Impact of Gastric Bypass Operation on Survival: A Population-Based Analysis

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BACKGROUND: Bariatric procedures are increasingly performed but their impact on survival is unknown.

STUDY DESIGN: We evaluated short- and longterm mortality rates of patients undergoing gastric bypass on a population level compared with a nonoperated cohort of patients with morbid obesity in a retrospective study, using the Washington State Comprehensive Hospital Abstract Reporting System database and the Vital Statistics database. The study included all patients (age 18 to 65 years) from 1987 to 2001 who underwent gastric bypass with ICD-9 diagnostic codes for obesity. The comparator group included patients of similar age with a diagnosis of obesity or morbid obesity who did not have a bariatric procedure. Survival analysis was used to determine the association of surgeon experience on 30-day mortality and of the procedure on survival while controlling for age, gender, and comorbidity index.

RESULTS: Of the 66,109 obese patients we evaluated, 3,328 had a bariatric procedure. Incidence of the procedure increased from 0.7 to 10.6 per 100,000 from 1987 to 2001, with a 2.5-fold increase in incidence rate of the procedure in the years after 1996 (incidence rate ratio, 2.5; 95% CI, 2.4 to 2.7). Thirty-day mortality was 1.9% and was associated with surgical inexperience. Within the surgeon's first 19 procedures the odds of death within 30 days were 4.7 times higher (95% CI, 1.2 to 18.2) than at later points in a surgeon's case order. At 15 years followup, 16.3% of nonoperated patients had died as compared with 11.8% of patients who had the bariatric procedure. When survival was compared beginning 1 year after the procedure, the adjusted hazard for death was 33% lower than that of nonoperated patients (hazard ratio 0.67; 95% CI, 0.54 to 0.85).

CONCLUSIONS: Thirty-day mortality after gastric bypass is higher than previously reported and closely linked to surgeon inexperience. A modest overall survival benefit was associated with the procedure but a marked survival advantage was noted for patients who survive to the first postoperative year. (J Am Coll Surg 2004;199:543–551. © 2004 by the American College of Surgeons)

Millions of Americans are now considered morbidly obese[1] and the impact of obesity on life expectancy is dramatic.[2,3] Bariatric procedures remain the only consistent means to provide considerable, sustainable weight loss[4] and have become increasingly attractive because they can be performed laparoscopically. Gastric bypass has been shown to improve quality of life[5] and reduce severity and importance of several comorbid conditions.[6-16] Despite these salutary effects, to date no survival advantage has been documented with either intentional weight loss[17] or bariatric procedures.[18,19]

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In determining a survival benefit, rate of perioperative mortality must be balanced against changes in longterm outcomes. Although in several large clinical series[16,20,21] early postoperative mortality has been reported at < 0.5%, community-level risk of the procedure has yet to be established. There are also limited data about longterm survival after bariatric procedures compared with nonoperated patients. Only one population-based longitudinal study comparing weight loss operation with other weight loss techniques has been conducted. The Swedish Obesity Study[22] has been collecting data prospectively since the 1980s. Despite its initial goal of trying to demonstrate survival differences, it has yet to demonstrate a survival benefit with the procedure.[19]

We hypothesized that there is a survival advantage associated with gastric bypass and that younger patients have the greatest advantage. Based on previous studies linking an individual surgeon's experience with develop-

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ing surgical technology and adverse outcomes,[23] we also suspected that surgical inexperience with the procedure is associated with higher mortality rates. The purpose of this study was to address these hypotheses on a population level.

METHODS

Study design

A retrospective cohort study was conducted using a statewide hospital administrative discharge database to determine the effects of surgical treatment of obesity on survival.

Setting

Data were obtained from the Washington State Comprehensive Hospital Abstract Reporting System database. This dataset is derived from all public and private hospitals in Washington State (Veterans Affairs and US Military hospitals excluded). It contains demographic variables, admission and discharge administrative details, payor status, ICD-9 procedure and diagnosis codes, and coded surgeon and hospital identifiers. These data were linked to the Washington State vital records databases to determine death and cause of death. This study was granted an exemption by agreement of the University of Washington Human Subject Review Committee and the Washington State Department of Health.

Patient definition

The cohort was defined by searching all Washington State Comprehensive Hospital Abstract Reporting System reports (1987 to 2001) for ICD-9 procedure codes pertaining to gastric bypass in patients age 18–65 years. Bariatric procedures were defined using ICD-9 codes for gastric bypass in patients with ICD-9 diagnostic codes for morbid obesity (this code developed in 1995) or obesity (before 1995) and excluding patients who had any other gastrointestinal diagnosis (Appendix). A control group was identified as all patients hospitalized with a diagnosis of morbid obesity, excluding those with malignancy or HIV and those who died within that hospitalization. Yearly Washington State population estimates were obtained from the US census bureau.

Variable definition

To adjust for potential confounding, a modified Charlson comorbidity index[24] (0 to 3, with 3 indicating greatest comorbidity) was calculated for each patient based on ICD-9 diagnostic codes from previous and index hospitalizations. Laparoscopic era was considered to be 1997 to present after the first report of laparoscopic gastric bypass in 1996.[25] Surgeon experience was derived by calculating patient order beginning in 1987 for bariatric procedures. For all surgeons, quartiles of experience were determined and the lowest quartile of patient order (first 19 procedures) was used to describe less-experienced surgeons. In-hospital death was determined by use of the administrative code for status on discharge from the hospital. Thirty-day mortality (a patient who died within 30 days of hospital discharge) was derived from analysis of the Washington State vital records division for all patients.

Analysis

Population-based rates were calculated by dividing the number of operated patients by the Washington State yearly population. Poisson regression was used to determine if the rate of patients per year changed significantly based on year and era of procedure performance. Results from this analysis are reported as incidence rate ratios (IRRs). Adjusted IRR provides a summary value of the comparative incidence of gastric bypass between time periods while adjusting for changes over time in population composition. IRR is reported as relative increase per year and by era as appropriate.

A multivariable, nonparsimonious logistic regression model was constructed to evaluate the patient, provider, and hospital factors that influenced operative death and to address the hypothesis that surgical inexperience is associated with 30-day mortality rates. Patient variables included age group, gender, and Charlson score. Provider variables included quartiles of surgical experience, and hospital characteristics such as rural, for-profit, and teaching institution.

To estimate probability of death over time, Kaplan-Meier curves were constructed. Survival was evaluated for the entire cohort and then for groups of patients with and without bariatric procedure. Survival curves were plotted after adjustment for gender and comorbidity index using Cox regression and compared using the log-rank test. The hazard of survival (hazard ratio) for patients undergoing gastric bypass versus those with morbid obesity diagnosis only was also compared using univariable and multivariable Cox proportional hazard regression analyses. The median followup was 4.4 years, with 25% of patients followed for 8.1 years or more, the

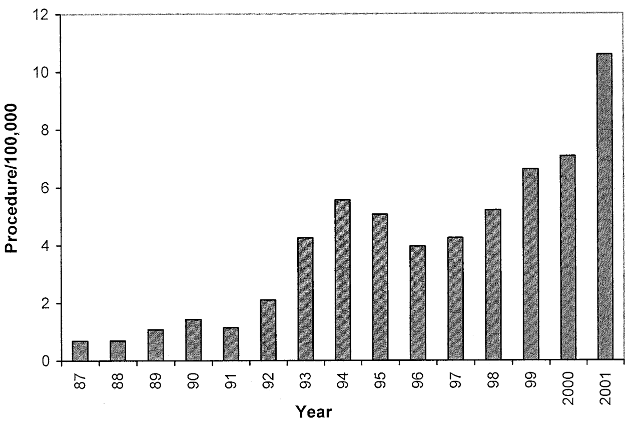


Figure 1. Population-based rate of gastric bypass procedures, by year.

longest followup time was 15.5 years. Survival time was measured as the time from initial hospitalization until death or August 15, 2002. The proportional hazards assumption was confirmed by inspection of Schoenfeld residuals and log-log plotting only for analyses that began 1 year after the procedure.

Because patients who did and did not have bariatric procedures might be different in ways other than those explicitly identified in this study, we controlled for their "propensity" to have gastric bypass and then repeated components of the analysis. To derive a propensity score we created a multivariable, nonparsimonious regression model with the outcomes variable being whether or not the patient underwent gastric bypass. The entire cohort (irrespective of whether a gastric bypass had been performed) was assigned a propensity score (0 to 1). A random sample of 5,000 propensity-matched patients was then evaluated using logistic regression to determine if gastric bypass was associated with increased 5-year survival. The outcome used for this analysis were 5-year mortality, and the primary predictor variable among this propensity score-matched cohort was if the patient had gastric bypass. The analysis was then repeated while controlling for the propensity score.

Statistical analysis was performed using STATA statistical analysis software (Stata Corp).

RESULTS

The records of 66,109 patients were evaluated, with 3,328 having an obesity procedure over the 15-year study period. Rate of procedure increased considerably over the study period (Fig. 1), with the most recent spike in frequency occurring in the late 1990s. Incidence of the procedure per 100,000 in the population increased steadily from 0.7 per 100,000 in 1987 to 10.6 per 100,000 in 2001. There was a 2.5-fold increase in the incidence rate of the procedure in the years after 1997 (the year laparoscopic gastric bypass was first reported) compared with the incidence rate before 1997 (IRR, 2.5; 95% CI, 2.4 to 2.7).

A comparison of characteristics of patients who did and did not have gastric bypass in this cohort (Table 1) indicates that patients undergoing operation were slightly younger and more commonly women. Although their overall comorbidity indices were similar between groups, operated patients had a higher rate of liver disease but a lower rate of diabetes and renal disease compared with the comparator group.

Survival after gastric bypass

In-hospital and 30-day mortality

A total 1.02% (n = 34) of operated patients died while in the hospital, but 30-day mortality was 1.9% (n = 64), indicating that close to half of all early deaths occurred after hospital discharge. Yearly rate of 30-day mortality did not significantly increase over time (IRR, 0.9; 95%

Table 1. Characteristics of Patients With and Without Bariatric Procedure

Characteristic	Morbid obesity diagnosis only (n = 62,781)	Morbid obesity diagnosis and bariatric procedure (n = 3,328)
Age* (y), mean ± SD	47.0 ± 6.2	43.1 ± 10.1
Women* (%)	64.3	80.5
Charlson comorbidity index, mean ± SD (scale 0–3, with 3 most severe)	0.52 ± 0.32	0.53 ± 0.41
Liver disease* (%)	0.5	1.1
Diabetes* (%)	19.9	13.1
Renal disease† (%)	1.4	0.6

*$p < 0.001$.
†$p = 0.006$ comparing those with and without the procedure.

Table 2. Association of Surgical Experience and 30-day Mortality, Adjusted and Unadjusted Using Multivariable Logistic Regression Model

Variable	Adjusted odds ratio* (95% CI)	Unadjusted odds ratio (95% CI)
Low volume (<20 procedures)	4.7 (1.2–18.2)	12.6 (6.7–23.0)
Male gender	2.3 (0.9–5.5)	5.2 (3.2–8.6)
Age	1.0 (0.9–1.1)	1.11 (1.1–1.1)
Charlson index†	1.9 (1.3–2.7)	3.4 (2.7–4.3)
Rural‡	2.6 (0.7–9.4)	4.1 (1.8–9.0)
Teaching§	0.4 (0.3–5.3)	1.4 (0.8–2.5)

*Each variable adjusted for all the others.
†For each increase in increment of Charlson comorbidity index.
‡Compared with urban/suburban hospitals.
§Compared with nonteaching hospitals.

CI, 0.9 to 1.0), with a rate of 3.3% in the prelaparoscopic era versus 1.8% in 1997 or later (p = 0.2). When considered in a multivariable logistic regression analysis, only surgical inexperience (first 19 procedures equivalent to the lowest quartile of surgical experience) and advanced Charlson comorbidity index were associated with increased 30-day mortality (Table 2). Of these variables, only surgeon experience is potentially modifiable. Within the surgeon's first 19 procedures the odds of patient death within 30 days of hospital discharge were 4.7 times higher than for procedures performed later in a surgeon's experience (95% CI, 1.2 to 18.2). The association between number of bariatric procedures performed by any given surgeon and predicted probability of 30-day mortality is demonstrated in Figure 2. Of the cases in which the patient died within 30 days of the procedure, 81% were among the surgeon's first 19 bariatric operations. Nineteen percent of surgeons in this dataset performed fewer than 20 procedures in total.

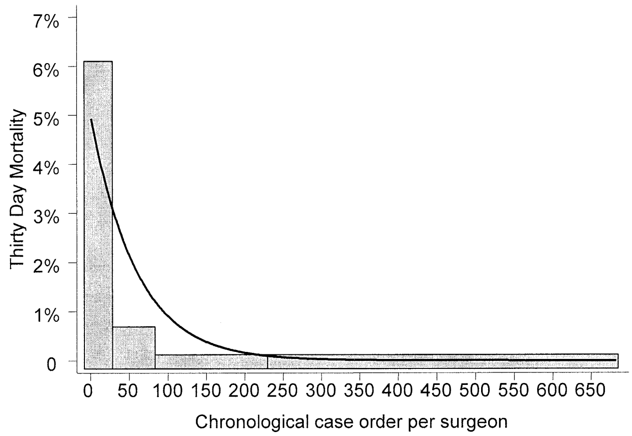
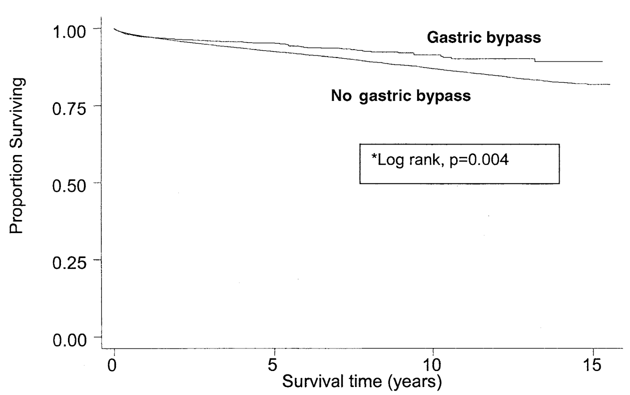


Figure 2. Surgeon experience and 30-day mortality after bariatric procedure. *Predicted probability of 30-day mortality derived using logistic regression model with outcomes 30-day mortality and predictor variable case order, $p < 0.001$. **Gray bars represent quartiles of surgical experience and actual rates of 30-day mortality: Quartile 1 = case order 1 to 19, 30-day mortality rate 6.2%, Quartile 2 = case order 20 to 85, 30-day mortality rate 0.73%, Quartile 3 = case order 86 to 220, 30-day mortality rate 0.37%, Quartile 4 = case order 221 to 650, 30-day mortality rate 0.34%.

Longterm survival

Ten-year survival after bariatric procedure was high (91.2%), and survival curves adjusted for gender and Charlson comorbidity index (Fig. 3) demonstrate significant comparative benefit in survival for operated patients (p = 0.004). At 15 years followup, 16.3% of nonoperated patients had died, compared with 11.8% of patients who had the bariatric procedure. Using Cox proportional hazards, when patient survival was compared starting at 1 year after hospitalization the hazard for death was significantly less for operated patients than for those who did not have the procedure (hazard ratio, 0.67; 95% CI, 0.54 to 0.85) after adjusting for age, gender, and comorbidity index. Among those patients less than 40 years of age, by 13.6 years followup (the longest common point of followup for operated and nonoperated patients under age 40) only 3% of those who had the bariatric procedure had died as compared with 13.8% of morbidly obese patients who did not have the procedure. The hazard for death in the under-40 age group adjusted for gender and comorbidity was 17% lower, but there were few deaths in this segment of the cohort and this estimated reduction in mortality risk was



Number of Subjects at Risk				
Year	0	5	10	15
No. procedures	66,109	28,482	11,132	1,131
Bariatric procedures	3,328	1,374	233	8

Figure 3. Survival after gastric bypass, adjusted for gender and Charlson comorbidity index, compared with no gastric bypass.

not statistically significant (hazard ration, 0.83; 95% CI 0.49 to 1.44).

Propensity score analysis

We evaluated the association between gastric bypass and 5-year survival in a randomly selected cohort of patients who were matched based on their propensity score (propensity for gastric bypass). Propensity score was a score from 0 to 1 that described the patient's propensity to have had the procedure based on available demographic and clinical variables. Among matched patients the unadjusted odds of surviving to 5 years after hospitalization were 19% greater for patients who had gastric bypass (odds ratio, 1.19; 95% CI, 1.11 to 1.27). When controlling for the propensity to have the procedure the adjusted odds of survival at 5 years were 59% higher (odds ratio, 1.59; 95% CI, 1.49 to 1.72) in the operated compared with the nonoperated group.

DISCUSSION

This study found that the population-level risk of dying within 30 days of gastric bypass was nearly 2%, a rate four times higher than reported in most published case series. Early mortality was directly linked to surgical inexperience with the procedure, and patients of less-experienced surgeons were nearly five times more likely to die within a month of the procedure than the patients of more-experienced surgeons. Overall, 10-year survival after the procedure was quite good (~91%), and 27% fewer patients in the surgical group had died after 15 years of followup. Once surgical patients survived to the first year the risk of dying during followup was 33% lower than nonoperated, morbidly obese patients.

For a procedure to provide a survival benefit the initial risk of death must be offset by improved longterm survival. For the growing number of patients undergoing bariatric procedure, neither of these outcomes has been effectively evaluated on a population level. Rather, our best estimates come from self-selected series;[26] technical trials performed by the most experienced surgeons;[21] and a single, nationwide study of experienced surgeons in Sweden (Swedish Obesity Subjects Study).[19,22] Given the growing popularity of the procedure, the introduction of advanced technology with variable training in the community, and the commercial interests involving bariatric operation, determining the actual rather than ideal outcomes is important. A recent study did attempt to address issues of short-term outcomes in a broader population. Pope and colleagues[27] calculated postbariatric procedure mortality using sampled administrative data and found a surprisingly low rate of in-hospital mortality (0.3%). Unfortunately, that study only evaluated procedures done before the laparoscopic approach was widespread and only in-hospital rates of death (rather than 30-day mortality) were used. Our study indicates that in-hospital mortality undercounts early mortality significantly. In Washington State almost half of the nearly 2% risk of early mortality occurred within the first month after discharge from the hospital.

Obesity usually represents a chronic disease state and much of its impact on end organs such as heart, kidney, and liver may have occurred by the time of operative intervention. The Swedish Obesity Subjects Study was designed to address the issue of survival improvement with operation but as yet has not reported on these outcomes. In addition to our study, a similar effect was identified in a nonrandomized case series of 232 patients undergoing gastric bypass compared with patients who refused the procedure. That study demonstrated a more than three-fold reduction in mortality rates among patients having the operation.[28] Part of the problem in identifying a survival benefit relates to the differential effect of the procedure on survival over time. Risk of dying is much higher within the time period right after the procedure than it is for any time in the cohort. For this reason, straightforward survival analytic tools cannot demonstrate an overall survival benefit because the proportional hazards assumption is not met. When considering patients who survived to the first year, a considerable survival advantage was demonstrated and this approach to survival analysis may appeal to stakeholders. We also expected that age of patient at the time of the procedure might have an impact on overall survival benefit of the procedure but failed to identify a marked benefit in younger patients. This may be because there were relatively few patients and fewer deaths in this group. Improvements in survival should also be considered in light of the dramatic improvements in quality of life demonstrated with bariatric procedures.[5] Our study did not address quality of life in the operated cohort.

The factor we found most associated with early mortality was surgeon inexperience. The "volume outcome" relationship on a surgeon level has been identified for many procedures[23,29] and is suggestive of a "practice makes perfect" paradigm for quality of care. Other important factors, such as nursing quality, presence of an intensivist, case-mix adjustment, and referral patterns, might have an important role in this association but have not been specifically addressed for bariatric procedures. The impact of surgeon inexperience on outcomes demonstrated in this study may be an important consideration in the decision-making processes of patients, providers, credentialing groups, and payors alike. A possible system-level modification to improve outcomes might be to better regulate credentialing of new bariatric procedures and to encourage proctoring during the early portion of the experience curve. The only other factors that have been associated with worsened short-term outcomes after bariatric operation are higher body mass index, male gender, and age.[30] Advancing age and male gender was associated with adverse outcomes in our study.

There are several limitations to our study. Because of a high degree of correlation between hospital and surgeon volume we could not determine if hospital factors were associated with 30-day mortality distinct from surgeon factors. Second, the comparator group was composed of hospitalized patients with the diagnostic code of morbid obesity. It is unclear how the baseline health of this population compares to patients having gastric bypass. Although the two groups had similar comorbidity indices and ages, operated patients were more likely women and had a different spectrum of comorbid illnesses. To improve the chance that the comparator group was as healthy if not healthier than the operated patients, we excluded patients in the comparator group who died during their hospitalization. Any comparison of 30-day mortality between operated and nonoperated patients is thereby biased, but we were more interested in comparing longterm survival in these populations. Given that the identified 30-day postoperative mortality rate was higher than previously reported, the longterm survival advantage identified with gastric bypass may in fact be a conservative estimate. Further evaluations using a nationwide cohort to address the same issue should be performed. Finally, propensity score analysis was performed to adjust for measured and unmeasured confounders that might distinguish patients who did and did not undergo bariatric procedures. Using this form of analysis we found that there were salutary effects of gastric bypass on longterm survival. These effects were noted (and actually augmented) once controlling for propensity score. Other limitations are that case-order as used in this study is a proxy for surgeon experience generated by cases started after 1987 rather than a true reflection of surgical case-order. Surgeons with experience before 1987 and those who migrated into the state with experience would be considered less experienced in this analysis then they really were. Given that we found a clear relationship between surgeon experience and outcomes, this classification bias would only act to diminish such an effect and might be considered a conservative bias. Coding inaccuracy is problematic for bariatric procedures because there is no unique ICD-9 code to describe all variations of this procedure. Rather, we used the ICD-9 codes commonly applied to gastric bypass and limited the population to those with morbid obesity and those without diagnostic codes that might be associated with other reasons for having the procedure. We did perform a validity check on these data with an internal database of procedures and found it to be highly concurrent though not perfect. Finally, we were unable to control for degree of obesity in the two populations and comorbidity adjustment does not adequately deal with differences in comorbid disease severity.

In conclusion, this first-ever population-based analysis of the impact of gastric bypass on longterm survival indicates rapid growth of the operation over the last decade, with fairly stable rates of early mortality. We found that rate of early mortality was at least four times higher than previously reported, but that experienced surgeons had a much lower rate of adverse outcomes. This study demonstrates that when considering these early deaths there was a modest overall survival benefit for patients having the procedure but a marked survival advantage for patients who survive to the first postoperative year. Survival advantage was quite significant (one-third less likely to die in the followup period) and may be a consideration for clinicians, patients, and payors when making decisions about bariatric procedures. Higher rates of early mortality among less-experienced surgeons may be considered an opportunity for system-level quality improvement. This too may have an impact on the survival advantage identified with bariatric procedures.

Appendix

Codes used for inclusion

44.31 high gastric bypass

or

44.39 other gastroenterostomy bypass, gastrojejunostomy without gastrectomy NOS

AND

Any ICD-9 codes for obesity

278.0 Obesity
278.00 Obesity, NOS
278.01 Morbid obesity
Excluding any following ICD-9 codes
Gastrointestinal disorders
531 Gastric ulcer
531.0 Acute with hemorrhage
531.1 Acute with perforation
531.2 Acute with hemorrhage and perforation
531.3 Acute without mention of hemorrhage or perforation
531.4 Chronic or unspecified with hemorrhage
531.5 Chronic or unspecified with perforation
531.6 Chronic or unspecified with hemorrhage and perforation
531.7 Chronic without mention of hemorrhage or perforation
531.9 Unspecified as acute or chronic, without mention of hemorrhage or perforation
532 Duodenal ulcer
532.0 Acute with hemorrhage
532.1 Acute with perforation
532.2 Acute with hemorrhage and perforation
532.3 Acute without mention of hemorrhage or perforation
532.4 Chronic or unspecified with hemorrhage
532.5 Chronic or unspecified with perforation
532.6 Chronic or unspecified with hemorrhage and perforation
532.7 Chronic without mention of hemorrhage or perforation
532.9 Unspecified as acute or chronic, without mention of hemorrhage or perforation
533 Peptic ulcer, site unspecified
533.0 Acute with hemorrhage
533.1 Acute with perforation
533.2 Acute with hemorrhage and perforation
533.3 Acute without mention of hemorrhage and perforation
533.4 Chronic or unspecified with hemorrhage
533.5 Chronic or unspecified with perforation
533.6 Chronic or unspecified with hemorrhage and perforation
533.7 Chronic without mention of hemorrhage or perforation
533.9 Unspecified as acute or chronic, without mention of hemorrhage or perforation
534 Gastrojejunal ulcer
534.0 Acute with hemorrhage
534.1 Acute with perforation
534.2 Acute with hemorrhage and perforation
534.3 Acute without mention of hemorrhage or perforation
534.4 Chronic or unspecified with hemorrhage
534.5 Chronic or unspecified with perforation
534.6 Chronic or unspecified with hemorrhage or perforation
534.7 Chronic without mention of hemorrhage or perforation
534.9 Unspecified as acute or chronic, without mention of hemorrhage or perforation
535 Gastritis and duodenitis
535.0 Acute gastritis
535.1 Atrophic gastritis
535.2 Gastric mucosal hypertrophy
535.3 Alcoholic gastritis
535.4 Other specified gastritis
535.5 Unspecified gastritis and gastroduodenitis
535.6 Duodenitis
536 Disorders of function of stomach
536.0 Achlorhydria
536.1 Acute dilation of stomach
536.2 Persistent vomiting
536.3 Gastroparesis
536.4 Gastrostomy complications
536.40 Gastrostomy complications, unspecified
536.41 Infection of gastrostomy
536.42 Mechanical complication of gastrostomy
536.49 Other gastrostomy complications
536.8 Dyspepsia and other specified disorder of function of stomach
536.9 Unspecified functional disorder of stomach
537 Other disorders of the stomach and duodenum
537.0 Acquired hypertrophic pyloric stenosis

537.1	Gastric diverticulum
537.2	Chronic duodenal ileus
537.3	Other obstruction of duodenum
537.4	Fistula of stomach or duodenum
537.5	Gastroptosis
537.6	Hourglass stricture or stenosis of stomach
537.8	Other specified disorders of stomach and duodenum
537.81	Pylorospasm
537.82	Angiodysplasia of stomach and duodenum without mention of hemorrhage
537.83	Angiodysplasia of stomach and duodenum with hemorrhage
537.84	Dieulafoy lesion (hemorrhagic) of stomach and duodenum
537.89	Other
537.9	Unspecified disorder of stomach and duodenum
Malignancy	
150	Malignant neoplasm of esophagus
150.0	Cervical esophagus
150.1	Thoracic esophagus
150.2	Abdominal esophagus
150.3	Upper third of esophagus
150.4	Middle third of esophagus
150.5	Lower third of esophagus
150.8	Other specified part
150.9	Esophagus unspecified
151	Malignant neoplasm of stomach
151.0	Cardia
151.1	Pylorus
151.2	Pyloric antrum
151.3	Fundus of stomach
151.4	Body of stomach
151.5	Lesser curvature, unspecified
151.6	Greater curvature, unspecified
151.8	Other specified sites of stomach
151.9	Stomach, unspecified
152	Malignant neoplasm of small intestine, including duodenum
152.0	Duodenum
152.1	Jejunum
152.2	Ileum
152.3	Meckel's diverticulum
152.8	Other specified sites of small intestine
152.9	Small intestine, unspecified
153	Malignant neoplasm of colon
153.0	Hepatic flexure
153.1	Transverse colon
153.2	Descending colon
153.3	Sigmoid colon
153.4	Cecum
153.5	Appendix
153.6	Ascending colon
153.7	Splenic flexure
153.8	Other specified sites of large intestine
153.9	Colon, unspecified
154	Malignant neoplasm of rectum, rectosigmoid junction, and anus
154.0	Rectosigmoid junction
154.1	Rectum
154.2	Anal canal
154.3	Anus, unspecified
154.8	Other
155	Malignant neoplasm of liver and intrahepatic bile ducts
155.0	Liver, primary
155.1	Intrahepatic bile ducts
155.2	Liver, not specified as primary or secondary
156	Malignant neoplasm of gallbladder and extrahepatic bile ducts
156.0	Gallbladder
156.1	Extrahepatic bile ducts
156.2	Ampulla of Vater
156.8	Other specified sites of gallbladder and extrahepatic bile ducts
156.9	Biliary tract, part unspecified
157	Malignant neoplasm of pancreas
157.0	Head of pancreas
157.1	Body of pancreas
157.2	Tail of pancreas
157.3	Pancreatic duct
157.4	Islets of Langerhans
157.8	Other specified sites of pancreas
157.9	Pancreas, part unspecified

158	Malignant neoplasm of retroperitoneum and peritoneum
158.0	Retroperitoneum
158.8	Specified parts of peritoneum
158.9	Peritoneum, unspecified
159	Malignant neoplasm of other and ill-defined sites within the digestive organs and peritoneum
159.0	Intestinal tract, part unspecified
159.1	Spleen, not elsewhere classified
159.8	Other sites of digestive system and intraabdominal organs
159.9	Ill-defined

Author Contributions

Study conception and design: Flum, Dellinger

Acquisition of data: Flum

Analysis and interpretation of data: Flum, Dellinger

Drafting of manuscript: Flum, Dellinger

Critical revision: Flum, Dellinger

Statistical expertise: Flum

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