J Gastrointest Surg (2015) 19:1093–1100
DOI 10.1007/s11605-015-2795-2

ORIGINAL ARTICLE

Delayed Gastric Emptying After Pancreaticoduodenectomy. Risk Factors, Predictors of Severity and Outcome. A Single Center Experience of 588 Cases

Ayman El Nakeeb · Waleed Askr · Youssef Mahdy · Ahmed Elgawalby · Mohamed El sorogy · Mostaffa Abu Zeied · Talaat Abdallah · Mohamed Abd elwahab

Received: 19 December 2014 / Accepted: 2 March 2015 / Published online: 11 March 2015

Abstract
Background Delayed gastric emptying (DGE) is a common complication after pancreaticoduodenectomy (PD). This study was designed to evaluate perioperative risk variables for DGE after PD and analyze the factors that predict its severity.
Patients and Method Demographic data, preoperative, intraoperative, and postoperative variables were collected.
Results A total of 588 consecutive patients underwent PD. One hundred and five patients (17.9 %) developed DGE of any type. Forty-three patients (7.3 %) had a type A, 53 patients (9.01 %) had DGE type B, and the remaining nine patients (1.5 %) had DGE type C. BMI>25, diabetes mellitus (DM), preoperative biliary drainage, retrocolic reconstruction, type of pancreatic reconstruction, presence of complications, postoperative pancreatic fistula (POPF), and bile leaks were significantly associated with a higher incidence of DGE. Thirty-three (31.4 %) patients were diagnosed as primary DGE, while 72 (68.5 %) patients had DGE secondary to concomitant complications. Type B and C DGE were significantly noticed in secondary DGE (P=0.04). Hospital stay was significantly shorter in primary DGE.
Conclusion Retrocolic GJ, DM, presence of complications, type of pancreatic reconstruction, and severity of POPF were independent significant risk factors for development of DGE. Type B and C DGE were significantly more in secondary DGE.

Keywords Delayed gastric emptying · Pancreaticduodenectomy · Pancreatic fistula

Introduction

Pancreaticoduodenectomy (PD) is now the cornerstone for treatment of pancreatic head and periampullary pathologies.[1] Recent advances in surgical technologies and techniques together with better surgical experience helped lowering the mortality rates in high-volume centers; however, delayed gastric emptying (DGE) and postoperative pancreatic fistula (POPF) remain the leading morbidities.[2]

A. El Nakeeb (✉) · W. Askr · Y. Mahdy · A. Elgawalby · M. El sorogy · M. Abu Zeied · T. Abdallah · M. Abd elwahab
Mansoura University, Gastroenterology Surgical Center, Mansoura, Egypt
e-mail: elnakeebayman@yahoo.com

DGE is a common complication after PD with reported incidence reaching up to 44 %.[3–6] It is not a life-threatening condition, but it is associated with delayed oral intake, prolonged hospital stay, affecting quality of life, and increased total cost of hospitalization. Several measures have been described to decrease the incidence of DGE as preoperative use of erythromycin, left gastric preservation, and enteral feeding.[5]

In 2007, the International Study Group of Pancreatic Surgeons (ISGPS) standardized a definition and a grading for DGE which helped to eliminate the confusion about the true incidence and risk factors associated with DGE.[7–9] Although this grading clearly defines the severity of DGE, it does not take in consideration the etiology of DGE and if it is secondary to a present postoperative complication.

The aim of this study is to analyze the risk factors for the occurrence, predictors of severity of DGE, and the impact of the etiology of DGE on the surgical outcomes (Table 1).

Table 1 Risk factors and outcome of DGE

Variables		No DGE (*N*=483)	DGE (*N*=105)	*P* value
Age (years)	52.79±10.8	52.43±10.81	54.44±10.67	0.08
<60 years	258 (60.9 %)	300 (62.1 %)	58 (55.2 %)	0.19
>60 years	230 (39.1 %)	183 (37.9 %)	47 (44.8 %)	
Sex				
Male	352 (59.9 %)	279 (57.8 %)	73 (69.5 %)	0.26
Female	236 (40.1 %)	204 (42.2 %)	32 (30.5 %)	
BMI (kg/m^2)				
≤25	429 (73 %)	369 (76.4 %)	60 (57.1 %)	0.0001
>25	159 (27 %)	114 (23.6 %)	45 (42.9 %)	
DM				
No	454 (77.2 %)	408 (84.5 %)	46 (43.8 %)0.	0001
Yes	134 (22.8 %)	75 (15.5 %)	59 (56.2 %)	
Liver status				
Normal	499 (84.9 %)	414 (85.7 %)	85 (81 %)	0.21
Cirrhotic	89 (15.1 %)	69 (14.3 %)	20 (19 %)	
Preoperative biliary drainage				
Yes	314 (53.4 %)	245 (50.7 %)	69 (65.7 %)	0.005
No	274 (46.6 %)	238 (49.3 %)	36 (34. %)	
Pancreatic consistency				
Firm	228 (38.8 %)	187 (38.7 %)	41 (39 %)	0.95
Soft	360 (61.2 %)	296 (61.3 %)	64 (61 %)	
Pancreatic duct diameter				
<3 mm	189 (32.1 %)	145 (30 %)	44 (41.9 %)	0.02
>3 mm	399 (67.9 %)	338 (70 %)	61 (58.1 %)	
Preoperative albumin (gm%)	3.98±0.52	3.98±0.53	3.95±0.47	0.51
Preoperative bilirubin (mg%)	8.38±8.83	8.63±8.9	7.2±8.4	0.13
Type of pancreatic reconstruction				
PG	474 (80.6 %)	380 (78.7 %)	94 (89.5 %)	0.04
Simple loop PJ	68 (11.6 %)	62 (12.8 %)	6 (5.7 %)	
Isolated loop PJ	46 (7.8 %)	41 (8.5 %)	5 (4.8 %)	
Type of GJ anastomosis				
Antecolic	450 (76.5 %)	433 (89.6 %)	17 (16.2 %)	0.0001
Retrocolic	138 (23.5 %)	50 (10.4 %)	88 (83.8)	
Operative time (hours)	5.33±1.08	5.24±1.05	5.7±1.09	0.0001
Blood loss (ml)	583.4±498.04	572.44±492.14	633.8±523.87	0.25
Blood transfusion (units)	0.69±0.99	0.66±0.97	0.82±1.05	0.12
Postoperative albumin (gm%)	3.01±1.59	2.94±0.44	3.3±3.63	0.04
Postoperative bilirubin (mg%)	6.56±6.67	6.62±6.6	6.3±6.7	0.65
Complications	168 (28.6 %)	96 (19.9 %)	72 (68.6 %)	0.0001
Pancreatic leakage	86 (14.6 %)	41 (8.5 %)	45 (42.9 %	0.0001
Pancreatic leakage grade A	39 (6.6 %)	25 (5.2 %)	14 (13.3 %)	
Pancreatic leakage grade B	31 (5.3 %)	11 (2.3 %)	20 (19 %)	0.0001
Pancreatic leakage grade C	16 (2.7 %)	5 (1 %)	11 (10.5 %)	
Biliary leakage	49 (8.3 %)	33 (6.8 %)	16 (15.2 %)	0.005
Abdominal collection	91 (15.5 %)	41 (8.5 %)	50 (47.6 %)	0.0001
Bleeding PG	10 (1.7 %)	7 (1.4 %)	3 (2.9 %)	0.31
Bleeding GJ	16 (2.7 %)	12 (2.5 %)	4 (3.8 %)	0.45
Pancreatitis	12 (2 %)	5 (1 %)	7 (6.7 %)	0.0001
Reoperation	46 (7.8 %)	32 (6.6 %)	14 (13.3 %)	0.2

Table 1 (continued)

Variables		No DGE (*N*=483)	DGE (*N*=105)	*P* value
Nasogastric tube removal (day)	6.23±4.8	5.45±4.25	9.77±5.53	0.01
Nasogastric tube reinsertion	33 (5.6 %)	0	33 (31.4 %)	0.0001
Amount of Nasogastric tube	3336.05±3975	2067.68±2129.1	9146.38±5144.99	0.0001
Oral intake (day)	7.59±5.6	6.36±4.7	13.21±5.9	0.0001
Type of pathology				
Benign	58 (9.7 %)	48 (9.8 %)	10 (9.5 %)	0.93
Malignant	530 (90 %)	235 (90.2)	95 (90.5 %)	
Hospital stay (day)	11.17±7.8	9.71±5.7	17.8±11.66	0.001

Patients and Methods

This is a retrospective analysis of 588 consecutive cases of PD done for any indication at Gastroenterology Surgical Center, Mansoura University, Egypt, in the period from January 2001 to October 2014. The study was approved by the institute's ethical committee. Patient's data were collected prospectively in a web-based data sheet. Informed consents were obtained from all patients.

Patient Evaluation

The diagnosis and resectability were confirmed in all patients by triphasic abdominal CT scan and magnetic resonance cholangiopancreatography (MRCP). Patients presenting with cholangitis, high serum bilirubin levels, or suspected delay in the surgical schedule underwent preoperative biliary drainage by the means of endoscopic stenting.

Operative Technique

All patients underwent laparotomy through a rooftop incision (bilateral subcostal incision). After assessment of resectability by exclusion of liver metastasis and superior mesenteric vein or portal vein invasion, a subtotal stomach preserving PD (SSPPD) was done. The resected specimen included the gall bladder, distal common bile duct, antrum of the stomach, duodenum, pancreatic head, and the proximal 10 cm of the jejunum. All patients underwent regional lymphadenectomy, which included resection of nodes within the outlines of the hepatoduodenal ligament, right side of the superior mesenteric vessels, and inferior vena cava.

Pancreatic Reconstruction

In cases with pancreatico-gastric anastomosis, an end to side pancreatico-gastrostomy (PG) was done using the invagination technique by continuous absorbable sutures in two layers without the use of pancreatic stents. While for those with a pancreatico-jejunal anastomosis, either a simple or isolated loop pancreatico-jejunostomy (PJ) was performed using the duct to mucosa or invagination technique with no pancreatic stents.

Gastro-Jejunal and Hepatico-Jejunal Reconstruction

The hepatico-jejunal anastomosis (HJ) was retro-colic in all cases using absorbable sutures in single layer (posterior continuous and anterior interrupted). The gastro-jejunal anastomosis was performed either antecolic or retrocolic, either end to side or side to side according to the surgeon's preference using absorbable sutures in two layers.

In the antecolic reconstruction, HJ (retrocolic) was done first, followed by an antecolic GJ either end to side or side to side according to the surgeon's preference using absorbable sutures in two layers. For the retrocolic reconstruction, a retrocolic GJ was performed first, followed by an end to side hepaticojejunostomy (retrocolic).

In our series, antecolic reconstruction was performed in all cases with PJ. While in cases with PG, the gastro-jejunostomy (GJ) and the hepatico-jejunostomy (HJ) were performed in either an antecolic or a retrocolic fashion according to the surgeon's preference.

After completion of reconstruction, an abdominal drain is placed in the hepato-renal pouch near the pancreatic and biliary anastomosis.

Postoperative Management

All patients were maintained on postoperative intravenous antibiotics and proton pump inhibitors. Octereotides were given to patients with soft pancreas or small pancreatic ducts (100 μg SC every 8 h, started intra-operatively). Nasogastric tube (NGT) was removed when the amount of suction was below 500 ml/day after which the patient was started on clear fluids and progressed to solid diet over the following days. The abdominal drain was removed after the solid diet is achieved with no signs of pancreatic fistula or intra-abdominal collections.

Definition of the Postoperative Complications

According to the ISGPS definition, DGE was classified into three grades[7]: grade A, need for NGT intubation for 4 days or NGT reinsertion after postoperative day (POD) 3, or inability to tolerate a solid diet by POD 7; grade B need for NGT intubation for 8 days or NGT reinsertion after POD 7, or inability to tolerate a solid diet by POD 14; and grade C need for NGT intubation for 15 days or NGT reinsertion after POD 14, or inability to tolerate a solid diet by POD 21.

According to the presence of postoperative complications including pancreatic leakage, biliary leakage, pancreatitis, and abdominal collection, DGE is classified into primary DGE (not associated with postoperative complications) and secondary DGE (associated with postoperative complications).

Pancreatic fistula (PF) was defined as amylase values of drained fluid greater than three times the upper limit of normal serum amylase values measured on or after POD 3.[8] Three grades of PF were defined by the ISGPS, grade A PF described as transient, and asymptomatic fistula evident only from elevated drain amylase values, while grades B and C PF are clinically obvious fistulas that require adequate therapeutic management.

Assessments

The primary outcome was DGE rate. According to the ISGPS definition, DGE was classified into three grades[7] as mentioned before.

Secondary outcomes were operative time, operative time needed for reconstruction, length of postoperative hospital stay, and postoperative morbidities including pancreatic fistula (POPF), pancreatitis, and biliary leakage.[9]

Primary DGE is made by exclusion of any intra-abdominal complications linked to secondary DGE, and the necessary investigations in patients with primary DGE were performed including abdominal U/S and abdominal CT scan even if the patient did not have signs of intra-abdominal collections (e.g., tachycardia, fever, and leukocytosis) to rule out subtle contained leak especially from the pancreatic anastomosis.

Follow-Up

Follow-up was carried out 1 week postoperatively, 3 months, 6 months, and then after 1 year.

Statistical Analysis

Statistical analysis of the variables was performed using SPSS software, version 17. Categorical variables were described using frequency distributions. Continuous variables were calculated and were reported as mean±standard deviation (SD). Independent sample *t* test was used to detect differences in the means of continuous variables, and chi-square test was used in cases with low expected frequencies. One-way analysis of variance (ANOVA) was used when comparing continued variable among three groups. *P* values <0.05 were considered to be significant. Variables with $P<0.05$ were entered into a logistic regression model to determine independent risk factors of postoperative PF (Table 2). The independent risk factors of the variables were expressed as odds ratios (OR) with their 95 % confidence intervals (CI).

Results

Of the 588 patients included in the study, the mean age was 52.79±10.8 years; 352 (59.9 %) were males, while 236 (40.1 %) were females. All patients underwent PD at Gastroenterology Surgical Center, Mansoura University, Egypt, in the period from January 2001 to October 2014. One hundred fifty-nine (27 %) patients had a preoperative BMI of more than 25, and 314 (53.4 %) had preoperative endoscopic biliary drainage.

Regarding the pancreatic reconstruction, PG was done in 474 (80.6 %) patients, simple loop PJ was performed in 68 (11.6 %) patients, and isolated loop PJ in 46 (7.8 %) patients.

Table 2 Multivariate logistic regression for risk factors of DGE

	Sig.	Exp (B)	95 % C.I. for EXP (B)	
			Lower	Upper
DM	.039	6.128	1.092	34.399
BMI	.073	5.097	.861	30.175
ERCP	.532	1.581	.377	6.637
Pancreatic duct diameter	.209	2.999	.540	16.663
Type of GJ	.000	230.424	28.609	1855.914
Type of panc. anastomosis	.045	.285	.083	.974
Duration of operation	.985	1.006	.559	1.809
Albumin in POD1	.898	.886	.138	5.664
Reinsertion of nasogastric tube	.997	1.810E8	.000	.
Nasogastric tube removal	.000	.522	.378	.722
Day to resume oral intake	.007	1.428	1.105	1.845
Amount of Nasogastric tube	.000	1.001	1.001	1.002
Pancreatic leakage (POPF)	.999	1170235.607	.000	.
Degree of POPF	.012	9.684	1.661	56.469
Complication	.031	18.511	1.300	263.661
Bile leakage	.433	.376	.033	4.334
Collection	.999	1.737E7	.000	.
Pancreatitis	.389	4.601	.143	147.803
Reexploration	.021	.076	.008	.678
Wound infection	.725	1.690	.091	31.514

While for the GJ and HJ, antecolic reconstruction was carried out in 450 (76.5 %) patients versus 138 (28.5 %) patients that had the retrocolic reconstruction.

DGE was found in 105 (17.8 %) patients, grade A in 43 (7.3 %) patients, grade B in 53 (9 %) patients, and grade C in 9 (1.5 %) patients.

After univariate analysis, BMI>25 (P=0.0001), diabetes mellitus (DM) (P=0.0001), preoperative biliary drainage (P=0.005), retrocolic reconstruction (P=0.0001), pancreatic duct less than 3 mm (P=0.02), type of pancreatic reconstruction (P=0.04), postoperative albumin level (P=0.04), presence of complications (P=0.0001), postoperative pancreatic fistula (POPF) (P=0.0001), bile leaks (P=0.005), presence of pancreatitis (P=0.0001), wound infection (P=0.001), and abdominal collections (P=0.001) were significantly associated with a higher incidence of DGE (Table 1). In multivariate analysis, diabetes mellitus, retrocolic GJ, type of pancreatic anastomosis, presence of complications, and severity of POPF were identified as independent significant risk factors.

Predictors of the Severity of DGE

The incidence of grades B and C DGE was significantly higher in BMI >25, DM, retrocolic reconstruction, POPF, bile leaks, and abdominal collections (Table 3).

Primary Versus Secondary DGE

Of the 105 patients complicated by DGE, 33 (31.4 %) patients were diagnosed as primary DGE without any obvious etiology and not associated with any signs of intraabdominal collections, while 72 (68.5 %) patients had DGE secondary to concomitant complications (Table 4). Secondary DGE was associated with wound infection in 18 (25 %) patients, abdominal collections in 50 (69.4 %) patients, POPF in 45 (62.5 %) patients, bile leaks in 16 (22.2 %) patients, and pancreatitis in 6 (8.3 %) patients. There was no statistical significance between primary and secondary DGE regarding the age, sex, BMI, presence of DM, liver status, preoperative biliary drainage, operative duration, blood loss, and rates of nasogastric tube reinsertion. All patients that had primary DGE were not associated with fever tachycardia or leucocytosis.

Types B and C DGE were significantly noticed in secondary DGE (P=0.04). Nasogastric tube removal and day to start oral intake were significantly earlier in primary DGE (7.84± 2.41 vs 10.65±6.32 days, P=0.01, and 11.21±2.5 vs 14.1± 6.79 days, P=0.02, respectively). Hospital stay was significantly shorter in primary DGE (13.84±11.61 vs 19.6± 11.31 days, P=0.02).

Discussion

Pancreaticoduodenectomy is now considered the only curative procedure in the management of periampulary neoplasms.[3–8] As a technically demanding, complex procedure, the main concern was always the high incidence of the associated postoperative morbidity and mortality. Upgrades in surgical techniques and evolutions in surgical technologies together with an increase in operative volume and surgeon's experience in high volume centers reduced the incidence of postoperative complications and improved the overall survival.[10] Recently, the hospital mortality rate after PD has dramatically decreased to less than 5 %, while the incidence of postoperative morbidity remains high, from 25 to 60 %.[1–7] However, even in high volume centers, pancreaticoduodenectomy-specific complications as POPF and DGE remain a particular concern for pancreatic surgeons.[11]

First described by Warsaw and Torching,[12] the incidence of DGE was reported to widely range from 11 to 57 %.[3–7, 13] This was attributed mainly to the lack of a standard definition for DGE. However, in 2007, the ISGPS standardized a clinically applicable definition and severity grading of DGE according to the clinical course of the patients.[8] After application of the ISGPS criteria to our cohort of patients, the incidence of DGE was 17.8 %, while that for grades B and C were 50.5 and 8.6 %, respectively. This is similar to results reported by Kunstman et al. which were 17.9 % for DGE and 61.9 % for grades B and C DGE.[14] However, Sakamoto et al. reported 49 % incidence for DGE and 18.1 % for grades B and C.[15] This variation in incidence may be explained by the different institutional practices with tendency to delay the NGT removal and starting the oral feeding in Japanese than Western centers where hospitalization costs and economic disincentives are low.[16]

The exact etiology and pathogenesis of DGE has been a field of controversy and hypotheses. Although the ISGPS criteria are strict regarding the definition and grading of DGE, it does not address the etiology.

In our study, the incidence and severity of DGE were significantly higher in cases with DM, BMI >25, retrocolic reconstruction, POPF, bile leak, and abdominal collections. Several reports identified certain postoperative complications to be important risk factors for the development of DGE such as POPF, pancreatitis, abdominal collections, and bile leaks.[17–19] Our results support the correlation between DGE and POPF (p=0.0001). Also, abdominal collections (p=0.0001) and bile leaks (p=0.0001) were independent risk factors. In our series out of 105 patients with DGE, POPF was present in 45 (42.9 %), abdominal collections were present in 50 (47.6 %), and bile leak in 16 (15.2 %).

Regarding preoperative variables, DM (P=0.0001), BMI> 25 (P=0.0001), and preoperative biliary drainage (P=0.005) were significantly associated with DGE. Some data suggest

Table 3 Predictive factors of severity of DGE

Variables	DGE type A (n=43)	DGE type B (n=53)	DGE type C (n=9)	P value
Age (years)				
<60 years	24 (55.8 %)	29 (54.7 %)	5 (55.6 %)	0.63
>60 years	19 (44.2 %)	24 (45.3 %)	4 (44.4 %)	
Sex				
Male	29 (67.4 %)	38 (71.7 %)	6 (66.7 %)	0.16
Female	14 (32.6 %)	15 (28.3 %)	3 (33.3 %)	
BMI (kg/m^2)				
≤25	22(51.2 %)	33 (62.3 %)	5 (55.6 %)	0.001
>25	21 (48.8 %)	20 (37.7 %)	4 (44.4 %)	
DM				
No	15(34.9 %)	26 (49.1 %)	5 (55.6 %)	0.0001
Yes	28 (65 %)	27 (50.9 %)	4 (44.4 %)	
Liver status				
Normal	36 (83.7 %)	44 (83 %)	5 (55.6 %	0.09
Cirrhotic	7 (16.3 %)	9 (17 %)	4 (44.4 %)	
Preoperative biliary drainage	24 (55.8 %)	39 (73.6 %)	6 (66.7 %)	0.13
Type of pancreatic reconstruction				
PG	38 (88.4 %)	47 (88.7 %)	9 (100 %)	
Simple PJ	2 (4.7 %)	4 (7.5 %)	0	0.26
Isolated loop PJ	3(7 %)	2(3.8 %)	0	
Type of GJ				
Antecolic	2 (4.7 %)	12 (22.6 %)	3 (33.3 %)	0.0001
Retrocolic	41 (95.3 %	41 (77.4 %)	6 (66.7 %)	
Pancreatic duct diameter				
<3 mm	15 (34.9 %)	22 (41.5 %)	7 (77.8 %)	0.008
>3 mm	28 (65.1 %)	31 (58.5 %)	2 (22.2 %)	
Operative time (hours)	5.7±1.12	6.79±1.06	6.05±1.26	0.0001
Blood loss (ml)	623.25±607.8	600.94±448	877.77±496.3	0.29
Blood transfusion (units)	0.79±1.1	0.79±0.69	1.22±1.2	0.27
Complication	24 (55.8 %)	40 (75.5 %)	8 (88.9)	0.0001
Abdominal collection	16 (37.2 %)	27 (50.9 %)	7 (77.8 %)	0.0001
Pancreatic leakage	13 (30.2 %)	25 (47.2 %)	7 (77.8 %)	0.0001
Pancreatic leakage grade A	10 (23.3 %)	4 (7.5 %)	0	
Pancreatic leakage grade B	3 (7 %)	17 (32.1 %)	0	0.0001
Pancreatic leakage grade C	0	4 (7.5 %)	7 (77.8 %)	
Pancreatitis	3 (7 %)	3 (5.7 %)	1 (11.1 %)	0.002
Biliary leakage	6 (14 %)	10 (18.9 %)	0	0.008
Reoperation	7 (16.3 %)	5 (9.4 %)	2 (22.2 %)	0.05
Nasogastric tube reinsertion	0	26 (49.1 %)	7 (77.8 %)	0.001
Nasogastric tube removal (days)	6.49±0.5	10.67±2.36	20.11±13.2	0.0001
Amount of Nasogastric tube drainage	6203.95±2090	9971.69±3830.21	18344.44±8921.44	0.0001
Oral intake	11.53±4.06	12.56±2.3	25.11±12.65	0.0001

that even mild degrees of hyperglycemia can affect the gastric emptying.[20] However, Gangavatiker et al. in a study of 68 patients stated that DM was not significantly correlated to DGE.[21] As patients presenting with cholangitis in our series underwent preoperative biliary endoscopic stenting first, the correlation of preoperative biliary drainage with DGE can be attributed to the existing history of cholangitis. Although reports in the literature suggested preoperative cholangitis as a risk factor for DGE,[18] Sakamoto et al. in 2011 after standardization of the ISGPS definition of DGE found no significant correlation between DGE and preoperative cholangitis in their study.[15]

Table 4 Comparison between primary DGE and secondary DGE

Variables	Primary DGE (*N*=33)	Secondary DGE (*N*=72)	*P* value
Age (years)	55.18±10.06	54.11±10.9	0.63
<60 years	17 (51.5 %)	41 (56.9 %)	0.36
>60 years	16 (48.5 %)	31 (43.1 %)	
Sex			
Male	21 (63.6 %)	52 (72.2 %)	0.37
Female	12 (36.4 %)	20 (27.8 %)	
BMI (kg/m^2)			
≤25	18 (54.5 %)	42 (58.3 %)	0.71
>25	15 (45.5 %)	30 (41.7 %)	
DM			
No	13 (39.4 %)	33 (45.8 %)	0.53
Yes	20 (60.6 %)	39 (54.2 %)	
Liver status			
Normal	28 (84.8 %)	57 (79.2 %)	0.49
Cirrhotic	5 (15.2 %)	15 (20.8 %)	
Preoperative albumin (gm%)	3.8±0.47	4±0.46	0.11
Preoperative bilirubin (mg%)	7.42±8.38	7.1±8.5	0.86
Preoperative biliary drainage	19 (57.6 %)	50 (69.4 %)	0.23
Type of pancreatic reconstruction			
PG	32 (97 %)	62 (86.1 %)	
Simple loop PJ	1 (3 %)	5 (6.9 %)	0.2
Isolated loop PJ	0	5 (6.9 %)	
Type of anastomosis			
Antecolic	4 (12.1 %)	14 (19.4 %)	0.35
Retrocolic	29 (87.9 %)	58 (80.6 %)	
Pancreatic duct diameter			
<3 mm	6 (18.2 %)	38 (52.8 %)	0.001
>3 mm	27 (81.8 %)	34 (47.2 %)	
Operative time (hours)	5.65±1.24	5.8±1.03	0.41
Blood loss (ml)	721.21±668.72	593.75±441.9	0.25
Blood transfusion (units)	0.93±1.17	0.77±0.99	0.47
Postoperative albumin (gm%)	2.9±0.36	3.47±4.38	0.42
Postoperative bilirubin (mg%)	5.44±5.48	4±4.97	0.46
Severity of DGE			
Type A	19 (57.6 %)	24 (33.3 %)	0.04
Type B	13 (39.4 %)	40 (55.6 %)	
Type C	1 (3 %)	8 (11.1 %)	
Abdominal collection	0	50 (69.4 %)	0.0001
Biliary leakage	0	16 (22.2 %)	0.003
Pancreatic leakage	0	45 (62.5 %)	0.0001
Bleeding PG	0	3 (4.15 %)	0.23
Bleeding GJ	0	4 (5.6 %)	0.16
Pancreatitis	0	6 (8.3	0.08
Nasogastric tube reinsertion	8 (24.2 %)	25 (34.7 %)	0.28
Nasogastric tube removal (days)	7.84±2.41	10.65±6.32	0.01
Amount of Nasogastric tube drainage (ml)	7582.42±4696.81	9863.19±5212.85	0.03
Oral intake (days)	11.21±2.5	14.1±6.79	0.02
Hospital stay (days)	13.84±11.61	19.6±11.31	0.02

The impact of antecolic versus retrocolic reconstruction on the incidence and severity of DGE has been an area of debate. In our study, of 138 patients with retocolic reconstruction 88 (83.8 %) patients developed DGE versus 16.2 % for patients with antecolic reconstruction (P=0.0001). This is similar to results published by some pre-ISGPS studies[22, 23]; however, Gangavatiker et al. and Kunstman et al. found no significant correlation between DGE and the method of reconstruction weather antecolic or retocolic.[14, 21]

Although strongly linked to certain postoperative complications, certain patients develop DGE without any obvious cause, recently called "primary DGE." Several hypotheses have been postulated in a trial to understand the pathogenesis of primary DGE in such cases. These include antroduodenal ischemia,[24] low plasma motilin levels,[25] peripancreatic inflammation,[26] twist in the gastrojejunostomy, aggressive lymphadenectomy, and pancreatic fibrosis.[27] In our study, the 33 patients with primary DGE had oral gastrograffin studies to confirm the patency of the gastrojejunostomy and exclude any torsions. Types B and C DGE were significantly noticed in secondary DGE (P=0.04). Nasogastric tube removal and day to start oral intake were significantly earlier in primary DGE (7.84±2.41 vs 10.65±6.32 days, P=0.01, and 11.21±2.5 vs 14.1±6.79 days P=0.02, respectively). Hospital stay was significantly shorter in primary DGE (13.84±11.61 vs 19.6±11.31 days, P=0.02). These patients were supported by total or partial parenteral nutrition, and DGE improved without any further treatments. In these patients, exclusion of all causes of secondary DGE was done; however, the etiology of DGE remained unclear.

Conclusion

DGE is strongly linked to the occurrence of other postoperative complications especially pancreatic leakage. However, in some cases, DGE occurs in the absence of any associated complications (primary DGE). Although ISGPS classification helped to standardize the definition and grading of DGE, it does not address the etiology. Primary DGE should therefore

be distinguished as a separate entity for better understanding of the pathogenesis and proper management.

References

1. Kurahara H, Shinchi H, Maemura K, Mataki Y, Iino S, Sakoda M et al. Delayed Gastric Emptying After Pancreatoduodenectomy. Journal of Surgical Research 2011; 171:187–192.
2. Hochwald SN, Grobmyer SR, Hemming AW, Curran E, Bloom DA, Delano M et al. Braun Enteroenterostomy is Associated With Reduced Delayed Gastric Emptying and Early Resumption of Oral Feeding Following Pancreaticoduodenectomy. Journal of Surgical Oncology 2010;101:351–355.
3. Akizuki E, Kimura Y, Nobuoka T, Imamura M, Nagayama M, Sonoda T, et al. Reconsideration of postoperative oral intake tolerance after pancreaticoduodenectomy: Prospective consecutive analysis of delayed gastric emptying according to the ISGPS definition and the amount of dietary intake. Ann Surg 2009; 249:986.
4. El Nakeeb A, Salah T, Sultan A, El Hemaly M, Askr W, Ezzat H et al. Pancreatic Anastomotic Leakage after Pancreaticoduodenectomy. Risk factors, Clinical predictors, and Management (Single Center Experience). World J Surg. 2013 Jun;37(6):1405-18.
5. Masui T, Doi R, Kawaguchi Y, Uemoto S. Delayed gastric emptying improved by straight stomach reconstruction with twisted anastomosis to the jejunum after pylorus-preserving pancreaticoduodenectomy (PPPD) in 118 consecutive patients at a single institution. Surg Today (2012) 42:441–446.
6. El Nakeeb A, Hamdy E, Sultan AM, Salah T, Askr W, Ezzat H, et al. Isolated Roux loop pancreaticojejunostomy versus pancreaticogastrostomy after pancreaticoduodenectomy: a prospective randomized study. HPB (Oxford). 2014 Aug;16(8): 713-22..
7. Wente MN, Bassi C, Dervenis C. Delayed gastric emptying (DGE) after pancreatic surgery: a suggested definition by the International Study Group of Pancreatic Surgery (ISGPS). Surgery 2007;142(5): 761–8.
8. Bassi C, Dervenis C, Butturini G, Fingerhut A, Yeo C, Izbicki J et al. Postoperative pancreatic fistula: An international study group (ISGPF) definition. Surgery 2005; 138:8–13.
9. Pratt WB, Maithel SK, Vanounou T. Clinical and economic validation of the International Study Group of Pancreatic Fistula (ISGPF) classification scheme. Ann Surg. 2007 ;245(3):443-51.
10. Meguid RA, Ahuja N and Chang DC. What constitutes a 'high-volume' hospital for pancreatic resection? J AM Coll Surg 2008;206: 622 e1-622 e9.
11. Balcom, JH, Rattner, DW, Warshaw, AL, Chang Y, Fernandez-del Castillo C. Ten-year experience with 733 pancreatic resections: changing indications, older patients, and decreasing length of hospitalization. Archives of surgery 2001;136: 391–398
12. Warshaw AL and Torchiana DL. Delayed gastric emptying after pylorus-preserving pancreaticoduodenectomy. Surg Gynecol Obstet 1985;160:1–4.
13. van Berge Henegouwen MI, van Gulik TM, DeWit LT, Allema JH, Rauws EA, Obertop H, et al. Delayed gastric emptying after standard pancreaticoduodenectomy versus pylorus-preserving pancreaticoduodenectomy: an analysis of 200 consecutive patients. J Am Coll Surg 1997;185:373–379.
14. Kunstman JW, Fonseca AL, Maria M, Cong X, Hochberg A, Salem RR.. Comprehensive Analysis of Variables Affecting Delayed Gastric Emptying Following Pancreaticoduodenectomy. Gastrointest Surg 2012;16:1354–1361.
15. Sakamoto Y, Yamamoto Y, Hata S, Nara S, Esaki M, Sano T,et al. Analysis of Risk Factors for Delayed Gastric Emptying (DGE) after 387 Pancreaticoduodenectomies with Usage of 70 Stapled Reconstructions. Journal of gastrointestinal surgery 2011;15: 1789–1797.
16. Sato G, Ishizaki Y, Yoshimoto J, Sugo H, Imamura H, Kawasaki S.. Factors Influencing Clinically Significant Delayed Gastric Emptying After Subtotal Stomach-Preserving Pancreatoduodenectomy. World J Surg 2014; 38:968–975.
17. Hashimoto Y and Traverse W. Incidence of pancreatic anastomotic failure and delayed gastric emptying after pancreatoduodenectomy in 507 consecutive patients: use of a web-based calculator to improve homogeneity of definition. Surgery 2010;147:503–515.
18. Park YC, Kim SW, Jang JT, Ahn YJ, Park YH. Factors influencing delayed gastric emptying after pylorus-preserving pancreatoduodenectomy. J Am Coll Surg 2003;196:859–865.
19. Park JS, Hwang HK, Kim JK, Cho SI, Yoon DS, Lee WJ et al. Clinical validation and risk factors for delayed gastric emptying based on the International Study Group of Pancreatic Surgery (ISGPS) Classification. Surgery 2009;146:882–887.
20. Schvarcz E, Palmer M, Aman J, Horowitz M, Stridsberg M, Berne C. Physiological hyperglycemia slows gastric emptying in normal subjects and patients with insulin-dependent diabetes mellitus. Gastroenterology 1997; 113: 60–6.
21. Gangavatiker R, Pal S, Javed A, Dash NR, Sahni P, Chattopadhyay TK. Effect of Antecolic or Retrocolic Reconstruction of the Gastro/Duodenojejunostomy on Delayed Gastric Emptying After Pancreaticoduodenectomy: A Randomized Controlled Trial. J Gastrointest Surg 2011;15:843–852.
22. Hartel M, Wente MN, Hinz U, Kleeff J, Wagner M, Müller MW, et al. Effect of antecolic reconstruction on delayed gastric emptying after the pylorus preserving Whipple procedure. Arch Surg 2005; 14: 1094–9.
23. Tani M, Terasawa H, Kawai M, Ina S, Hirono S, Uchiyama K, et al. Improvement of delayed gastric emptying in pylorus-preserving PD.Ann Surg 2006; 243: 316–320.
24. Liberski SM, Koch KL, Atnip RG, Stern RM. Ischemic gastroparesis: resolution after revascularization. Gastroenterology 1990;99:252–257.
25. Yeo CJ, BarryMK, Sauter PK, Sostre S, Lillemoe KD, Pitt HA, et al. Erythromycin accelerates gastric emptying after pancreaticoduodenectomy: a prospective, randomized, placebo-controlled trial. Ann Surg 1993;218:229–238.
26. Hocking MP, Harrison WD, Sninsky CA. Gastric dysrhythmias following pylorus-preserving pancreaticoduodenectomy: possible mechanism for early delayed gastric emptying. Dig Dis Sci 1990;35:1226–1230.
27. Kurahara H, Takao S, Shinchi H, Mataki Y, Maemura K, Sakoda M, et al. Subtotal stomach preserving pancreaticoduodenectomy (SSPPD) prevents postoperative delayed gastric emptying. J Surg Oncol 2010;102:615–619.