Proposal and Critical Appraisal of Exclusion Criteria to the International Study Group for Pancreatic Surgery Definition of Delayed Gastric Emptying

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BACKGROUND: The International Study Group for Pancreatic Surgery (ISGPS) defined criteria to objectively standardize delayed gastric emptying (DGE) after pancreaticoduodenectomy (PD). These criteria are inclusive by design, and may overestimate actual DGE incidence. This study critically examined individual DGE cases after PD to determine which patients are misclassified by these criteria, and for what reasons. Exclusion criteria designed to optimize the accepted DGE definition are proposed and evaluated.

STUDY DESIGN: We performed a retrospective review of prospectively collected data. We reviewed 357 consecutive patients undergoing PD by a single surgeon; included were 52 cases of ISGPS-defined DGE (14.6%). A detailed evaluation was conducted of cases using accepted and novel diagnostic criteria.

RESULTS: Of 52 ISGPS-defined DGE cases, 12 (23%) appeared not to represent genuine DGE on clinical review. Six required nasogastric tube placement for reoperation or management of emesis secondary to non-DGE conditions, 4 for reintubation without other evidence of DGE, and 2 remained NPO to treat non-DGE conditions. The proposed exclusion criteria use absence of gastric distention, passage of oral contrast, and presence of documented non-DGE conditions to determine genuine DGE. The incidence of true DGE was 11.2% in this cohort. The overall positive predictive value of the ISGPS criteria was 76.9%. Preoperative variables, DGE class, and incidence of disease-specific outcomes were similar with both definitions.

CONCLUSIONS: The ISGPS consensus guidelines promote a standardized, sensitive, and easily applicable definition of DGE, but may falsely classify DGE in approximately 23.1%. Introduction of the proposed exclusion criteria, which establish objective radiologic data as a component of the definition, could substantially limit this overestimation. (J Am Coll Surg 2015;220: 1036−1043. © 2015 by the American College of Surgeons)

Delayed gastric emptying (DGE) remains one of the most common complications after pancreaticoduodenectomy (PD), with a variably reported incidence between 7.9% and 57%.[1-4] Standardized evaluation of DGE has long been complicated by inconsistent definitions of the condition, usually characterized by days of postoperative nasogastric tube (NGT) decompression, days until tolerance of liquid or solid diet, and use of prokinetic agents postoperatively. Formerly, multiple institutions used these characteristics in different measures, and several definitions ensued.[5]

In 2007, the International Study Group of Pancreatic Surgery (ISGPS) proposed a consensus definition for DGE, based on severity of DGE and clinical significance.[5]

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Abbreviations and Acronyms
DGE = delayed gastric emptying
ISGPS = International Study Group of Pancreatic Surgery
NGT = nasogastric tube
PD = pancreaticoduodenectomy
PPPD = pylorus-preserving pancreatico-duodenectomy

These guidelines have quickly become indispensable for the classification of DGE after PD.

The ISGPS definition has been evaluated in a small number of studies, assessing the differences in outcomes between patients with ISGPS grades A through C,[4,6-9] and outcomes appear to correlate well with ISGPS grade. These studies have demonstrated that the criteria proposed by the ISGPS readily identify patients with DGE, but also questioned whether the inclusive design of these criteria may overestimate the incidence of genuine DGE.[8]

Our institution previously reported a comprehensive analysis of indicators of DGE, and suggested a modification to the ISGPS criteria that excluded patients who required relaparotomy during the same hospital stay, leading to NGT replacement, required mechanical ventilation (beyond postoperative day 2) and NGT placement, or who required prolonged NPO status for an objectively diagnosed non-DGE cause (ie, high-output pancreatic fistula).[1] Our previous findings suggested that the ISGPS criteria potentially overclassify numerous patients as having DGE when they actually require NGT placement for indications other than DGE.

In order to address these concerns, this study was designed to critically analyze every case of DGE identified by the ISGPS criteria in 357 consecutive PD patients, to determine which diagnoses of DGE were confounded by other conditions and potentially misclassified. This study attempted to characterize which non-DGE conditions most frequently result in diagnoses of DGE and which objective clinical data may help ascribe true positivity to the ISGPS criteria, with a goal of optimizing the definition of DGE.

METHODS

Patient selection

Between the years 2003 and 2013, a total of 357 patients underwent either classic Kausch-Whipple (PD) or pylorus-preserving pancreatico-duodenectomy (PPPD) by a single surgeon at Yale-New Haven Hospital. Perioperative characteristics were prospectively collected for all consecutive patients undergoing PD or PPPD for any indication. Data collection and analysis followed a protocol approved by the Yale University School of Medicine Human Investigations Committee. Demographic characteristics, comorbid conditions, operative and perioperative variables, and complications were identified and evaluated for each patient. Perioperative complications were assessed within a 90-day follow-up period.

Operative technique

When not precluded by oncologic or disease-specific considerations, PPPD was performed. In all other cases, a classic PD was performed. Pancreatico-jejunostomy was performed in a 2-layer end-to-side fashion using duct-to-mucosa reconstruction, while hepaticojejunostomy was performed in a single-layer end-to-side fashion. Gastro- or duodeno-jejunostomy was performed in an end-to-side (Billroth II) fashion. Early in the case series, these were performed in a retrocolic fashion, but our approach changed to antecolic positioning in 2008. Similarly, closed suction drainage of the peritoneum was routinely used early in the series, with placement of 2 drains adjacent to the hepatico- and pancreatico-jejunostomies, respectively. However, intraperitoneal drains were rarely used after 2005, as evidence suggesting they were unnecessary was integrated into our practice.[10]

Definitions of delayed gastric emptying and exclusion criteria

The ISGPS criteria for DGE (Table 1) were applied to each patient, resulting in classification from grades A through C, or negative for DGE.[5] Patients with ISGPS-classified DGE underwent comprehensive chart review to determine the reason they were so classified. Patients were subcategorized based on the conditions leading to their need for nasogastric decompression, including genuine DGE, reintubation, relaparotomy, secondary to other postoperative complication, or "early clinical practice" (when patients were kept NPO or NGTs were routinely used for long enough to qualify a patient as having DGE by ISGPS criteria). Patients classified as early clinical practice (n = 3) were included in the analysis because they could not be excluded based on our criteria.

Review of each clinical course, the causes of reintubation or reoperation, and CT scans or x-rays demonstrating gastric distention and either failure or ready passage of contrast through to small bowel were evaluated to ensure that the classifications of primary DGE represented clinical reality. No standard radiographic definition of gastric distention after PD exists, so presence or absence of gastric distention was assessed subjectively, defined by an enlarged gastric pouch, often with a large amount of air or fluid within. For the purposes of this study, passage of contrast was most often assessed by analysis of CT

Table 1. Consensus Definition of Delayed Gastric Emptying after Pancreatic Surgery

DGE Grade	NGT required	Unable to tolerate solid oral intake by POD	Vomiting/gastric distention	Use of prokinetics
A	4–7 d or reinsertion > POD 3	7	+/−	+/−
B	8–14 d or reinsertion > POD 7	14	+	+
C	>14 d or reinsertion > POD 14	21	+	+

DGE, delayed gastric emptying; NGT, nasogastric tube; POD, postoperative day.
(Adapted from Wente MN, Bassi C, Dervenis C, et al. Delayed gastric emptying (DGE) after pancreatic surgery: a suggested definition by the International Study Group of Pancreatic Surgery (ISGPS). Surgery 2007;142:761–768, with permission.)

scan, rather than a formal gastric emptying study. Patients demonstrating delayed passage, or those who required positional changes to prompt passage of contrast on gastric emptying studies, were considered to have DGE. Ultimately, we applied specific exclusion criteria, the "modified ISGPS criteria" (Tables 2 and 3) to determine which patients were excluded. Patients who were unable to tolerate a diet, who experienced nausea and vomiting requiring NGT placement, or who had an NGT replaced for another reason (eg, reintubation, relaparotomy, or pharyngeal dysfunction) were excluded only if they had documented radiographic absence of gastric distention and normal passage of contrast into the small bowel. Cases without radiographic images (n = 13) demonstrating gastric distention or passage of contrast were considered "genuine" by default and not excluded. Patients receiving NGT decompression for a non-DGE reason with gastric distention or delayed passage of contrast were classified as having genuine DGE (Fig. 1).

Analysis

Preoperative characteristics, intraoperative variables, and postoperative outcomes were subject to comparison by univariate analysis. Two comparisons were made: first between patients classified as having DGE by ISGPS criteria and DGE-negative patients, then between patients using the "modified ISGPS criteria" and DGE-negative patients. All data analyses were performed using SPSS version 19.0 software (IBM SPSS Software). Continuous variables were assessed for normality of distribution using the Kolmogorov-Smirnov test, then analyzed using a 2-tailed *t*-test for normally distributed variables, or the Mann-Whitney U test for variables with a skewed distribution. For categorical variables, the Pearson chi-square test or Fisher's exact test were used, as appropriate. A 2-tailed p value <0.05 was considered statistically significant. Because the objective was to compare results between groups to critically appraise our test criteria, a multivariate analysis was not indicated. Positive predictive value, sensitivity, specificity, and prevalence were calculated in the standard manner, based on Bayes' Theorem.[11]

RESULTS

Overall demographics

A total of 357 patients underwent resection of the pancreatic head using either the classic (Kausch-Whipple) PD (n = 138) or PPPD (n = 219) during the 10-year period of 2003 to 2013. There were 186 men and 171 women included in the study, with a median age of 66 years and range of 13 to 85 years old. Approximately 74% underwent resection for malignant disease, the majority for a diagnosis of pancreatic ductal adenocarcinoma.

Comparison of ISGPS-defined delayed gastric emptying with delayed gastric emptying defined by modified criteria

There were 52 cases of ISGPS-defined DGE identified in our cohort. After application of the modified ISGPS criteria, 12 cases (23%) of ISGPS-defined DGE were excluded (Table 4). Of these, 4 patients (7.7%) in whom NGTs were placed due to respiratory failure and intubation were excluded because they had been previously

Table 2. Proposed Exclusion Criteria to the International Study Group for Pancreatic Surgery Consensus Definition of Delayed Gastric Emptying

Exclusions	n	% of DGE classified patients
Exclusion 1: NGT replacement for treatment of non-DGE medical conditions		
With documented radiographic absence of gastric distention and passage of contrast to the small bowel	6	11.5
With prior ability to tolerate a diet and no prior evidence of DGE by consensus definition before NGT reinsertion	4	7.7
Exclusion 2: Prolonged NPO status for treatment of a documented non-DGE medical condition	2	3.8

Examples: pancreatic fistula; relaparotomy; ileus; pharyngeal dysfunction; reintubation; mechanical small bowel obstruction.
DGE, delayed gastric emptying; NGT, nasogastric tube.

Table 3. Application of Exclusion Criteria to the International Study Group for Pancreatic Surgery Consensus Definition of Delayed Gastric Emptying

Application of exclusion criteria	n	% of all patients
ISGPS DGE by ISGPS criteria alone	52	14.6
DGE by modified ISGPS criteria, after exclusions	40	11.2

DGE, delayed gastric emptying; ISGPS, International Study Group for Pancreatic Surgery.

tolerating a liquid diet or demonstrated radiographic evidence of contrast passing to the small bowel and no gastric distention. Six patients (11.5%) who required NGT placement for relaparotomy or an interventional radiology procedure were excluded because they also met these criteria. Two additional patients (3.8%) were kept NPO for a prolonged period for treatment of a non-DGE condition: one remained NPO for an interventional radiology procedure, and another due to a pancreatic fistula. Both were excluded, as they were able to tolerate a diet, but were kept NPO for treatment of other conditions.

Univariate analysis was performed, first comparing patients with DGE by ISGPS criteria with patients without DGE, then comparing patients with DGE by modified ISGPS criteria with all other patients. These analyses were then compared side-to-side, to evaluate which factors remained statistically significant after removing the confounding cases of false-positive ISGPS-defined DGE. A single operative variable significantly predicted increased risk for DGE by ISGPS criteria, using a PPPD resection rather than PD (Supplementary Table 1, online only). However, the type of resection was not a significant predictor of genuine DGE because no significant difference was apparent when the modified criteria were used.

Delayed gastric emptying-specific outcomes (Table 5) were statistically significant ($p < 0.05$) in both comparisons, including length of stay, days until oral liquids or solids were tolerated, need for postoperative parenteral or enteral nutrition, number of ICU days, minor and major Clavien scores, pneumonia, cardiac arrhythmias, need for postoperative transfusion, reoperation, reintubation, presence of pancreatic fistula, and mortality. When our modified criteria were applied, several outcomes no longer demonstrated a statistically significant difference between DGE and non-DGE patients, including leakage at any anastomosis, myocardial infarction, intra-abdominal abscess formation, and need for readmission. However, our study was not powered to detect a significant difference in these rare outcomes.

Three patients classified as having DGE experienced no complications during their admission, reflected in Clavien-Dindo classification scores[12] of 0. Two of these patients were part of our "early clinical practice" cohort ($n = 3$), when NGTs were routinely left in place long enough to classify these patients as having DGE by ISGPS criteria. The other patient with a Clavien score of 0 was classified as having DGE due to inability to tolerate solid food until postoperative day 8, although he was able to tolerate liquids during this time.

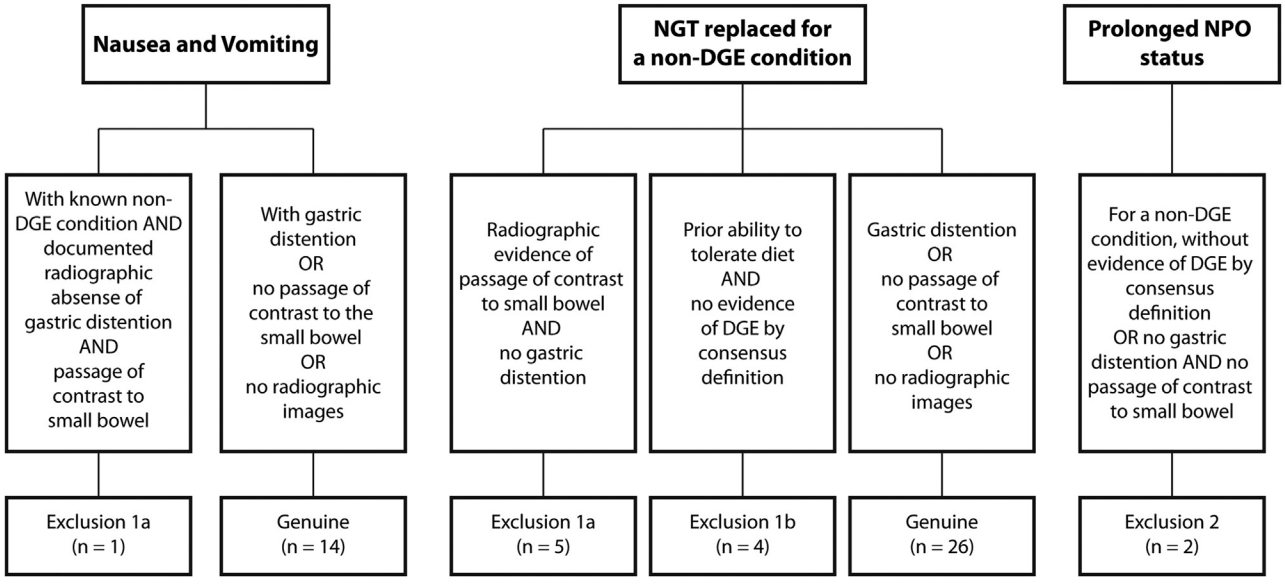

Figure 1. Clinical pathway for proposed modified exclusion criteria. Demonstrates the clinical decision process to determine whether a suspected case of delayed gastric emptying is genuine or should be excluded by the modified criteria. DGE, delayed gastric emptying; NGT, nasogastric tube.

Table 4. Details of the 12 Patients with International Study Group for Pancreatic Surgery-Defined Delayed Gastric Emptying Who Were Excluded by Modified Criteria

Age, y	M/F	Length of stay, d	Solids tolerated, POD	NGT removed, POD	Presence of gastric distention	Passage of contrast to small bowel	DGE details	DGE class	30-d Clavien score
68	M	14	12	n/a	N	n/a	Excluded, prolonged NPO for pancreatic fistula	A	2
54	F	13	9	n/a	N	Y	Excluded, made NPO for IR procedure, NGT not replaced	A	3a
31	M	18	17	16	N	Y	Excluded, reoperation for internal hernia	C	3b
68	M	22	20	18	N	Y	Excluded, return to OR for evisceration	C	4a
73	M	58	55	50	N	Y	Excluded, reintubation for pneumonia	C	4a
77	M	16	9	6	N	Y	Excluded, pancreatic fistula	A	4a
76	M	86	163	44	N	Y	Excluded, reoperation for gastrojejunostomy leak	C	4b
73	F	30	100	15	N	Y	Excluded, reintubation for pneumonia, prolonged NPO for pharyngeal dysfunction	C	4b
50	F	7	12	n/a	N	Y	Excluded, enteritis and ileus, contrast passes to rectum	A	2
83	M	7	20	17	n/a	n/a	Excluded, reoperation for evisceration	C	3b
69	F	21	18	14	n/a	n/a	Excluded, reoperation for pancreatic fistula and evisceration	B	3b
67	F	8	7	4	N	n/a	Excluded, NGT replaced for prolonged intubation	A	4a

AC, antecolic; F, female; IR, interventional radiology; M, male; NGT, nasogastric tube; OR, operating room; POD, postoperative day; POPF, postoperative pancreatic fistula; PPPD, pylorus-preserving pancreaticoduodenectomy; RC, retrocolic.

We then evaluated the positive predictive value of the current ISGPS criteria in this cohort. Our data suggest that the genuine DGE incidence is approximately 11.2% (95% CI 8.1% to 14.9%). The sensitivity of the unmodified ISGPS criteria is nearly 100% (95% CI 91.1% to 100%), specificity is 96.2% (95% CI 93.5% to 98.0%), and positive predictive value is approximately 76.9% (95% CI 63.2% to 87.5%).

DISCUSSION

The ISGPS criteria are indispensable guidelines that have standardized the definition of DGE after PD and have provided a uniform language for clinical studies examining this incompletely understood outcome. In the years since their introduction, these criteria have been further validated by several well-designed retrospective analyses. However, some of these studies and additional editorial critiques have questioned whether the ISGPS criteria overestimate the true incidence of DGE, and suggest including more objective criteria to make the definition of DGE more precise.

An evaluation of the ISGPS criteria by Welsch and colleagues[8] raised a concern that classification based strongly on NGT use may unintentionally include a high proportion of patients who require NGT decompression for other indications besides DGE. They further suggested that the ISGPS criteria might be limited in ability to distinguish primary DGE as a sole complication from postoperative ileus or secondary complications such as mechanical obstruction distal to the gastric outlet. Reber,[13] in a response to the proposed ISGPS definition, further argued that the ISGPS criteria lack the necessary components of objective evidence required to diagnose the condition, stating "the diagnosis of DGE should require in every case the demonstration by a radiographic contrast study that the stomach is emptying at a slower rate than normal, and that there is no mechanical cause for the problem." He suggested that diagnosing DGE solely on the basis of NGT reinsertion is imprecise and may overdiagnose the condition.[13] In another response, Fernández-del Castillo[14] described the consensus ISGPS definition as a "common starting point that can be refined further as studies evaluate and validate the definition."

Although a high index of suspicion for DGE is appropriate after PD, misclassification is potentially confusing. Furthermore, in order to accurately define the true risk factors for primary DGE and guide proper medical management, a precise definition of the condition is mandatory. This also facilitates comparison across institutions and may allow for improved analysis of causative factors and responses to interventions.

Table 5. Outcomes

	DGE by ISGPS		No DGE by ISGPS			DGE by modified criteria		No DGE		
Characteristic	**n**	**% or range**	**n**	**% or range**	**p Value**	**n**	**% or range**	**n**	**% or range**	**p Value**
Length of stay, d, median (range)	14	(7−86)	6	(3−20)	<0.001	14	(7−65)	6	(3−86)	<0.001
Tolerance of liquid diet, d, median (range)	10	(2−163)	3	(0−7)	<0.001	9.5	(2−43)	3	(0−163)	<0.001
Tolerance of solid diet, d, median (range)	12	(4−163)	4	(2−7)	<0.001	11	(4−43)	4	(2−163)	<0.001
Time in ICU, total d, median (range)	2	(1−42)	1	(1−9)	<0.001	2	(1−41)	1	(1−42)	<0.001
Specific morbidity										
None	3	5.8	57	18.7	0.021	3	7.5	57	18.0	0.095
Minor (Clavien ≤ 2)	20	38.4	222	72.8	<0.001	18	45.0	224	70.7	0.001
Major (Clavien ≥ 3)	29	55.7	26	5.6	<0.001	19	47.5	36	11.4	<0.001
Anastomotic leak	4	7.7	5	1.6	0.029	3	7.5	6	1.9	0.068
Myocardial infarction	5	9.6	9	3.0	0.039	3	7.5	11	3.5	0.198
Cardiac arrhythmia	8	15.4	12	3.9	0.004	7	17.5	13	4.1	0.003
Pneumonia	13	25.0	12	3.9	<0.001	6	15.0	19	6.0	0.047
Intra-abdominal abscess	3	5.8	11	3.6	0.334	3	7.5	11	3.5	0.198
Need for postoperative transfusion	18	34.6	30	9.8	<0.001	15	37.5	33	10.4	<0.001
Need for return to ICU	17	32.7	14	4.6	<0.001	12	30.0	19	6.0	<0.001
Need for postoperative parenteral/enteral nutrition	29	55.8	10	3.3	<0.001	22	55.0	17	5.4	<0.001
Need for readmission	18	34.6	62	20.3	0.022	13	32.5	67	21.1	0.104
Need for reoperation	15	28.8	5	1.6	<0.001	9	22.5	11	3.5	<0.001
Need for reintubation	15	28.8	7	2.3	<0.001	11	27.5	11	3.5	<0.001
Clinically-relevant pancreatic fistula (ISGPS grade B/C)	15	28.8	23	7.5	<0.001	11	27.5	27	8.5	0.001
Mortality	4	7.7	1	0.3	0.002	4	10.0	1	0.3	0.001
DGE Class										
A	22	42.3				17	42.5			
B	13	25.0				12	30.0			
C	17	32.7				11	27.5			

DGE, delayed gastric emptying; ISGPS, International Study Group for Pancreatic Surgery.

Lack of a consistent definition has led to uncertainty regarding the etiology of DGE. For example, when PD is compared with PPPD, different studies concluded that incidence of DGE was increased,[15-17] equivalent,[1,18-20] or even decreased.[21,22] This conflict is presumably secondary to use of multiple different definitions of DGE, and our results support this assumption. Currently, the risk factors frequently associated with DGE include retrocolic vs antecolic anastomosis,[23,24] Billroth I vs Billroth II reconstruction,[25,26] and disruption of the operative bed.[1] Other factors believed to influence the incidence of DGE include female sex, New York Heart Association class greater than 1, body mass index, and presence of comorbid complications such as pancreatic fistula, biliary fistula, or intra-abdominal abscess formation.[4,8,9] However, without a precise standard definition used across these trials, their results are limited, and are potentially confounded by multiple non-DGE patients.

For these reasons, we performed a thorough clinical review of every patient classified as having DGE by ISGPS criteria during the last 10 years, in order to critically assess the positive predictive value of the classification against clinical review. Furthermore, we propose a set of exclusions to modify the ISGPS criteria, in order to introduce objective radiologic data to the diagnosis and reduce false-positive classification of patients with DGE.

This study approximates the positive predictive value of the ISGPS criteria at 76.9%, suggesting that 12.5% to 36.8% of patients classified as having DGE may only meet criteria due to qualifying symptoms from synchronous non-DGE conditions. These conditions are varied, but most often include reintubation due to respiratory failure and reintubation as a component of relaparotomy. In fact, this percentage may be higher because this study retrospectively applied strict exclusion criteria to prospectively collected data and, by default, classified some patients as having "genuine" DGE when they lacked

Table 6. Clinical Vignettes Demonstrating Case-Based Examples of the Application of the Proposed Modified Exclusion Criteria

Variable	Illustration
Genuine	A patient develops nausea and emesis on postoperative day 3, without clinical evidence of other complications. An abdominal x-ray demonstrates a dilated gastric remnant without significant small bowel dilation. An NGT is placed and prokinetic medications initiated. The patient tolerates solid food by hospital day 8, and is discharged to home without additional complication.
Exclusion 1-a	A patient with a history of deep venous thrombosis is acutely hypoxic on postoperative day 3 and is reintubated (including placement of an NGT.) A CT scan of the abdomen and pelvis reveals no gastric distention, and normal passage of oral contrast to the distal small bowel.
Exclusion 1-b	On postoperative day 7, a patient with a wound infection has a coughing fit and evisceration. He is taken to the operating room and reintubated. An NGT is placed and maintained after the operation. He had previously been tolerating a diet without any nausea or vomiting.
Exclusion 2	A patient develops a fever and worsening abdominal pain on postoperative day 6. A CT scan shows normal passage of contrast, no gastric distention, but a peri-pancreatic collection later confirmed to be a pancreatic fistula. Although she had been tolerating a diet, she is made NPO for a prolonged period and TPN is initiated.
Unclassifiable	A patient develops respiratory failure on postoperative day 2, requiring re-intubation and NGT placement. No imaging of the abdomen is ordered. His breathing improves, he is extubated, and the remainder of his course is unremarkable.

NGT, nasogastric tube; TPN, total parenteral nutrition.

definitive evidence to qualify them for exclusion. For example, a patient with an ileus, but no available radiographic contrast study would be classified as "genuine" for the purposes of this study, and not excluded. Strict adherence to the proposed exclusion criteria was used in order to limit potential bias and promote general application of the results by clinicians and researchers.

Due to the strict study design, 10 patients were classified as "genuine" DGE by default, owing to the lack of radiographic evidence to the contrary, though they may or may not have truly suffered from DGE. Furthermore, the 3 "early clinical practice" patients, who had NGTs in place between 2 and 4 days, followed by gradual return to oral intake, were unlikely to truly have had DGE, but were unable to be excluded by our criteria due to lack of radiographic evidence. These cases illustrate that the results of this study may actually underestimate the true degree to which the ISGPS criteria misclassify other conditions as DGE. In the absence of previous diet tolerance or confirmative radiology, we suggest these patients may actually be "unclassifiable" with regard to DGE. Without radiographic evidence, it may not be possible to discern DGE from other complications that can present with the same symptoms. Clinical vignettes illustrating genuine DGE, situations that should be excluded, and patients who should be considered unclassifiable are presented in Table 6.

This study compared preoperative and intraoperative variables as well as outcomes, using both the ISGPS definition and our modified criteria. The DGE-specific outcomes were highly significant in both comparisons, suggesting that our modified ISGPS criteria remained a valid characterization of patients suffering from DGE, and that our study cohort was adequately powered to detect a difference between groups. The outcomes expected to be significantly different between DGE patients and non-DGE patients included length of stay, days until oral liquids or solids were tolerated, and need for postoperative parenteral or enteral nutrition. These factors all demonstrated statistically significant ($p < 0.05$) differences whether the ISGPS or modified ISGPS criteria were applied. In addition, both DGE definitions showed that patients with DGE were more likely to return to the ICU, require reoperations, reintubation, postoperative transfusions, experience clinically relevant pancreatic fistulae, and suffer in-hospital mortality.

Several outcomes were no longer statistically significant after application of the modified criteria, including need for readmission, anastomotic leak, and myocardial infarction. However, anastomotic leak and myocardial infarction occurred with a low prevalence within our cohort, and our study was not adequately powered to detect a true difference in these outcomes.

Our findings suggest that ISGPS criteria overestimate the true incidence of DGE; however, our data are limited to the results of 1 surgeon at a single large tertiary referral center. This study design serves to highlight differences in patient characteristics, with the benefit of reducing variability in surgical technique, approach, and postoperative care.

CONCLUSIONS

Delayed gastric emptying is currently an imprecise diagnosis, often confounded by synchronous complications and patient disease factors. However, the understanding and reporting of this phenomenon have been very positively affected by the ISGPS standardized definition. In order to more accurately define these factors and the operative

variables predisposing to DGE, a more exact definition is required. By excluding conditions misclassified as DGE from further analyses, we anticipate future studies may be able to characterize DGE with greater precision. Based on these data, we recommend that replacement of an NGT or delay in resumption of diet due to returning to the operating room, intubation for respiratory failure, and prolonged NPO status as a treatment for a non-DGE condition should not be included in the definition of DGE, as long as these patients have previously tolerated a diet or have no radiographic evidence of DGE. In addition, without evidence of previous diet tolerance or radiographic signs of DGE, such patients should be considered unclassifiable.

Author Contributions

Study conception and design: Healy, Kunstman, Salem
Acquisition of data: Healy, Kunstman
Analysis and interpretation of data: Healy, Kunstman, Salem
Drafting of manuscript: Healy
Critical revision: Healy, Kunstman, Salem

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Supplementary Table 1. Preoperative Variables

	DGE by ISGPS		No DGE by ISGPS			DGE by modified ISGPS criteria		No DGE		
Characteristic	**n**	**% or range**	**n**	**% or range**	**p Value**	**n**	**% or range**	**n**	**% or range**	**p Value**
Total	52	14.6	305	85.4		40	11.2	317	88.8	
Sex										
Male	31	59.6	155	50.8	0.241	24	60.0	162	51.1	0.289
Female	21	40.4	150	49.2		16	40.0	155	48.9	
Age, y, median (range)	66.5	(28–84)	66	(13–85)	0.672	64.5	(28–84)	66	(13–85)	0.958
Tumor type										
Malignant	41	78.8	223	73.1	0.384	31	77.5	233	73.5	0.587
Benign	11	21.2	82	26.9		9	22.5	84	26.5	
Type of resection										
Pylorus–preserving PD	39	75.0	180	59.0	0.019	27	67.5	192	60.6	0.396
Classic (Kausch–Whipple) (PD)	13	25.0	125	41.0		13	32.5	125	39.4	
Gastro-/duodenojejunostomy										
Antecolic	36	69.2	207	68.5	0.921	30	75.0	213	67.8	0.358
Retrocolic	16	30.8	95	31.5		10	25.0	101	32.2	
Pancreatic duct size, mm, mean (95% CI)	4.3	(3.6–5.0)	4.2	(3.9–4.5)	0.614	4.4	(3.5–5.3)	4.2	(3.9–4.5)	0.491
Pancreatic texture										
Soft	31	59.6	170	55.7	0.602	23	57.5	178	56.2	0.871
Firm	21	40.4	135	44.3		17	42.5	139	43.8	
Estimated intraoperative blood loss, mL, mean (95% CI)	678	(451–904)	523	(472–574)	0.402	690	(399–980)	527	(478–577)	0.92
Intraoperative crystalloid infused, L, mean (95% CI)	4.9L	(4.4–5.5)	4.5L	(4.3–4.6)	0.210	5.0L	(4.3–5.6)	4.5L	(4.3–4.7)	0.218
Intraoperative transfusion, U, median (range)	0	(0–13)	0	(0–9)	0.227	0	(0–13)	0	(0–9)	0.511
Comorbidities										
Diabetes	15	28.8	70	23.0	0.356	10	25.0	75	23.7	0.851
Hypertension	27	51.9	154	50.5	0.849	20	50.0	161	50.8	0.925
Pancreatitis	11	21.2	50	16.4	0.399	7	17.5	54	17.0	0.941
Pulmonary disease	8	15.4	30	9.8	0.230	6	15.0	32	10.1	0.240
Coronary artery disease	10	19.2	46	15.1	0.447	5	12.5	51	16.1	0.557
Preoperative creatinine, mean (95% CI)	1.02	(0.90–1.14)	0.91	(0.88–0.94)	0.062	1.02	(0.87–1.18)	0.91	(0.88–0.95)	0.687
ASA										
2	19	36.5	94	30.8	0.592	14	35.0	99	31.2	0.301
3	32	61.5	199	65.2		26	65.0	205	64.7	
4	1	1.9	12	3.9		0	0.0	13	4.1	

ASA, American Society of Anesthesiologists class; DGE, delayed gastric emptying; ISGPS, International Study Group for Pancreatic Surgery; PD, pancreaticoduodenectomy.