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CLINICAL RESEARCH

# Cholecystectomy Concomitant with Laparoscopic Gastric Bypass: A Trend Analysis of the Nationwide Inpatient Sample from 2001 to 2008

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**Abstract**
*Background* Gallstone formation is common in obese patients, particularly during rapid weight loss. Whether a concomitant cholecystectomy should be performed during laparoscopic gastric bypass surgery is still contentious. We aimed to analyze trends in concomitant cholecystectomy and laparoscopic gastric bypass surgery (2001–2008), to identify factors associated with concomitant cholecystectomy, and to compare short-term outcomes after laparoscopic gastric bypass with and without concomitant cholecystectomy.
*Methods* We used data from adults undergoing laparoscopic gastric bypass for obesity from the Nationwide Inpatient Sample. The Cochran–Armitage trend test was used to assess changes over time. Unadjusted and risk-adjusted generalized linear models were performed to assess predictors of concomitant cholecystectomy and to assess postoperative short-term outcomes.
*Results* A total of 70,287 patients were included: mean age was 43.1 years and 81.6% were female. Concomitant cholecystectomy was performed in 6,402 (9.1%) patients. The proportion of patients undergoing concomitant cholecystectomy decreased significantly from 26.3% in 2001 to 3.7% in 2008 ($p$ for trend<0.001). Patients who underwent concomitant cholecystectomy had higher rates of mortality (unadjusted odds ratios [OR], 2.16; $p$=0.012), overall postoperative complications (risk-adjusted OR, 1.59; $p$=0.001), and reinterventions (risk-adjusted OR, 3.83; $p$<0.001), less frequent routine discharge (risk-adjusted OR, 0.70; $p$=0.05), and longer adjusted hospital stay (median difference, 0.4 days; $p$<0.001).
*Conclusions* Concomitant cholecystectomy and laparoscopic gastric bypass surgery have decreased significantly over the last decade. Given the higher rates of postoperative complications, reinterventions, mortality, as well as longer hospital stay, concomitant cholecystectomy should only be considered in patients with symptomatic gallbladder disease.

**Keywords** Bariatric surgery · Laparoscopic gastric bypass · Cholecystectomy · Gallstones · Adverse outcomes

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## Introduction

Obesity has reached epidemic proportions in the USA and, with the prevalence of obesity of approximately 34% [1], bariatric surgery is performed more frequently than ever before [2, 3]. Weight loss surgery is a fast and mostly permanent way to lose weight for those with severe obesity [4, 5]. Bariatric surgery not only decreases morbidity and mortality in obese patients [4, 6], but also has been estimated to reduce health care costs up to 45% by 5 years postoperatively [6, 7]. However, the formation of gallstones in these patients remains a subject of concern [8, 9]. Despite the benefits of bariatric surgery, obesity and rapid weight loss increase the risk of gallstone formation [8–10] with a 1-year cumulative incidence after bariatric surgery ranging from 30% to 53% [11, 12]. Although routine prophylactic cholecystectomy [13–15] can be performed to remove gallstones or to prevent gallstone formation, several alternative approaches have been suggested regarding the management of the gallbladder during bariatric surgery. These include cholecystectomy only after preoperatively detected gallbladder pathology by ultrasound [16, 17], cholecystectomy after intraoperative verification of gallstones with ultrasound [11, 18], routine administration of ursodeoxycholic acid to all patients to prevent gallstone formation [11, 19, 20], and no treatment for asymptomatic patients before or after surgery [21, 22]. Yet, little is known about the nationwide rate of cholecystectomies in laparoscopic gastric bypass surgery and about the short-term outcomes compared to laparoscopic gastric bypass surgery without concomitant cholecystectomy.

We undertook a secondary data analysis using the Nationwide Inpatient Sample (NIS) database to assess trends in concomitant cholecystectomy among patients undergoing laparoscopic gastric bypass procedures. We also sought to identify potential predictors of concomitant cholecystectomy among patients undergoing laparoscopic gastric bypass surgery and to determine whether there were differences between short-term postoperative outcomes between patients with and without concomitant cholecystectomy.

## Methods

The Institutional Review Board approved the study protocol. We conducted a secondary analysis of data from 2001 to 2008 from a national administrative database, the NIS, a Healthcare Cost and Utilization Project. In the USA, the NIS represents the largest all-payer inpatient database: five to eight million inpatients are included annually. NIS data are based on both clinical discharge diagnosis and resource use for about 20% of all hospital discharges per year of nonfederal, short-term, general, and other specialty hospitals in the USA. The data set is stratified by various hospital characteristics, such as region, urban/rural locations, teaching status, number of beds, and ownership. All hospital discharges are included in this publicly available, accredited database. No personal identifiers are contained in the NIS.

We identified our sample from the NIS database based on the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM). All patients 18 years of age or older undergoing laparoscopic gastric bypass surgery for obesity were included. We defined obesity using the following ICD-9 diagnosis codes: V85.3x (body mass index [BMI] 35.0–39.9 kg/m$^2$), V85.4 (BMI >40 kg/m$^2$), V77.8 (obesity), 278.0 (overweight and obesity), 278.00 (obesity unspecified), 278.01 (morbid obesity), and 278.02 (overweight). Laparoscopic gastric bypass procedure was either defined as ICD-9 44.38 (laparoscopic gastric bypass) or a combination of a procedure code for open gastric bypass (44.31, 44.39, and 44.3) and either a procedure code for laparoscopy (54.21), laparoscopic cholecystectomy (51.23), laparoscopic lysis of adhesions (54.51), or an ICD-9 diagnosis code for conversion from laparoscopic to open surgery (V64.4, V64.41). Patients with the following ICD-9 diagnosis codes were excluded from our analysis: 253.8 (adiposogenital dystrophy), 259.9 (obesity of endocrine origin NOS), 150–159.9 (gastrointestinal track neoplasm), 555.0–556.9 (inflammatory bowel disease), and 557.0–558.9 (noninfectious colitis). Patients admitted through the emergency department were excluded.

The primary outcome of interest was change from 2001 to 2008 in the proportion of patients who underwent cholecystectomy during a laparoscopic gastric bypass procedure. Patients undergoing concomitant cholecystectomy were identified through ICD-9 procedure codes for cholecystectomy (51.2, 51.21–51.24). Demographic characteristics included age, gender, ethnicity (White, Black, Hispanic, other), ZIP code-related household income per year (1, $1–34,999; 2, $35,000–44,999; 3, ≥$45,000), and insurance status (Medicare, Medicaid, private including health maintenance organization (HMO), others). Hospital characteristics included hospital region (South, Northeast, Midwest, West), hospital location/teaching status (rural, urban nonteaching, urban teaching), and hospital volume (in quintiles).

We used a modified comorbidity index based on the Charlson index [23], developed for use with administrative data and previously described by Deyo et al. [24]. Patients were divided into three groups: Deyo category 0, 1, or >1. Gallbladder disease was identified through the following ICD-9 diagnosis codes: 574.0–574.91 and 575.0–575.9.

We further identified intraoperative and postoperative complications as well as reinterventions through ICD-9 codes as listed in the Appendix modified from Guller et al. [25]. We only included complications that were clearly identifiable as postoperative to avoid overlap with preoperative comorbidity. In addition, we captured data on in-hospital mortality, discharge status (routine, nonroutine), and length of hospital stay.

## Statistical Analysis

Demographic characteristics were assessed for the entire study period using means and standard deviations or counts and percentages. Comparisons were performed using Student's *t* test and chi-squared test where appropriate.

We determined the annual incidence of concomitant cholecystectomy by dividing the number of patients undergoing laparoscopic gastric bypass procedures combined with concomitant cholecystectomy by the number of patients undergoing laparoscopic gastric bypass surgery performed for each year. The trend for concomitant cholecystectomy was ascertained using the Cochran–Armitage trend test for all patients undergoing laparoscopic gastric bypass surgery as well as for subgroups of patients with and without gallbladder disease.

To identify predictors of concomitant cholecystectomy, such as year of procedure (to assess changes over time), age, gender, ethnicity, ZIP code-related income, insurance status, hospital region, hospital location/teaching status, hospital volume, Deyo score, and gallbladder disease among patients undergoing laparoscopic gastric bypass surgery, we performed univariate and multivariate logistic regression analysis. Odds ratios (OR) and 95% confidence intervals (95% CI) were calculated.

Using the same predictors as above, we compared intraoperative and postoperative adverse events as well as hospital discharge using univariate and multivariate logistic regression. The same set of covariates was used in multiple linear regression analysis for length of hospital stay. Year of operation was added as a covariate to account for outcome improvements in laparoscopic gastric bypass surgery over time. Since length of hospital stay was substantially skewed to the right, we performed log transformation before performing multiple linear regression analysis. The estimates were retransformed using exponential formula, and median values as well as the 95% CI are provided. Due to the very small number of events for retained foreign bodies, bile duct lesions, and mortality, we did not perform multivariate analysis for those outcomes.

Ethnicity was missing for 20.3% of the subjects. Multivariate regression analyses were, therefore, performed with and without ethnicity in the model. Since the results from the two models were very similar, only the model including ethnicity is presented.

A significance level ($\alpha$) of 0.05 was used for all analyses. *p* values for all tests were two-sided. All statistical calculations were performed using Stata/SE version 10 (Stata Corporation, College Station, TX, USA).

# Results

We evaluated data from a total of 70,287 patients undergoing laparoscopic gastric bypass surgery for obesity between 2001 and 2008. There were 57,332 (81.6%) women and mean age was 43.1 (SD, 10.8) years. Overall, 6,402 (9.1%) patients underwent concomitant cholecystectomy and 6,245 (8.9%) patients suffered from any gallbladder disease. Patients who underwent cholecystectomy had fewer comorbidities as measured by the Deyo score before the operation than those who did not. Subject characteristics are provided in Table 1.

The proportion of patients undergoing concomitant cholecystectomy during the laparoscopic gastric bypass procedure decreased from 26.3% to 3.7% over the 8-year time period ($p$ for trend<0.001) (Table 1, Fig. 1). This trend holds true for both patients with and without gallbladder disease, whereas the trend is more pronounced among patients without gallbladder disease ($p$ for trend<0.001 for both) (Fig. 2a, b).

Using 2001 as reference, year of operation was a strong negative predictor for concomitant cholecystectomy with risk-adjusted OR decreasing from 0.20 (95% CI, 0.13–0.32; $p<0.001$) (relative to 2001) for 2002 to 0.042 (95% CI, 0.028–0.063; $p<0.001$) in 2008 (Table 2). Patients operated in hospitals either located in rural (risk-adjusted OR, 0.51; 95% CI, 0.31–0.86; $p=0.011$) or teaching hospitals in urban areas were *less* likely to undergo cholecystectomy (risk-adjusted OR, 0.54; 95% CI, 0.46–0.62; $p<0.001$) compared to urban nonteaching hospitals. The strongest predictor of concomitant cholecystectomy was the presence of any gallbladder disease (risk-adjusted OR, 1,400.1; 95% CI, 1,187.7–1,650.4; $p<0.001$).

Intraoperative complications occurred in 2.37% ($n=$1,516) of patients without concomitant cholecystectomy and in 2.86% ($n=183$) of patients with concomitant cholecystectomy ($p=0.016$) (Table 3). After adjusting for multiple confounders, no difference for overall intraoperative complications between the two groups was observed (risk-adjusted OR, 1.22; 95% CI, 0.80–1.85; $p=0.36$). In spite of the fact that the patients who underwent cholecystectomy had fewer comorbidities than those who did not, patients undergoing concomitant cholecystectomy showed a higher rate of postoperative complications (6.22%, $n=398$) than patients without concomitant cholecystectomy (5.06%, $n=$3,235) ($p<0.001$). Even after adjustment for potential confounders, this difference remained significant (OR, 1.59; 95% CI, 1.21–2.10; $p=0.001$). The following postoperative adverse events showed higher risk-adjusted relative OR in patients undergoing concomitant cholecystectomy: postoperative infections (OR, 3.31; 95% CI, 1.58–6.94; $p=0.002$), pulmonary complications (OR, 2.29; 95% CI, 1.53–3.42; $p<0.001$), and gastrointestinal complications (OR, 1.88; 95% CI, 1.21–2.91; $p=0.005$). The in-hospital rate of postoperative reinterventions was higher in patients with

**Table 1** Characteristics of patients undergoing laparoscopic gastric bypass surgery for obesity

| Variable | Without concomitant cholecystectomy (*n*=63,885, 90.89%) | With concomitant cholecystectomy (*n*=6,402, 9.11%) | *p* value |
|---|---|---|---|
| Age (mean, SD) | 43.10 (10.9) | 42.76 (10.5) | 0.019 |
| Gender | | | |
| Female | 51,874 (81.2) | 5,458 (85.3) | <0.001 |
| Male | 11,713 (18.3) | 923 (14.4) | |
| Missing | 298 (0.5) | 21 (0.3) | |
| Ethnicity | | | |
| White | 38,335 (60.0) | 4,021 (62.8) | <0.001 |
| Black | 5,710 (8.9) | 474 (7.4) | |
| Hispanic | 4,488 (7.0) | 557 (8.7) | |
| Other | 2,276 (3.6) | 161 (2.5) | |
| Missing | 13,076 (20.5) | 1,189 (18.6) | |
| ZIP code-related income | | | |
| 1–34,999 | 12,279 (19.2) | 1,229 (19.2) | 0.61 |
| 35,000–44,999 | 16,154 (25.3) | 1,586 (24.8) | |
| 44,999 or more | 33,595 (52.6) | 3,404 (53.2) | |
| Missing | 1,857 (2.9) | 183 (2.9) | |
| Insurance | | | |
| Private including HMO | 49,733 (77.8) | 5,335 (83.3) | <0.001 |
| Medicare | 4,502 (7.0) | 354 (5.5) | |
| Medicaid | 3,312 (5.2) | 227 (3.6) | |
| Other | 6,049 (9.5) | 475 (7.4) | |
| Missing | 289 (0.5) | 11 (0.2) | |
| Hospital region | | | |
| South | 20,191 (31.6) | 1,995 (31.2) | <0.001 |
| Northeast | 14,394 (22.5) | 1,190 (18.6) | |
| Midwest | 10,083 (15.8) | 1,099 (17.2) | |
| West | 19,217 (30.1) | 2,118 (33.1) | |
| Hospital location/teaching | | | |
| Rural | 1,446 (2.3) | 160 (2.5) | <0.001 |
| Urban nonteaching | 29,373 (46.0) | 3,545 (55.4) | |
| Urban teaching | 33,066 (51.8) | 2,697 (42.1) | |
| Hospital volume (quintiles) | | | |
| <Q1 (1–58) | 12,502 (19.6) | 1,728 (27.0) | <0.001 |
| Q1–Q2 (59–114) | 12,776 (20.0) | 1,328 (20.7) | |
| Q2–Q3 (115–173) | 13,324 (20.9) | 870 (13.6) | |
| Q3–Q4 (174–289) | 12.924 (20.2) | 1,065 (16.6) | |
| >Q4 (>289) | 12,359 (19.4) | 1,411 (22.0) | |
| Deyo score | | | |
| 0 | 48,881 (76.5) | 5,090 (79.5) | <0.001 |
| =1 | 10,914 (17.1) | 910 (14.2) | |
| >1 | 4,090 (6.4) | 402 (6.3) | |
| Gallbladder disease | | | |
| Yes | 523 (0.82) | 5,722 (89.38) | <0.001 |
| No | 63,362 (99.18) | 680 (10.62) | |
| Year | | | |
| 2001 | 498 (73.7) | 178 (26.3) | <0.001[a] |
| 2002 | 2,178 (81.4) | 497 (18.6) | |

**Table 1** (continued)

| Variable | Without concomitant cholecystectomy ($n$=63,885, 90.89%) | With concomitant cholecystectomy ($n$=6,402, 9.11%) | $p$ value |
|---|---|---|---|
| 2003 | 4,160 (73.5) | 1,501 (26.5) | |
| 2004 | 6,600 (83.8) | 1,273 (16.2) | |
| 2005 | 13,897 (93.6) | 950 (6.4) | |
| 2006 | 11,640 (93.1) | 868 (6.9) | |
| 2007 | 9,920 (94.6) | 566 (5.4) | |
| 2008 | 14,992 (96.3) | 569 (3.7) | |

Data are provided as number ($n$) and percentage, if not otherwise indicated. $p$ values are given for $t$ test and chi-squared test as appropriate

[a] Cochran–Armitage trend test, $p$ for trend

concomitant cholecystectomy (0.73%, $n$=47) than in patients without concomitant cholecystectomy (0.47%, $n$=302) ($p$=0.005). This difference remained in multivariate regression analysis (risk-adjusted OR, 3.83; 95% CI, 2.00–7.34; $p$<0.001). The unadjusted risk of in-hospital mortality was 2.16 times higher for patients undergoing concomitant cholecystectomy than for the others (95% CI, 1.19–3.94; $p$=0.012).

Routine discharge for patients with concomitant cholecystectomy was lower than for patients without concomitant cholecystectomy (risk-adjusted OR, 0.70; 95% CI, 0.49–1.00; $p$=0.05) (Table 3). Patients undergoing cholecystectomy had a longer risk-adjusted median hospital stay with 2.61 days (95% CI, 2.55–2.68) than patients without cholecystectomy with 2.22 days (95% CI, 2.21–2.23) ($p$<0.001) (Table 4).

## Discussion

We investigated the trend in the practice of concomitant cholecystectomy during laparoscopic gastric bypass procedures in the USA over an 8-year period. The annual rate of concomitant cholecystectomy decreased significantly in patients both with and without gallbladder disease. When cholecystectomy was performed in addition to laparoscopic gastric bypass surgery, postoperative adverse outcomes were more frequent; in particular, we found an increase in in-hospital mortality and higher rates of infections, pulmonary and gastrointestinal complications, and reinterventions. The duration of hospital stay was longer in patients

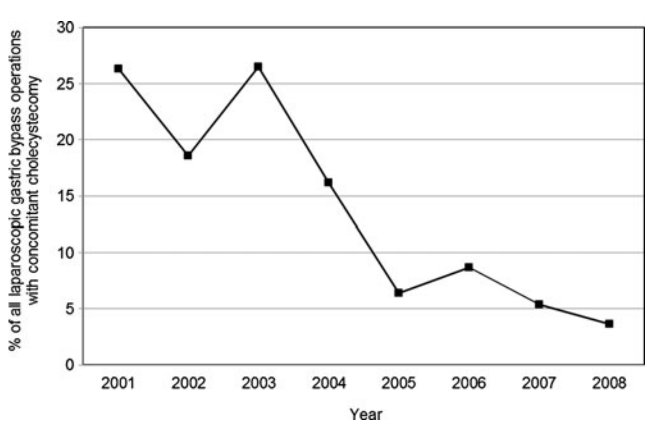


**Fig. 1** Percentage of laparoscopic gastric bypass with concomitant cholecystectomy by year; Cochran–Armitage trend test: $p$ for trend<0.001

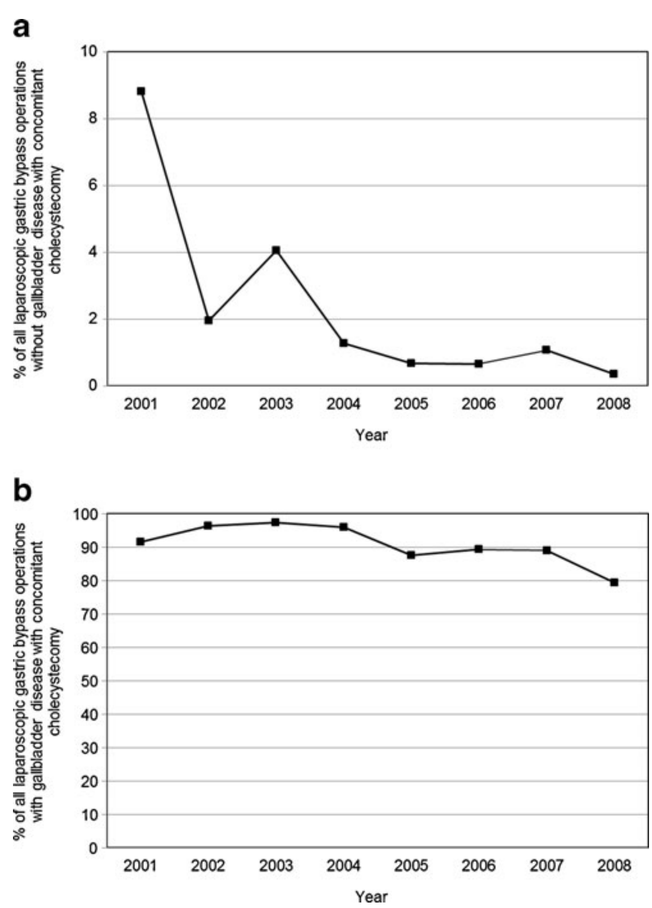


**Fig. 2** **a** Percentage of laparoscopic gastric bypass without gallbladder disease with concomitant cholecystectomy by year; Cochran–Armitage trend test: $p$ for trend<0.001. **b** Percentage of laparoscopic gastric bypass with gallbladder disease with concomitant cholecystectomy by year; Cochran–Armitage trend test: $p$ for trend<0.001

**Table 2** Predictors of concomitant cholecystectomy in patients undergoing laparoscopic gastric bypass

| | Univariate analysis, OR (95% CI) | *p* value | Multivariate analysis, OR (95% CI) | *p* value |
|---|---|---|---|---|
| Year | | | | |
| 2001 | Ref. | | Ref. | |
| 2002 | 0.64 (0.52–0.78) | <0.001 | 0.20 (0.13–0.32) | <0.001 |
| 2003 | 1.01 (0.84–1.21) | 0.919 | 0.46 (0.31–0.68) | <0.001 |
| 2004 | 0.54 (0.45–0.65) | <0.001 | 0.16 (0.11–0.25) | <0.001 |
| 2005 | 0.19 (0.16–0.23) | <0.001 | 0.053 (0.035–0.080) | <0.001 |
| 2006 | 0.21 (0.17–0.25) | <0.001 | 0.058 (0.038–0.086) | <0.001 |
| 2007 | 0.16 (0.13–0.19) | <0.001 | 0.077 (0.050–0.12) | <0.001 |
| 2008 | 0.11(0.088–0.13) | <0.001 | 0.042 (0.028–0.063) | <0.001 |
| Age | 0.997 (0.995–0.9995) | 0.019 | 1.00 (0.0.99–1.01) | 0.96 |
| Gender | | <0.001 | | 0.85 |
| Male | Ref. | | Ref. | |
| Female | 1.34(1.24–1.44) | | 1.02 (0.85–1.22) | |
| Ethnicity | | | | |
| White | Ref. | | Ref. | |
| Black | 0.79(0.72–0.87) | <0.001 | 1.03 (0.82–1.30) | 0.78 |
| Hispanic | 1.18(1.08–1.30) | <0.001 | 0.98 (0.77–1.23) | 0.83 |
| Other | 0.67(0.57–0.79) | <0.001 | 0.93 (0.64–1.36) | 0.72 |
| ZIP code-related income | | | | |
| 45,000 or more | Ref. | | Ref. | |
| 1–34,999 | 0.99(0.92–1.06) | 0.725 | 1.06 (0.89–1.27) | 0.51 |
| 35,000–44,999 | 0.97(0.91–1.03) | 0.323 | 1.04 (0.89–1.22) | 0.62 |
| Insurance | | | | |
| Private including HMO | Ref. | | Ref. | |
| Medicare | 0.73(0.66–0.82) | <0.001 | 0.87 (0.66–1.17) | 0.36 |
| Medicaid | 0.64(0.56–0.73) | <0.001 | 0.73 (0.51–1.03) | 0.07 |
| Other | 0.73(0.66–0.81) | <0.001 | 1.13 (0.88–1.45) | 0.34 |
| Hospital region | | | | |
| South | Ref. | | Ref. | |
| Northeast | 0.84(0.78–0.90) | <0.001 | 0.68 (0.56–0.83) | <0.001 |
| Midwest | 1.10(1.02–1.19) | 0.013 | 0.60 (0.45–0.79) | <0.001 |
| West | 1.12(1.05–1.19) | 0.001 | 0.69 (0.57–0.83) | <0.001 |
| Hospital location/teaching status | | | | |
| Urban nonteaching | Ref. | | Ref. | |
| Rural | 0.92(0.78–1.08) | 0.31 | 0.51 (0.31–0.86) | 0.011 |
| Urban teaching | 0.68(0.64–0.71) | <0.001 | 0.54 (0.46–0.62) | <0.001 |
| Deyo score | | | | |
| 0 | Ref. | | Ref. | |
| =1 | 0.78 (0.74–0.83) | <0.001 | 0.83 (0.72–0.96) | 0.014 |
| >1 | 0.64 (0.57–0.71) | <0.001 | 0.86 (0.66–1.14) | 0.30 |
| Gallbladder disease | | | | |
| No | Ref. | | Ref. | |
| Yes | 1019.5 (906.7–1146.2) | <0.001 | 1400.1 (1187.7–1650.4) | <0.001 |

Adjustment for age, gender, ethnicity, Deyo score, gallbladder disease, ZIP code-related income, hospital volume, hospital location/teaching status, hospital region, insurance status, and year of operation. Total number of patients in the multivariate analysis: $n$=54,124

undergoing concomitant cholecystectomy compared with those only undergoing laparoscopic gastric bypass surgery.

Definitive consensus on whether concomitant cholecystectomy should be performed does not yet exist. Still, some

**Table 3** Short-term outcomes after laparoscopic gastric bypass procedure with and without concomitant cholecystectomy (reference category)

| | Without concomitant cholecystectomy (*n*=63,885, 90.89%) | With concomitant cholecystectomy (*n*=6,402, 9.11%) | Unadjusted analysis, OR (95% CI) | *p* value | Adjusted analysis[a], OR (95% CI) | *p* value |
|---|---|---|---|---|---|---|
| Intraoperative complications | | | | | | |
| Injury to adjacent structures | 644 (1.01) | 89 (1.39) | 1.38 (1.11–1.73) | 0.004 | 0.94 (0.50–1.77) | 0.85 |
| Retained foreign body | 17 (0.03) | 5 (0.08) | 2.94 (1.08–7.96) | 0.034 | N/A | N/A |
| Hemorrhage complicating procedure | 890 (1.39) | 99 (1.55) | 1.11 (0.90–1.37) | 0.32 | 1.25 (0.73–2.15) | 0.41 |
| Bile duct complications | 3 (0.005) | 2 (0.03) | 6.65 (1.11–39.82) | 0.038 | N/A | N/A |
| Overall | 1,516 (2.37) | 183 (2.86) | 1.21 (1.04–1.41) | 0.016 | 1.22 (0.80–1.85) | 0.36 |
| Postoperative complications | | | | | | |
| Mechanical wound complications | 318 (0.50) | 32 (0.50) | 1.00 (0.70–1.45) | 0.98 | 1.62 (0.69–3.84) | 0.27 |
| Infections | 266 (0.42) | 49 (0.77) | 1.84 (1.36–2.50) | <0.001 | 3.31 (1.58–6.94) | 0.002 |
| Urinary/renal complications | 217 (0.34) | 27 (0.42) | 1.24 (0.83–1.86) | 0.29 | 2.28 (0.90–5.82) | 0.08 |
| Pulmonary complications | 1,087 (1.70) | 150 (2.34) | 1.39 (1.17–1.65) | <0.001 | 2.29 (1.53–3.42) | <0.001 |
| Gastrointestinal complications | 1,122 (1.76) | 143 (2.23) | 1.28 (1.07–1.52) | 0.006 | 1.88 (1.21–2.91) | 0.005 |
| Cardiovascular complications | 628 (0.98) | 71 (1.11) | 1.13 (0.88–1.45) | 0.33 | 1.55 (0.82–2.93) | 0.17 |
| Systemic complications | 302 (0.47) | 33 (0.52) | 1.09 (0.76–1.56) | 0.64 | 0.90 (0.35–2.35) | 0.83 |
| Overall | 3,235 (5.06) | 398 (6.22) | 1.24 (1.12–1.38) | <0.001 | 1.59 (1.21–2.10) | 0.001 |
| Mortality | 60 (0.09) | 13 (0.2) | 2.16 (1.19–3.94) | 0.012 | N/A | N/A |
| Reintervention | 302 (0.47) | 47 (0.73) | 1.56 (1.14–2.12) | 0.005 | 3.83 (2.00–7.34) | <0.001 |
| Conversion rate | 1,201 (1.88) | 190 (2.97) | 1.60 (1.37–1.86) | <0.001 | 1.487 (0.998–2.230) | 0.07 |
| Discharge status[b] | | | | | | |
| Nonroutine discharge | 2,021 (3.17) | 263 (4.12) | Ref. | | Ref. | |
| Routine discharge | 61,751 (96.83) | 6,121 (95.88) | 0.76 (0.67–0.87) | <0.001 | 0.70 (0.49–1.00) | 0.05 |

Due to small outcome events for retained foreign body, bile duct lesions, and mortality, multivariate analysis was not performed for those outcomes

[a] Adjustment for age, gender, ethnicity, Deyo score, gallbladder disease, ZIP code-related income, hospital volume, hospital location/teaching status, hospital region, insurance status, and year of operation

[b] 113 patients in the group without concomitant cholecystectomy and 18 patients in the group with concomitant cholecystectomy have unknown discharge status

authors suggest that every patient should undergo prophylactic cholecystectomy during laparoscopic gastric bypass surgery [13, 17, 26], while others favor cholecystectomy only after preoperative confirmation of gallstones [16, 27]. However, there is increasing evidence that cholecystectomy should only be performed in symptomatic patients since symptomatic gallbladder disease necessitating cholecystectomy following laparoscopic gastric bypass surgery is as low as 7% to 15% [11, 19, 22, 28–30]. The limited need for cholecystectomy in the early follow-up period after bariatric surgery is in stark contrast to the much higher incidence of gallstone formation of 30% to 53% within

**Table 4** Median length of hospital stay with and without concomitant cholecystectomy

| | Unadjusted | | | Adjusted | | |
|---|---|---|---|---|---|---|
| | Without concomitant cholecystectomy | With concomitant cholecystectomy | *p* value | Without concomitant cholecystectomy | With concomitant cholecystectomy | *p* value |
| Length of hospital stay | 2.23 (2.22–2.24) | 2.50 (2.47–2.53) | <0.001 | 2.22 (2.21–2.23) | 2.61 (2.55–2.68) | <0.001 |

Adjustment for age, gender, ethnicity, Deyo score, gallbladder disease, ZIP code-related income, hospital volume, hospital location/teaching status, hospital region, insurance status, and year of operation. Values are given as median and 95% CI. Calculations are performed after natural logarithm transformation, estimates are provided after retransformation

1 year of the operation [11, 12], but highlights the fact that not all patients with gallstones require cholecystectomy. However, the growing evidence that a cholecystectomy after a laparoscopic gastric bypass procedure can be done in a minimally invasive fashion with low morbidity is most likely responsible for the significant decrease in concomitant cholecystectomy [11, 16, 19, 22, 28, 31]. The situation was different in the era of open gastric bypass procedures where a postoperative cholecystectomy was difficult to perform in a minimally invasive fashion and a second open procedure was often inevitable. Descriptions of laparoscopic revisions after open bariatric surgery are not available before 2001 [32, 33].

Our findings suggest that, even if the overall in-hospital mortality rate is very low, 0.1%, the mortality rate is significantly higher in patients undergoing concomitant cholecystectomy. Earlier single-center studies have demonstrated equal mortality rates for patients with and without concomitant cholecystectomy [16, 17, 26, 34]. The use of a large national registry such as the NIS allows for the detection of even small effects. In our study, the mortality risk is about twice as high for patients undergoing concomitant cholecystectomy compared with patients who are not.

Despite similar rates of intraoperative complications in the two groups, we demonstrate that rates of postoperative complications and reinterventions are higher among patients undergoing concomitant cholecystectomy. In particular, this is true for postoperative infections, pulmonary and gastrointestinal complications, and reinterventions. The findings of Hamad and colleagues are consistent with these findings, suggesting that major early postoperative complications in patients undergoing concomitant cholecystectomy are more frequent than in patients not undergoing cholecystectomy [34]. Nonetheless, others have suggested no difference in adverse postoperative outcomes [17, 26, 27, 35]. Even though the absolute risk of those complications in our study is low, an overall 1.6-fold increase in relative risk still remains. For bariatric patients, the laparoscopic view is often impaired through increased visceral fat and hepatomegaly. Additionally, adding a cholecystectomy to the already difficult laparoscopic gastric bypass procedure increases operative time [27, 31] and tissue damage. This may reduce the function of the right diaphragm and can lead to increased postoperative pain [36]. The overall lower preoperative Deyo score among patients undergoing concomitant cholecystectomy suggests that their higher rate of complications postoperatively may be primarily due to the operation itself rather than the preoperative differences in comorbidities between the two patient groups.

Postoperative hospital stay was increased by approximately 0.4 days for patients undergoing concomitant cholecystectomy. This finding concurs with those of others who have demonstrated hospital stays that are 0.6 to 1.7 days longer for these patients [31, 34]. In contrast, others did not find any differences in postoperative stay [16, 17, 26, 27]. Even if the increase in length of hospital stay for patients undergoing concomitant cholecystectomy is small, it should not be neglected. These findings are consistent with those of Hamad and colleagues who found a significantly higher major early postoperative complication rate together with prolonged hospital stay [34].

This study has several potential limitations. We were limited by the variables available in the data set. Therefore, even though multivariable regression analysis is able to adjust for the measured confounding variables, unmeasured confounding may still be possible. For example, some known risk factors for adverse outcomes are unmeasured in NIS, such as BMI. In addition, the clinical encounter in the NIS is limited to a single inpatient stay and, as such, does not capture complications after hospital discharge. The incidence of cholecystectomy after bariatric surgery is thus also unknown. The strengths of this analysis are the inclusion of a national cohort and a large sample size and, therefore, broad generalizability and the power to detect even small effects.

## Conclusions

In essence, the proportion of patients in the USA undergoing laparoscopic gastric bypass surgery with concomitant cholecystectomy has decreased significantly over time. Given the much higher rate of adverse short-term postoperative outcomes in patients undergoing concomitant cholecystectomy and laparoscopic gastric bypass surgery relative to those undergoing laparoscopic gastric bypass surgery alone, our findings suggest that concomitant cholecystectomy should only be indicated for patients with symptomatic gallbladder disease.

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## Appendix

**Table 5** Intraoperative and postoperative complications as well as reinterventions identified through ICD-9-CM codes

| | ICD-9-CM code |
|---|---|
| Intraoperative complication | |
| Injury to adjacent structures, accidental puncture or laceration complicating surgery | 998.2 |
| Retained foreign body | 998.4 |
| Hemorrhage complicating procedure | 998.11 |
| Bile duct complications | |
| Obstruction of bile duct (that with calculus is excluded here) | 576.2 |
| Perforation of bile duct | 576.3 |
| Fistula of bile duct | 576.4 |
| Unspecified disorder of biliary tract | 576.9 |
| Postoperative complications | |
| Mechanical wound complications | |
| Postoperative hematoma | 998.12 |
| Postoperative seroma (noninfected) | 998.13 |
| Disruption of operative wound | 998.3 |
| Disruption of wound unspecified | 998.30 |
| Disruption of internal operation (surgical) wound | 998.31 |
| Disruption of external operation (surgical) wound | 998.32 |
| Persistent postoperative fistula | 998.6 |
| Delayed wound healing | 998.83 |
| Infections | |
| Postoperative infection | 998.5 |
| Postoperative infected seroma | 998.51 |
| Postoperative skin abscess/infection | 998.59 |
| Postoperative septic wound complications | 998.59 |
| Postoperative intra-abdominal/subdiaphragmatic abscess | 998.59 |
| Urinary/renal complications | |
| Postoperative urinary retention | 997.5 |
| Postoperative urinary tract infection | 997.5 |
| Acute renal failure | 997.5 |
| Pulmonary complications | |
| Postoperative acute pneumothorax | 512.1 |
| Postoperative pulmonary edema | 518.4 |
| Adult respiratory distress syndrome following surgery | 518.5 |
| Transfusion-related acute lung injury | 518.7 |
| Postoperative atelectasis/pneumonia | 997.3 |
| Mendelson's syndrome resulting from a procedure | 997.3 |
| Gastrointestinal complications | |
| Postoperative vomiting | 564.3 |
| Diarrhea following gastrointestinal surgery | 564.4 |
| Postoperative small bowel obstruction/ileus (requiring nasogastric tube) | 997.4 |
| Complication of anastomosis of gastrointestinal tract | 997.4 |
| Cardiovascular complications | |
| Postoperative hypotension | 458.29 |
| Postoperative stroke | 997.02 |
| Cardiac arrest/insufficiency during or resulting from a procedure | 997.1 |
| Phlebitis or thrombophlebitis from procedure | 997.2 |
| Systemic complications | |
| Postoperative shock | 998.0 |
| Postoperative fever | 998.89 |
| Unspecified complication of procedure, not elsewhere classified | 998.9 |
| Blood transfusion | 99.04 |
| Reinterventions | |
| Exploratory laparotomy | 54.11 |
| Reopening of recent laparotomy site for control of hemorrhage, exploration, incision of hematoma | 54.12 |
| Drainage of intraperitoneal abscess or hematoma | 54.19 |
| Reclosure of postoperative disruption of abdominal wall | 54.61 |
| Percutaneous drainage of abdomen | 54.91 |
| Removal of foreign body from peritoneal cavity | 54.92 |

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