Thirty- and 90-Day Morbidity and Mortality by Clavien-Dindo after Surgery for Antireflux and Hiatal Hernia

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BACKGROUND: The historic morbidity and mortality rates of antireflux and hiatal hernia operation are reported as 3% to 21% and 0.2% to 0.5%, respectively. These data come from either large national and population level or small institutional studies, with the former focusing on broad 30-day outcomes while lacking granular data on complications and their severity. Institutional studies tend to focus on long-term and quality-of-life outcomes. Our objective is to describe and evaluate the incidence of 30- and 90-day morbidity and mortality in a large, single-institution dataset.

STUDY DESIGN: We retrospectively reviewed 2,342 cases of antireflux and hiatal hernia operation from 2003 to 2020 for intraoperative complications causing postoperative sequelae, as well as morbidity and mortality within 90 days. All complications were graded using the Clavien-Dindo (CD) grading system. The highest grade of complication was used per patient during 30- and 31- to 90-day intervals.

RESULTS: Of 2,342 patients, the overall 30-day morbidity and mortality rates were 18.2% (427 of 2,342) and 0.2% (4 of 2,342), respectively. Most of the complications were CD less than 3a at 13.1% (306 of 2,342). In the 31- to 90-day postoperative period, morbidity and mortality rates decreased to 3.1% (78 of 2,338) and 0.09% (2 of 2,338). CD less than 3a complications accounted for 1.9% (42 of 2,338).

CONCLUSIONS: Antireflux and hiatal hernia operations are safe with rare mortality and modest rates of morbidity. However, the majority of complications patients experience are minor (CD less than 3a) and are easily managed. A minority of patients will experience major complications (CD 3a or greater) that require additional procedures and management to secure a safe outcome. These data are helpful to inform patients of the risks of operation and guide physicians for optimal consent. (J Am Coll Surg 2024;239:323–332. © 2024 by the American College of Surgeons. Published by Wolters Kluwer Health, Inc. All rights reserved.)

GERD is a common medical problem that exists on a spectrum from nonerosive reflux disease to erosive with complications such as strictures and Barrett's esophagus.[1] Closely aligned with this is the presence of a hiatal hernia that also exists on a spectrum and with increasing incidence as one ages. Initial management consists of lifestyle and dietary changes with the addition of proton pump inhibitors. Additionally, hiatal hernias, in particular larger hernias, may also present with a reasonable frequency of non-GERD symptoms that may not respond to traditional therapies.[2] As a result of incomplete symptom resolution, many patients have considered surgical management, but

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Abbreviations and Acronyms

ARS	=	antireflux surgery
ASA	=	American Society of Anesthesiologists
CD	=	Clavien-Dindo
EGD	=	esophagogastroduodenoscopy
HHR	=	hiatal hernia repair
IQR	=	interquartile range
OR	=	odds ratio
UTI	=	urinary tract infection

despite multiple published studies displaying comparable or even improved outcomes, surgery is completed in <1% of these patients for a multitude of reasons.

One of the concerns cited surrounding surgical treatment is the risk and degree of postoperative complications, and this may be a deterrent when considering antireflux surgery (ARS) and hiatal hernia repair (HHR) operations.[3-13] ARS and HHR operations are common and have evolved over time with the majority being performed minimally invasively. Previous studies have reported morbidity and mortality rates ranging from 3% to 21% and 0.2% to 0.5%, respectively.[3,4,8,10,11,13-26] However, these data either come from large national- and population-based studies, which typically report complications in broad, overarching categories such as "pulmonary complications" or "infectious complications" with little granular detail,[3,4,8,10,13,14,16-20,22] or institutional studies that report complications but often list them as major or minor without characterization of severity.[11,12,23,24] Both granular detail and an understanding of severity are important to counsel patients and educate referring physicians about the true risks of these operations. We aim to describe and grade 30- and 31- to 90-day morbidity and mortality using the Clavien-Dindo (CD) grading system[27,28] and determine potential risk factors for these complications that can inform both surgeons and patients about the risks of these operations.

METHODS

Study design and setting

We performed a retrospective review of a prospectively maintained esophageal surgery database from January 1, 2003, to December 31, 2020, identifying all patients who underwent ARS or HHR operations. Consecutive cases of both ARS and HHR were included because they exist on a spectrum of disease severity. The complications in the database were correlated with review of the patient's electronic medical record. Each case was reviewed for intraoperative complications causing postoperative sequelae and morbidity and mortality within 30 and 90 days. All patients undergoing ARS or HHR with at least 90-day follow-up were included. Patients were excluded if the operation was performed for a primary reason other than GERD or a symptomatic hiatal hernia. Magnetic sphincter augmentation and bariatric operations were excluded. This study was approved by the Swedish or Providence Health System IRB, and individual patient consent was waived given the minimal risk nature of the research (IRB #2019000479).

Charts were reviewed for demographics, including criteria for the Charlson Comorbidity Index. Steroid use was defined as 5 mg or more of prednisone, or equivalent for at least 2 weeks preoperatively, up until the operation. A history of previous foregut operations included any ARS, HHR, bariatric surgery, or another operation of the esophagogastric junction. Concurrent operations were defined as additional operations not considered part of the standard ARS or HHR, such as cholecystectomy, incisional hernia repair, pyloromyotomy, lap band or magnetic sphincter augmentation removal, and gastrointestinal stromal tumor resection. Cases were considered urgent or emergent if admitted via the emergency room and operated on the same day of admission.

Morbidity and mortality were graded using the CD grading system,[28,29] with the highest grade of complication being used per patient during postoperative 0- to 30- and 31- to 90-day intervals. Intraoperative complications, such as enterotomies, gastrotomies, and bleeding, were captured; however, these were not counted in the analysis unless leading to a postoperative sequela. The highest CD graded postoperative complication related to the intraoperative complication was captured. Per the CD grading system, CD grade 1 complications include any divergence from the standard postoperative course not requiring pharmacologic, surgical, endoscopic, or radiological interventions. However, the use of antiemetics, antipyretics, analgesics, diuretics, and electrolytes is acceptable in CD grade 1. The need for straight catheterization, placement of a Foley catheter, and nasogastric tubes at bedside were included in CD grade 1 complications. CD grade 2 morbidities required pharmacologic treatment other than those allowed for CD grade 1,

as well as blood transfusions and total parenteral nutrition. CD grade 3a included the need for surgical, endoscopic, and radiologic interventions not requiring general anesthesia. Those interventions or procedures requiring general anesthesia were CD grade 3b. Enteral feeding access, such as endoscopically placed nasogastric tube, postpyloric feeding tubes, and gastrostomy tubes, was counted as CD grade 3a, except when requiring general anesthesia. CD grade 4 morbidities were life-threatening complications requiring intensive care management with CD grade 4a involving single-organ dysfunction and 4b multiorgan dysfunction. Mortalities were categorized as CD grade 5. CD grade 3a or greater were considered to be major complications.

Patients needing IV hydration due to poor oral intake—either inpatient or outpatient—were categorized as "poor PO intake," under CD 1. Traditional definitions of early and late dumping syndrome were used and counted as a complication if confirmed by the attending surgeon.[29] Pneumonia was counted if patients had clinical and radiographic diagnosis and treated with antibiotics. The diagnosis of superficial site infections was based on clinical diagnosis with signs or symptoms ranging from induration only to any or all of erythema, warmth, pain, tenderness, or edema with local wound care and antibiotics. Postoperative dysphagia was recorded if additional medical, endoscopic, or surgical treatment was needed.

Statistical analyses and modeling were performed using R version 2023.06.0 + 421 (Vienna, Austria). Continuous data were reported as medians with interquartile ranges (IQRs). Discrete data were reported as numbers and percentages. Univariable analysis was performed for complications occurring in the first 30 and 31 to 90 days postoperatively. Multivariable logistic regression analysis was performed for complications occurring within 30 days postoperative. The small numbers in the 31- to 90-day period prevented multivariable regression. A significance level (α) of 0.05 was used for all analyses.

RESULTS

A total of 2,342 operations were performed. Patients were mostly women (1,511 of 2,342, 64.5%) with a median age of 60 years (IQR 50 to 69 years) and a median BMI of 29 kg/m^2 (IQR 25.95 to 32.32 kg/m^2). Patients were generally healthy with a Charlson Comorbidity Index of 2 (IQR 1 to 3) and an American Society of Anesthesiologists (ASA) score of 1 or 2 in 1,593 (68.0%) of 2,342 patients. Most were nonsmokers and few used chronic steroids. Erosive esophagitis of any grade was seen in 941 (40.2%) of 2,342, and Barrett's esophagus was demonstrated in 563 (24%) of 2,343 (Table 1).

Most operations were elective (2,286 of 2,343, 97.6%) and primary repairs (2,024 of 2,342, 86.4%). More operations were performed for reflux as the primary indication (1,460 of 2,342, 62.3%) when compared with hiatal hernias (882 of 2,342, 37.7%). Laparoscopy was the predominant surgical approach in 2,255 (96.3%) of 2,342 patients. Nissen fundoplication was most common, accounting for 1,067 (45.6%) of 2,342 cases. The next

Table 1. Patient Characteristics (N = 2,342)

Demographic	Data
Sex, n (%)	
Male	831 (35.5)
Female	1,511 (64.5)
Age, y, median (IQR)	60 (50–69)
BMI, kg/m^2, median (IQR)	29.03 (25.95–32.32)
Charlson Comorbidity Index, median (IQR)	2 (1–3)
Smoking, n (%)	
Never	1,424 (60.8)
Ever	918 (39.2)
Steroid use, n (%)	
Yes	92 (3.9)
No	2,250 (96.1)
Anticoagulation use, n (%)	
Yes	110 (4.7)
No	2,232 (95.3)
Esophagitis, n (%)	
None	1,401 (59.8)
A/B	662 (28.3)
C/D	279 (11.9)
Barrett's esophagus, n (%)	
Yes	563 (24.0)
No	1,779 (76)
Hernia size, cm, median (IQR)	4 (2–6)
None, n (%)	204 (8.7)
<3, n (%)	581 (24.8)
3–6, n (%)	983 (42.0)
>6, n (%)	510 (21.8)
No data	64 (2.7)
Hernia type, n (%)	
None	204 (8.7)
Sliding	1,183 (50.5)
Paraesophageal	950 (40.6)
No data	17 (0.7)
American Society of Anesthesiologists class, n (%)	
Class 1	137 (5.8)
Class 2	1,456 (62.2)
Class 3	739 (31.6)
Class 4	10 (0.4)

IQR, interquartile range.

most common approach was Nissen-Hill hybrid (775 of 2,342, 33.0%) and partial fundoplication (309 of 2,342, 13.2%). A total of 169 (7.2%) of 2,342 patients underwent Collis gastroplasty. Biologic mesh reinforcement of the hiatus was used in 338 (14.4%) of 2,342 cases, and 176 (7.5%) of 2,342 patients required a diaphragmatic relaxing incision. Only 240 (10.2%) of 2,342 cases had a concurrent operation performed (Table 2).

There were 144 of 2,342 reported intraoperative complications, but only 36 (25.0%) of 144 led to postoperative sequela. The most common intraoperative complication associated with further postoperative consequences was an incidental enterotomy, with 17 (47.2%) of 36 gastrotomies and 8 (22.2%) of 36 esophageal enterotomies. Additional intraoperative complications included 4 (11.1%) of 36 instances of significant intraoperative blood loss of more than 500 mL, 3 (8.3%) of 36 small bowel injuries, 2 (5.6%) of 36 splenic injuries, 1 (2.8%) of 36 pleurotomies requiring intervention, and 1 (2.8%) of 36 vagal nerve injuries.

Table 2. Surgical Characteristics (N = 2,342)

Variable	Data
Urgency	
Elective	2,286 (97.6)
Urgent/emergent	56 (2.4)
Primary vs redo	
Primary	2,024 (86.4)
Redo	318 (13.6)
Operation type	
Nissen	1,067 (45.6)
Partial fundoplication (Toupet, Dor)	309 (13.2)
Hill repair	166 (7.1)
Nissen-Hill hybrid	775 (33.0)
Gastropexy	22 (1.0)
Belsey fundoplication	3 (0.1)
Concurrent operation	
Yes	240 (10.2)
No	2,102 (89.8)
Approach	
Laparoscopic	2,255 (96.3)
Open	18 (0.8)
Laparoscopic converted to open	8 (0.3)
Transthoracic	16 (0.7)
Robotic	45 (1.9)
Collis	
Yes	169 (7.2)
No	2,173 (92.8)
Mesh	
Yes	337 (14.4)
No	2,005 (85.6)
Relaxing incision	
Yes	175 (7.5)
No	2,167 (92.5)

Data presented as n (%).

The overall 90-day mortality rate was 0.26% (6 of 2,342) with 4 deaths occurring within 30 days. The mortalities in the first 30 days included a 78-year-old woman undergoing primary elective laparoscopic Toupet complicated by a pancreatic leak and multisystem organ failure; a 69-year-old woman undergoing an elective redo laparoscopic Nissen fundoplication complicated by ARDS and pulmonary failure; a 72-year-old man undergoing a primary elective laparoscopic Nissen-Hill hybrid repair complicated by gastric fundic ischemia, pancreatitis, and multisystem organ failure; and a 66-year-old woman undergoing an elective transthoracic Belsey after failure of 2 previous Nissen fundoplications, complicated by an ischemic event resulting in gastric, small bowel, and colonic necrosis and septic shock. Between 31 and 90 days, there were 2 additional deaths. One occurred in a 73-year-old woman with underlying cryptogenic pneumonia who underwent an urgent redo laparoscopic Nissen fundoplication and died from aspiration pneumonia and acute on chronic respiratory failure. The other occurred in a 43-year-old man undergoing a primary elective laparoscopic Nissen, for which the cause of death is unknown.

A total of 427 (18.2%) of 2,342 complications occurred in the first 30-day period. Of these, complications occurred in 217 (14.9%) of 1,460 patients with GERD compared with 210 (23.8%) of 882 patients with hiatal hernia. Patients undergoing primary repair experienced complications in 346 (17.1%) of 2,024 compared with 81 (25.5%) of 318 revisional repairs. Of 427, 306 (71.7%) complications were considered minor (CD less than 3a). Comparatively, major complications occurred in 121 of 427 patients (28.3%) in the first 30 days. In the 31- to 90-day postoperative period, 71 additional complications occurred in 3.1% of 2,338 patients, with minor and major complications being 43 (60.6%) of 71 and 28 (39.4%) of 71, respectively. Readmissions within 90 days accounted for 125 (5.3%) of 2,338 cases.

Grade 1 complications at 30 days occurred in 208 (8.9%) of 2,342 patients, with urinary retention and poor PO intake occurring most frequently. An additional 37 (1.6%) of 2,338 complications occurred by 90 days, with dumping syndrome most common. Within the first 30 days postoperative, grade 2 complications occurred in 98 (4.2%) of 2,342 patients. Superficial surgical site infections were most common, occurring in 24 (24.5%) of 98 patients. A total of 6 (0.3%) of 2,338 grade 2 complications occurred in the subsequent 31 to 90 days (Tables 3, 4).

Table 3. Thirty-Day Clavien-Dindo Graded Complications

Grade, complication	Data (N = 2,342)
1, N = 208 (8.9)	
Urinary retention	140 (67.3)
Poor PO intake/nausea	34 (16.3)
Dumping syndrome	12 (5.8)
Fluid-overload requiring diuretic	10 (4.8)
Nasal gastric tube placement	7 (3.4)
Other	5 (2.4)
2, N = 98 (4.2)	
Superficial surgical site infection	24 (24.5)
Urinary tract infection	21 (21.4)
Pneumonia	15 (15.3)
Total parenteral nutrition	14 (14.2)
New onset atrial fibrillation	13 (13.3)
Deep vein thrombosis or pulmonary embolism	7 (7.1)
Blood transfusion	4 (4.1)
3a, N = 59 (2.5)	
Thoracentesis or tube thoracostomy	32 (54.2)
Esophagogastroduodenoscopy ± dilation	18 (30.5)
Enteral feeding access	6 (10.2)
3b, N = 39 (1.7)	
Takeback to operating room	38 (97.4)
Hiatal obstruction and revision of fundoplication	21 (55.3)
Esophageal leak, gastric leak, perforation	9 (23.7)
Chyle leak or thoracic duct ligation	3 (7.9)
Early hernia recurrence	3 (7.9)
Incarcerated incisional hernia	2 (5.3)
Unplanned splenectomy	1 (2.6)
4a, N = 12 (0.5)	
Respiratory failure	9 (75.0)
Septic shock	2 (16.7)
Renal failure	1 (8.3)
4b, N = 7 (0.3)	—

Data presented as n (%).

Table 4. Thirty-One to 90-Day Clavien-Dindo Complications

Grade, complication	Data (N = 2,338)
1, N = 37 (1.6)	
Dumping syndrome	24 (64.9)
Poor PO intake	11 (29.7)
Small bowel obstruction conservative management	2 (5.4)
2, N = 6 (0.3)	
Total parenteral nutrition	4 (66.7)
Chyle leak	2 (33.3)
3a, N = 21 (0.9)	
Esophagogastroduodenoscopy ± dilation	17 (81.0)
Thoracentesis	2 (9.5)
Enteral feeding access	2 (9.5)
3b, N = 5 (0.2)	
Takeback to operating room	5 (100.0)
Abdominal abscess washout	2 (40.0)
Lung herniation	1 (20.0)
Esophageal, gastric leak, perforation	1 (20.0)
Small bowel obstruction	1 (20.0)
4a, N = 2 (0.1)	
Respiratory failure	2 (100.0)
4b, N = 0 (0)	

Data presented as n (%).

For the first 30 days, 59 (2.5%) of 2,342 patients suffered a grade 3a complication. The need for a thoracentesis or tube thoracostomy accounted for 32 (54.2%) of 59 of these complications. A total of 21 (0.9%) of 2,338 patients suffered grade 3a complications that occurred within 90 days, with esophagogastroduodenoscopy (EGD) ± dilation being the most common. There were 39 (1.7%) of 2,342 patients who suffered CD 3b complications in the first 30 days with takeback to the operating room accounting for 38 (97.4%) of 39 operations. Hiatal obstruction and fundoplication revision made up 21 of 38 operations (55.2%), followed by 9 (23.7%) of 38 operations for esophageal or gastric leak or perforation, 3 (7.9%) of 38 chyle leaks requiring operative thoracic duct ligation, 3 (7.9%) of 38 acute reherniations, and 2 (5.3%) of 38 acute incarcerated incisional hernias. The remaining 3b complication was an unplanned splenectomy. There were fewer grade 3b complications in the next 31 to 90 days, with only 5 (0.2%) of 2,338 patients returning to the operating room. There were 2 (40.0%) of 5 patients who underwent surgery for abdominal washout or intra-abdominal abscess drainage. The remaining complications included 1 (20.0%) of 5 patients with a delayed presentation of a gastric leak, 1 (20.0%) of 5 patients who underwent surgery for a small bowel obstruction, and 1 (20.0%) of 5 patients who underwent surgery for lung herniation after a transthoracic Belsey (Tables 3, 4).

Grade 4a and 4b complications were rare with 12 (0.5%) of 2,342 and 7 (0.3%) of 2,342 occurring respectively at 30 days and only 2 (0.09%) of 2,338 additional 4a complications by 90 days (Tables 3, 4). The majority of 4a complications in the first 30 days were respiratory failure requiring reintubation, with 9 (75%) of 12 patients in total. In the first 30 days postoperative, the remaining single-organ system failure included 2 (16.7%) of 12 patients with septic shock and 1 (8.3%) of 12 patients with acute renal failure requiring new dialysis. From 31 to 90 days postoperative, there were only 2 (0.09%) 4a complications—both of which were respiratory failure. Grade

4b complications occurred only during the first 30 days, with the most common combination of multiorgan failure being pulmonary failure with sepsis (Tables 3, 4).

Univariable analysis of risk factors for any complication within the first 30 days identified increasing ASA score, open surgical approach, redo operation, partial fundoplication, increasing hernia size, and increasing age. After multivariable analysis, laparoscopic converted to open was the highest risk factor for complication (odds ratio [OR] 10.81) followed by increasing ASA status (OR 6.87), open approach (OR 2.77), redo operations (OR 1.75), partial fundoplication (OR 1.5), increasing hernia size (OR 1.05), and increasing age (OR 1.01, Table 5). For major complications (CD 3a or greater) within the first 30 days, the risk factors were similar to those found to be risk factors for any complication (Table 6).

DISCUSSION

The primary findings in this analysis confirm the safety of ARS and HHR operations with an extremely low mortality rate and a modest overall morbidity rate at 30 days for which the majority were minor complications managed with medical therapy. A small rate of mortality and morbidity were also identified out to 90 days. We identified laparoscopic converted to open as the highest risk factor for complications within the first 30 days. An increasing ASA score, open surgical approach, partial fundoplication, redo operations, increasing hernia size, and increasing age are also key risk factors determining the risk for any and major complications.

The overall mortality rate of 0.26% is like those reported in 2 studies using the American College of Surgeons NSQIP database that reported a mortality of rate of 0.43% from 2005 to 2007[22] and 0.19% from 2005 to 2009.[3] Both studies had slightly different patient populations compared with this study. Similarly, the Nationwide Inpatient Sample from 2005 to 2010[20] reported a 30-day mortality rate of 0.21%. At the upper end, a mortality rate of 0.8% was reported from 1992 to 1997 using the Nationwide Inpatient Sample-Healthcare Cost and Utilization Project and the Washington State Comprehensive Hospital Abstract Reporting System[19]; whereas a rate of 0.03% was reported at the lower end using the Sweden's Patient Registry.[10] Comparatively, a multicenter review of 2,453 patients undergoing laparoscopic Nissen fundoplication reported a mortality rate of 0.2%.[26] Rarely was 90-day mortality reported though a rate of 0.08% was reported from the Sweden's Patient Registry. The similarities of these results confirm the safety of ARS and HHR surgery that has been achieved.

The rates of postoperative morbidity vary considerably and are dependent on how the researchers or database defined morbidity and more specifically serious morbidity. One large database series reported a rate of overall morbidity of 3.8% from the NSQIP database that included a predefined list of serious complications plus urinary tract infection (UTI), deep vein thrombosis, unplanned intubation, pneumonia, and surgical site infection.[3] An older single-institution study of laparoscopic Nissen fundoplication[25] reported intraoperative and hospital morbidity of 7.5% and also an additional 19 (9.6%) morbidities within 35 days that ranged from minor complications (CD 1), such as UTIs, to major (CD 3a and 3b), such as EGD with dilation and reoperations. Comparatively, an older multicentered review of published articles[26] included 2,453 patients undergoing laparoscopic Nissen fundoplication with overall morbidity around 10% of which postoperative complications accounted for 4.4% and another 5% occurred within the 30 days after surgery and included EGD for dilation and reoperative surgery. The current study using the CD grading of complications puts the postoperative morbidity rate of 18% in an easier to understand format with 13.1% being minor (CD 1 and 2), 2.5% (CD 3a) requiring a minor procedure, such as EGD or thoracentesis, 1.7% requiring a return to the operating room, and single or multisystem failure only 0.8%.

Because postoperative complications can be related to a patient's comorbidities, risk of anesthesia, and the procedure itself, the rate is likely higher in institutional series that have granular data but also capture other events that may not be part of the database. For example, the rate of UTIs in the NSQIP database is 1.1%[3] which is similar to this study at 0.9% but we recorded additional morbidity with urinary retention at 6.0% because patients needed catheterization. Similarly, pulmonary complications are 1.3% in the NSQIP database that includes ventilation more than 48 hours and constitutes a major complication, whereas this study reports pneumonia (0.6%), reintubation (0.4%), and thoracentesis or chest tube placement for effusions (1.4%) for a higher rate of pulmonary complications but a lower rate of severe complications because only reintubation is considered severe (CD more than 3b).

Serious morbidity or major complications are key focus and, in truth, what most patients and referring physicians are concerned about. Although the incidence of serious complication or CD 3b or greater are similar, most large database studies are lacking on the details. In HHR and ARS, return to the operating room (CD 3b) rates are similar to the NSQIP database,[3] but most commonly these are for hiatal obstruction with a need to revise the hiatal repair and fundoplication. Less commonly, it is for

Table 5. Univariable and Multivariable Logistic Regression Analysis

	Any complication up to 30 d postoperative					
	Univariable			Multivariable		
Variable	**OR**	**95% CI**	**p Value**	**Adjusted OR**	**95% CI**	**p Value**
Age	1.03	1.02–1.03	<0.001	1.01	1.00–1.02	0.009
Male	0.82	0.66–1.03	0.0831	—	—	—
BMI	0.98	0.96–1.00	0.112	—	—	—
Smoking	1.03	0.83–1.28	0.773	—	—	—
Steroid	1.09	0.65–1.85	0.763	—	—	—
Anticoagulation	1.34	0.85–2.12	0.213	—	—	—
Esophagitis						
None	Ref	—	—	—	—	—
A/B	0.79	0.62–1.01	0.059	—	—	—
C/D	0.79	0.56–1.11	0.089	—	—	—
Barrett's esophagus	0.96	0.75–1.23	0.74	—	—	—
Increasing hernia size	1.08	1.04–1.12	<0.001	1.05	1.00–1.09	0.029
Hernia type						
None	Ref	—	—	—	—	—
Sliding	0.73	0.24–2.18	0.567	—	—	—
Paraesophageal hernia	1.29	0.43–3.88	0.649	—	—	—
American Society of Anesthesiologists						
Class 1	Ref	—	—	Ref	—	—
Class 2	4.16	1.81–9.54	<0.001	2.67	1.24–6.97	0.023
Class 3	7.24	3.14–16.68	<0.001	4.2	1.92–11.06	0.001
Class 4	14.56	3.23–65.67	<0.001	6.87	1.38–33.56	0.016
Surgical approach						
Laparoscopic	Ref	—	—	Ref	—	—
Robotic	0.45	0.16–1.26	0.128	0.5	0.15–1.29	0.192
Transthoracic	2.09	0.72–6.04	0.174	1.38	0.29–5.08	0.655
Open	5.74	2.25–14.65	<0.001	2.77	0.78–9.02	0.023
Laparoscopic converted to open	7.66	1.82–32.18	0.005	10.81	1.68–210.21	0.024
Type of antireflux operation						
Nissen	Ref	—	—	Ref	—	—
Partial	1.73	1.28–2.35	<0.001	1.5	1.06–2.10	0.021
Hill	1.04	0.67–1.61	0.856	1.56	0.92–2.55	0.086
Hybrid	1.14	0.89–1.46	0.289	1.17	0.89–1.53	0.268
Gastropexy	1.51	0.55–4.15	0.424	0.93	0.25–2.82	0.903
Belsey	2.57	0.23–28.46	0.443	0.5	0.15–1.27	0.809
Nonelective	1.82	1.01–3.29	0.046			
Redo	1.66	1.26–2.19	<0.001	1.75	1.27–2.40	<0.001
Concurrent operation	1.5	1.09–2.05	0.012	1.16	0.79–1.67	0.436
Collis	1.76	1.23–2.51	0.002	1.43	0.95–2.15	0.084
Relaxing incision	1.62	1.13–2.31	0.008	1.96	0.80–1.76	0.372
Mesh	0.83	0.62–1.10	0.192	—	—	—

OR, odds ratio; Ref, reference.

a perforation or leak. Organ failure, single or multisystem is what defines CD 4 grade. Most commonly, this is respiratory failure as a single system with rare instances of multiorgan failure. These data should be reassuring to prospective patients that serious complications remain rare after HH and ARS.

Table 6. Univariable Regression for Clavien-Dindo Grade 3+

	Univariable regression for Clavien-Dindo grade 3+ up to 30 d postoperative		
Variable	**Odds ratio**	**CI**	**p Value**
Age	1.02	1.00–1.03	0.029
Male	0.75	0.50–1.12	0.158
BMI	0.95	0.91–0.98	0.004
Smoking	1.25	0.86–1.80	0.24
Steroid	1.05	0.42–2.63	0.922
Anticoagulation	1.67	0.82–3.39	0.155
Charlson Comorbidity Index (without age)	1.37	1.10–1.69	0.004
Esophagitis			
None	Ref	—	—
A/B	0.53	0.33–0.85	0.008
C/D	0.55	0.28–1.07	0.077
Barrett's esophagus	0.94	0.61–1.45	0.773
Increasing hernia size	1.16	1.09–1.23	<0.001
Hernia type			
None	Ref	—	—
Sliding	0.66	0.30–1.46	0.304
Paraesophageal hernia	2.05	0.97–4.32	0.059
Surgical approach			
Laparoscopic	Ref	—	—
Robotic	0.89	0.21–3.72	0.873
Transthoracic	1.28	0.17–9.74	0.814
Open	9.57	3.53–25.96	<0.001
Laparoscopic convert to open	2.73	0.33–22.41	0.349
Type of antireflux operation			
Nissen	Ref	—	—
Partial	1.7	1.01–2.88	0.047
Hill	1.27	0.61–2.65	0.52
Hybrid	1.3	0.85–2.00	0.223
Gastropexy	1.06	0.14–8.03	0.957
Belsey	11.1	0.99–124.63	0.051
Nonelective	1.41	0.50–3.97	0.512
Redo	2.88	1.91–4.33	<0.001
Concurrent operation	2.01	1.24–3.26	0.005
Collis	2.73	1.64–4.53	0.001
Relaxing incision	3.16	1.95–5.12	<0.001
Mesh	1.18	0.72–1.93	0.518

Ref, reference.

The use of this information is also pertinent to surgeons and the hospitals with which we are associated. Tracking our morbidity allows us and the hospital to understand patient safety. Our rate of morbidity has increased over time (data not shown) but is in correlation with our practice maturation as evidenced by increases in cases, case complexity, and complex revision surgeries. We were also able to improve patient safety. For example, when we identified urinary retention and UTIs as the most common complication 7 years ago, we worked with nursing to ensure hospital protocols were being followed to lessen them. We moved away from routine Foley catheter placement and from operative placement and removal, which was a cause of many retention cases. Some patients may be at higher risk for urinary retention, and so careful and appropriate identification of high-risk individuals followed

by medical management and urologic consultation before surgery with operative Foley catheters and postoperative Foley catheter management may mitigate the complication of postoperative urinary issues.

We identified several risk factors for the development of any major complications. Similar to previous studies, age and ASA classification are consistent predictors of overall and major (CD more than 3) morbidity.[3,20] Unlike other studies, we also identified revisional surgery, conversion to open and open surgery as risk factors for morbidity but surprisingly, partial fundoplication was also a risk factor for postoperative complications. During this era, we used partial fundoplication in patients undergoing revisional surgery, especially with dysphagia, with poor motility, and older ages, which may explain its identification as a risk factor. In the current era of laparoscopic surgery, these factors might be considered as competing because they are surrogate markers for the complexity of the operation rather than being true predictors of morbidity. Finally, paraesophageal hernias—especially those in patients of increasing age—have been identified as an independent risk factor for morbidity.[3] These studies used CPT codes to distinguish between patients. Given that GERD and hiatal hernias exist on a spectrum we used hernia size (measured axial length) and hernia type (sliding vs paraesophageal hernia) and found that size of hernia was a more important factor. Intuitively, this make sense because a large sliding hernia with an axial length of 6 cm requires a similar dissection to a paraesophageal hernia that is 4 cm with only 25% of the stomach in the chest. Even then the OR of 1.05 ranks hernia size as the second lowest risk factor for morbidity.

One unique feature to our study is the addition of 90-day morbidity. For most patients, this is unlikely; however, a very small percentage of patients (3.1%) will have complications that arise or continue out to 90 days. The majority of these issues are gastrointestinal related with dumping syndrome and oral intake or nutrition issues being the dominant sources of morbidity. The oral intake or nutritional issues are in keeping with postoperative rates of dysphagia that occur with this type of surgery and are not captured in any large database analysis. Fortunately, these issues often return to baseline at 3 to 4 months. Unfortunately, when a CD 3b complication occurs, nearly 25% of them had ongoing issues to at least 90 days postoperative, whereas CD 4 complications resolve by 30 days.

There are limitations and strengths to our study. First, this is a retrospective study with the usual limitations. However, our esophageal database including most complications has been collected prospectively since 2009. Second, surgeon-specific nuances are difficult to account for but likely plays a role in patient selection, surgical approach, type of operation, and management of postoperative complications. Third, our practice has evolved from a single surgeon to a practice with 5 surgeons; as a result, our center has a high volume of cases and is a referral center for ARS, HHR, and complex esophagogastric surgery which makes it difficult to generalize to smaller community practices. Finally, intraoperative complications may be incomplete as lacerations of the liver for example are commonly seen but rarely reported. One strength of our study is our definition and inclusion of specific complications to ARS and HHR such as poor PO tolerance or dumping syndrome. These are not captured in large databases but are important nonetheless because the patient must undergo medical treatment to improve their quality of life. The second strength is the granular description and severity grading of what our patients experienced, such as a chyle leak, new onset atrial fibrillation, or need for feeding access, which in large databases are missed or incorporated into broad categories such as cardiovascular or return to the operating room. This provides both surgeons, referring providers, and patients with a transparent view of HHR operations and ARS.

HHR and antireflux operations are conducted safely with very low mortality rates and modest rates of morbidity. The CD grading system allows the severity of complications to be graded, with the majority being CD 1 and 2 which require medical management, whereas CD 3a or greater are more significant complications that occur in <5% of patients but are often treated with minor procedures, endoscopy, or supportive care. Across the spectrum of disease, risk factors for complications relate to the complexity of the operation with age and hernia size less impactful compared with these other factors. Categorizing complications in this manner moves surgeons away from poorly defined terms of major or minor and provides patients and referring physicians with a complete picture after surgery.

Author Contributions

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