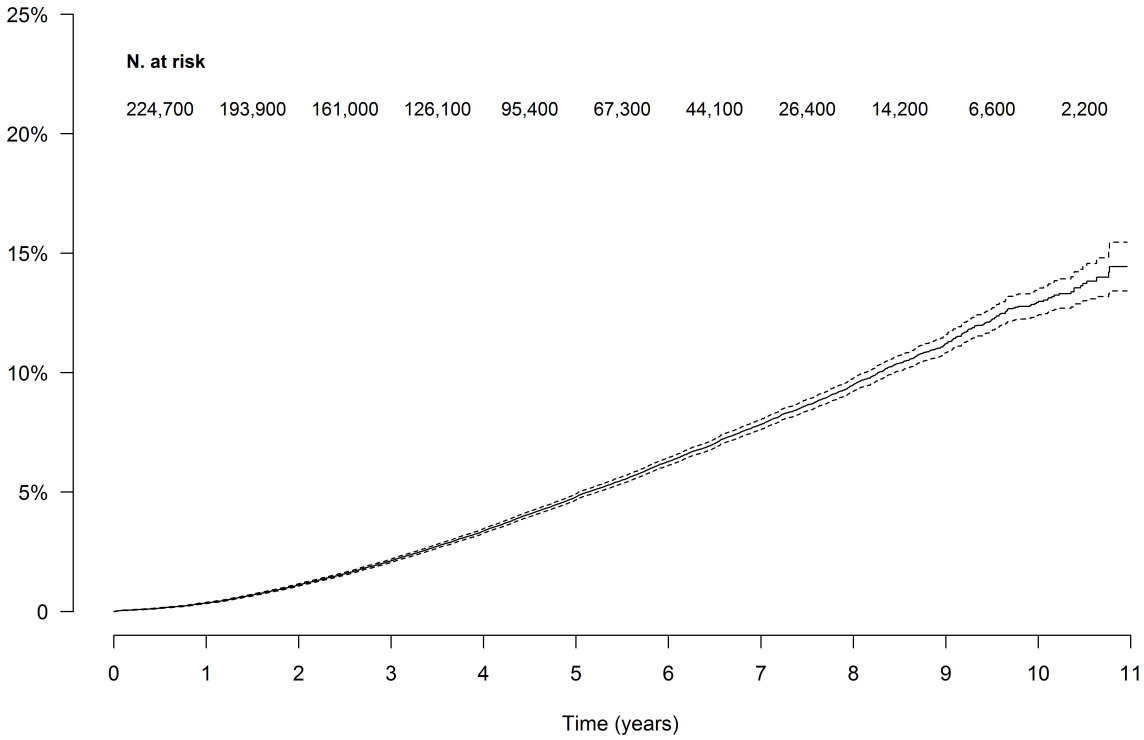
		Principal Diagnosis					Any diagnosis
	ICD-10 code	**Overall (n = 8,051)**	**Adjustable gastric banding (n = 68)**	**Gastric bypass (n = 421)**	**Sleeve gastrectomy (n = 5,965)**	**Bilio-pancreatic diversion (n = 1,597)**	**Overall (n = 8,051)**
Obesity, n (%)	E66x	6,837 (87)	43 (63.2)	381 (86)	5,064 (91.2)	1,349 (90.5)	7,305 (93.1)
GERD, n (%)	K21x	406 (5.2)	7 (10.3)	14 (6.4)	374 (0.7)	11 (3.3)	1,199 (15.3)
Other diseases of stomach and duodenum[a], n (%)	K31x	280 (3.6)	2 (2.9)	10 (3.6)	213 (3.7)	55 (2.4)	579 (7.4)
Intraoperative and postprocedural complications[b], n (%)	K91x	75 (1)	2 (2.9)	4 (1)	60 (0.6)	9 (1)	446 (5.7)
Complications of other internal prosthetic devices[c], n (%)	T85x	56 (0.7)	8 (11.8)	3 (0.5)	31 (1)	14 (0.7)	206 (2.6)

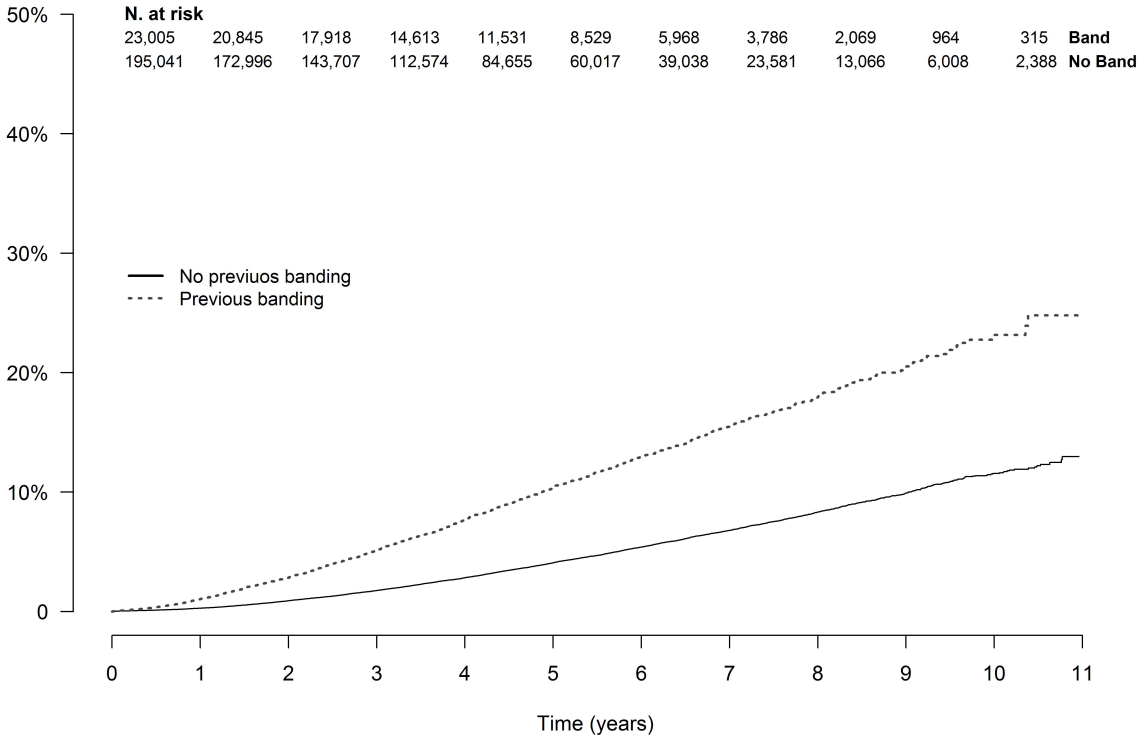
[a] Includes the codes K316 (Fistula of stomach and duodenum) and K312 (Hourglass stricture and stenosis of stomach);
[b]Extended label: “Intraoperative and postprocedural complications and disorders of digestive system, not elsewhere classified”;
[c]Extended label: “Complications of other internal prosthetic devices, implants and grafts”.

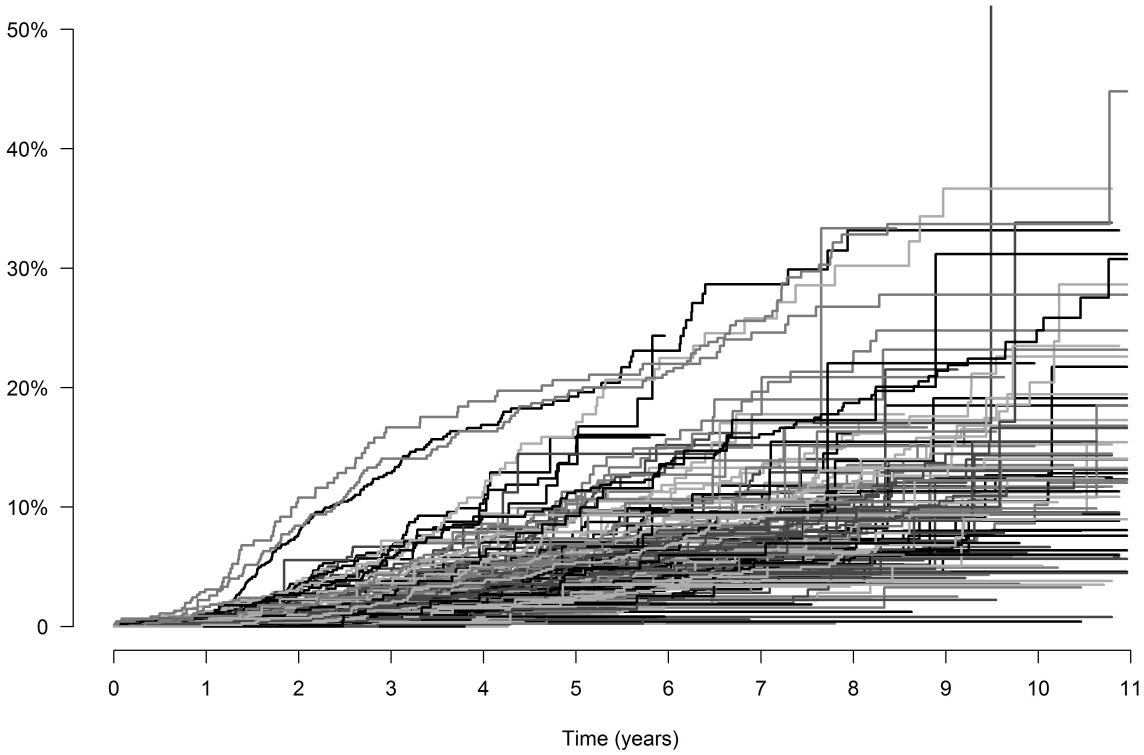
Table 4. Morbidity for revision surgery stratified by bariatric procedure.

Covariate	Overall (n = 8,051)	Adjustable gastric banding (n = 68)	Gastric bypass (n = 5,965)	Sleeve gastrectomy (n = 1,597)	Biliopancreatic derivation (n = 421)
LoS, mean (SD)	5.74 (6.56)	2.97 (2.61)	5.90 (6.98)	5.21 (5.30)	6.03 (4.77)
LoS, days, n (%)					
0-1	183 (2.3)	15 (22.1)	133 (2.2)	31 (1.9)	4 (1.0)
2-7	6,683 (83.0)	51 (75.0)	4917 (82.4)	1390 (87.0)	325 (77.2)
>7	1,185 (14.7)	2 (2.9)	915 (15.3)	176 (11.0)	92 (21.9)
Leak, n (%)	410 (5.1)	0 (0.0)	303 (5.1)	90 (5.6)	17 (4.0)
Peritonitis, n (%)	266 (3.3)	0 (0.0)	200 (3.4)	54 (3.4)	12 (2.9)
Leak or Peritonitis, n (%)	510 (6.3)	0 (0.0)	379 (6.4)	107 (6.7)	24 (5.7)
Bleeding, n (%)	146 (1.8)	0 (0.0)	129 (2.2)	11 (0.7)	6 (1.4)
Transfusion, n (%)	58 (0.7)	0 (0.0)	46 (0.8)	11 (0.7)	1 (0.2)
ICU stay, n (%)	168 (2.1)	0 (0.0)	116 (1.9)	31 (1.9)	21 (5.0)
ICU, LoS, median (IQR)	10 (3–28.5)	0	10 (3–24)	13 (3.5–52)	6 (3–15)
Surgical reoperation, n (%)	518 (6.4)	4 (5.9)	398 (6.7)	93 (5.8)	23 (5.5)
Endoscopic reoperation, n (%)	256 (3.2)	2 (2.9)	169 (2.8)	77 (4.8)	8 (1.9)
Radiological drainage, n (%)	109 (1.4)	0 (0.0)	72 (1.2)	31 (1.9)	6 (1.4)
Nutrition, artificial, n (%)	171 (2.1)	1 (1.5)	120 (2.0)	41 (2.6)	9 (2.1)
Death, n (%)	10 (0.1)	0 (0.0)	5 (0.1)	3 (0.2)	2 (0.5)

Abbreviations: LoS, length of stay; ICU, intensive care unit; IQT, interquartile range.


25%
20%
15%
10%
5%
0
N. at risk
224,700 193,900 161,000 126,100 95,400 67,300 44,100 26,400 14,200 6,600 2,200
0 1 2 3 4 5 6 7 8 9 10 11
Time (years)


N. at risk
23,005 20,845 17,918 14,613 11,531 8,529 5,968 3,786 2,069 964 315 Band
195,041 172,996 143,707 112,574 84,655 60,017 39,038 23,581 13,066 6,008 2,388 No Band
50%
40%
30%
20%
10%
0
No previuos banding
Previous banding
0 1 2 3 4 5 6 7 8 9 10 11
Time (years)



HIGHLIGHTS

- Rate of revisional surgery after sleeve gastrectomy was 4 12.2%, at 10 years.
- Revisional procedures was gastric bypass (75.2%), and by re-sleeve (18.7%).
- Reasons for revision were persistence of obesity (87.0%) and GERD (5.2%)
- Early complications: 5.1% gastric leak, 18% bleeding and a reoperation rate of 6.4%.