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• BRIEF REPORTS •

Analysis of multiple factors of postsurgical gastroparesis syndrome after pancreaticoduodenectomy and cryotherapy for pancreatic cancer

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Abstract

AIM: To explore the etiology, pathogenesis, diagnosis, and treatment of postsurgical gastroparesis syndrome (PGS) after pancreatic cancer cryotherapy (PCC) or pancreaticoduodenectomy (PD), and to analyze the correlation between the multiple factors and PGS caused by the operations.

METHODS: Clinical data of 210 patients undergoing PD and 46 undergoing PCC were analyzed retrospectively.

RESULTS: There were 31 (67%, 31/46) patients suffering PGS in PCC group, including 29 with pancreatic head and uncinate tumors and 2 with pancreatic body and tail tumors. Ten patients (4.8%, 10/210) developed PGS in PD group, which had a significantly lower incidence of PGS than PCC group (χ = 145, P<0.001). In PCC group, 9 patients with PGS were managed with non-operative treatment (drugs, diet, nasogastric suction, *etc.*), and one received reoperation at the 16th day, but the symptoms were not relieved. In PD group, all the patients with PGS were managed with non-operative treatment. The PGS in patients undergoing PCC had close association with PCC, tumor location, but not with age, gender, obstructive jaundice, hypoproteinemia, preoperative gastric outlet obstruction and the type and number of gastric biliary tract operations. The mechanisms of PGS caused by PD were similar to those of PGS following gastrectomy. The damage to interstitial cells of Cajal might play a role in the pathogenesis of PGS after PCC, for which multiple factors were possibly responsible, including ischemic and neural injury to the antropyloric muscle and the duodenum after freezing of the pancreatico-duodenal regions or reduced circulating levels of motilin.

CONCLUSION: PGS after PCC or PD is induced by multiple factors and the exact mechanisms, which might differ between these two operations, remain unknown. Radiography of the upper gastrointestinal tract and gastroscopy are main diagnostic modalities for PGS. Non-operative treatments are effective for PGS, and reoperation should be avoided in patients with PGS caused by PCC.

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INTRODUCTION

Postsurgical gastroparesis syndrome (PGS) is a complex disorder characterized by postprandial nausea, vomiting, and gastric atony in the absence of mechanical gastric outlet obstruction. Patients frequently suffer marked weight loss and malnutrition that require hospitalization and prolonged parenteral nutrition (PN). These symptoms can be disabling and often fail to be alleviated by drug therapy, for which gastric reoperations usually prove unsuccessful. An identified cause for PGS has not been available, nor is its mechanism quite clarified. PGS after gastrectomy or pancreatoduodenectomy (PD) has been reported in a number of literatures[1-5]. Based on the results of clinical investigations[6-9], cryosurgery targeting at the pancreaticoduodenal region was considered safe and effective for unresectable pancreatic cancer. However, PGS caused by cryotherapy for pancreatic cancer (PCC), to our knowledge, has not been reported. As a unique complication of PCC, gastric stasis occurs in the early postoperative period in most of cases receiving PCC (67%), resulting in long-term loss of a large amount of gastric juice and delayed recovery of oral food intake, and occasionally, excessive gastric juice loss leads to body fluid deficit and metabolic alkalosis. To define the factors contributing to the development of PGS following PD or PCC, we performed this study to retrospectively examine the clinical data of 210 patients undergoing PD and 46 undergoing PCC.

MATERIALS AND METHODS

Subjects

From January 1990 to June 2003, 210 patients (147 male and 63 female patients, aged 35 to 75 years with a mean of 53.6 years) received PD in our hospital for pancreatic cancer or periampullary adenocarcinoma. None of the patients were preoperatively identified to have mechanical gastric outlet obstruction, but 95 had obstructive jaundice and 15 had hypoproteinemia.

During the period between January 1995 to March 2003, another 46 patients (including 31 male and 15 female patients, aged between 39 and 78 years with a mean of 54 years) underwent PCC for unresectable advanced pancreatic cancer, located in the pancreatic head in 21 cases, in the uncinate process in 15 cases, and in the pancreatic body and tail in 10 cases. All the tumors were identified by preoperative helical computed tomography (CT) scan and by intraoperative exploration, including 31 tumors with local involvement and 15 metastatic tumors. Preoperatively, 34 patients were identified to have obstructive jaundice and 6 had hypoproteinemia. All the patients, excluding the 8 with preoperative duodenal obstruction, were free of preoperative mechanical gastric outlet obstruction. Gastrojejunostomy was performed in 37 cases, and cholecystojejunostomy or choledochojejunostomy done in 32 cases during PCC for relief or prevention of the common bile duct and gastric outlet obstruction. Four patients also had concurrent splanchnicectomy with ethanol.

Endoscopy or radiography was employed to identify and exclude cases of mechanical gastric outlet obstruction, and also to detect such problems of anastomotic stricture, efferent

limb obstruction, and jejunogastric intussusception *etc*., as well as food retention after a 4- to 8-h fast, for validating the diagnosis of gastroparesis.

Diagnostic criteria for PGS

At present, consensus has not been reached on the criteria for diagnosis of PGS. Stanciu[10] suggested using gastric scintigraphy with ^{99}Tc-labeled low-fat meal as the gold standard for diagnosing delayed gastric emptying, which utilized gamma camera imaging of the abdomen following the ingestion of a radiolabeled meal, performed at regular intervals of 2 to 4 h to quantify the meal emptying in terms of percentages. Typically, meal emptying of over 50% within 2 h was considered normal, whereas delayed gastric emptying was indicated if gastric retention greater than 10% at 4 h. In this study, we formulated practical diagnostic criteria for PGS after consultation of the previous documentations in the literature[5-7,10], as the following: (1) Absence of mechanical gastric outlet obstruction identified by one or more medical examination modalities; (2) A volume of gastric juice aspirate exceeding 800 mL/d that sustained for more than 10 d; (3) No abnormalities in water, electrolytes, or acid-alkali balance. (4) Absence of underlying diseases causing gastroparesis, such as diabetes, chorionitis, hypothyrosis, *etc*. (5) No history of using such agents as morphine, atropine, *etc*. that affected contraction function of the smooth muscle.

Surgical procedures

In PD group, the organs resected during PD included the gallbladder, common bile duct, head of the pancreas, the entire duodenum, with also subtotal gastrectomy. Proximal jejunum of 10 to 15 cm was also resected. The alimentary and biliary tracts were reconstructed with methods of Child or Whipple.

In patients of PCC group that defied surgical resection of the tumor, cryoprobes were deployed directly into the tumor for freezing to -196 °C twice, lasting for 10-15 min (using LCS 2000 cryogenic surgical system), with the common bile duct, stomach, and jejunum protected by dry cotton pads. Subsequent gastroenteroanastomosis, cholecystojejunostomy, or choledochojejunostomy were performed to reconstruct the alimentary and biliary tracts, according to the findings by intraoperative exploration. Care was taken to avoid freezing of the duodenal wall or causing other iatrogenic injuries such as damage to the biliary system or gastroduodenal artery. Jejunostomy was performed in some cases highly suspected of gastroparesis after PCC for postoperative enteral nutrition (EN) support.

Statistical analysis

The incidence of PGS in the two groups was compared and multiple factors were analyzed using χ^2 test. A P value less then 0.05 was considered statistically significant.

RESULTS

No serious complications took place in the PCC group, nor did operative death or complications occur in relation to the anastomosis. None of the patients developed fistula or pancreatitis. There was only transient elevation of amylase following the operation and the liver function and blood sugar remained normal. In PD group, in contrast, 4 patients developed serious complications after PD, including leakage at the pancreatojejunostomy in 2, bleeding at the anastomosis in 2 cases, stenosis of the anastomosis in 1 and stress peptic ulcer in 1 case. The mortality rate of PD in the perioperative period was 1.5%.

Ten of the 210 patients in PD group presented PGS within 5-10 d postoperatively. PGS developed in 31 of the 46 patients in PCC group, occurring within 5-7 d after the operation, including 29 patients with pancreatic head and uncinate tumors and 2 with pancreatic body and tail tumors. In PD group, 14 patients with PGS received non-operative treatment such as medication, diet therapy, and nasogastric suction *etc*, and 1 patient underwent reoperation on postoperative day 16, which, however, failed to relieve the symptoms. All patients with PGS in PCC group received non-operative treatment. Altogether 41 patients developed PGS in the two groups according to our diagnostic criteria, 15 of these cases were identified 4-7 d after withdrawal of the nasogastric tube and 10 were found to have a gradually increasing volume of gastric juice aspirate to 800 mL/d till 3-7 d after operation. Twenty of the 40 patients developed PGS 2-3 d after intake of liquid or semiliquid diet. Furthermore, the volume of gastric juice suction exceeded 2 000 mL/d in 4 cases following PCC and persisted for ten or more days (Table 1).

PGS following cryosurgery was closely associated with PCC, tumor location, but not with age, gender, obstructive jaundice, hypoproteinemia, preoperative gastric outlet obstruction or the type and number of gastric biliary tract operations (Table 2). PGS following PD was related with age, hypoproteinemia, preoperative gastric outlet obstruction and the type and number of gastric operations performed. Patients undergoing PCC were more likely to develop PGS than those undergoing PD (67% *vs* 4.8%, $\chi = 145$, $P<0.001$).

DISCUSSION

Many debates over the etiology and pathophysiology of PGS remain unresdved. Clinically, the frequency of this complication varies in close association with the type and number of gastric operations performed. Donahue *et al*.[11] reported a 26% incidence of chronic morbidity in patients after truncal vagotomy and antrectomy compared with a 5% incidence after highly selective vagotomy. There also appears to be a greater incidence of PGS associated with antrectomy and Roux-en-Y reconstruction compared with more conventional Billroth I and Billroth II reconstructions. Therefore, the main factor contributing to PGS is denervation and the consequent atony of the gastric remnant rather than disruption of the pacemaker activity in the Roux limb.

The exact mechanisms responsible for PGS after gastric surgery remain unclear but are likely to be multifactorial. The loss of gastric parasympathetic control resulted from vagotomy contributes to PGS via several mechanisms. In the proximal stomach, loss of vagal control leads to accelerated emptying of liquids by disrupting the late-stage tonic contractions responsible for relaxation and accommodation of the gastric fundus. In the distal stomach, vagotomy weakens antral peristaltic contraction responsible for breakdown of chyme. When coupled with the observed decrease in intestinal secretion of prokinetic hormones seen after truncal vagotomy, this leads to delayed emptying of solid substances. Also, the loss of vagal suppression of the ectopic intestinal pacemakers may cause dissociation of the antral pressure waves from the duodenal waves. The consequent disruption of wave sequence prolongs the lag phase of solid food digestion during which food is broken down into small particles by retropulsion and further delays the digestive process[12,13].

Recently, it has been recognized that interstitial cells of Cajal generate electrical pacemaker activity and mediate motor neurotransmission in the stomach. The interstitial cells of Cajal are located in the muscular wall of the gastric corpus and antrum. Gastric dysrhythmias (tachygastrias and bradygastrias) are disturbances of the normal gastric pacesetter potentials and are associated with such symptoms as nausea, epigastric fullness, bloating and delayed gastric emptying. Ordog *et al*.[14] suggest that damage to interstitial cells of Cajal may play a key role in the pathogenesis of diabetic gastropathy. Meanwhile, Zarate *et al*.[15] reported that histological and immunohistochemical

Table 1 Clinical data of the PGS cases

Patient No	Gender	Age (yr)	Operation type	Mean volume of gastric juice aspirate / d (mL)	Period of nasogastric tube aspirate(d)	Period of recovery (d)	Outcome
1	M	53	PCC+A+B	2 200	56	70	Recovery
2	F	39	PCC+B	1 200	13	28	Recovery
3	F	62	PCC+A+C	1 000	10	14	Recovery
4	M	60	PCC+A+C	1 000	21	21	Recovery
5	M	51	PCC+A	850	10	30	Recovery
6	M	61	PCC+A+B	1 250	15	26	Recovery
7	M	62	PCC+A+C	1 200	13	35	Recovery
8	F	60	PCC+C	1 300	11	43	Recovery
9	F	40	PCC+A+B	2 000	25	25	Recovery
10	F	61	PCC +C	1 200	19	14	Recovery
11	M	64	PCC+A+B	1 200	18	Death on d 13 for diabetes complication	Death
12	F	78	PCC	1 500	19	Discharged on d 24[1]	Recovery
13	M	50	PCC+A+C	1 050	12	49	Recovery
14	M	50	PCC+A+C	1 400	15	Transferred to another hospital on d 16	Recovery
15	M	42	PCC	1 450	17	14	Recovery
16	M	46	PCC+A+C	2 000	18	21	Recovery
17	M	43	PCC+A+B	1 200	13	20	Recovery
18	M	73	PCC +B	800	10	19	Recovery
19	M	46	PCC	1 350	14	18	Recovery
20	M	62	PCC+A+B+D	900	11	19	Recovery
21	M	40	PCC+A+C	1 300	15	20	Recovery
22	F	50	PCC +C	2 050	24	32	Recovery
23	F	61	PCC+A+C	1 200	15	20	Recovery
24	M	39	PCC+A+B	1 000	12	Discharged on d 16[1]	Recovery
25	M	53	PCC+A	1 050	13	17	Recovery
26	F	42	PCC+A+B	900	11	18	Recovery
27	M	60	PCC+A+C	1 800	19	25	Recovery
28	M	62	PCC	1 700	20	30	Recovery
29	M	60	PCC+A+C	1 050	12	20	Recovery
30	M	40	PCC+A+C	1 250	12	17	Recovery
31	F	64	PCC+A+B	1 300	13	31	Recovery
32	M	75	PD	1 200	12	16	Recovery
33	F	42	PD	850	10	15	Recovery
34	F	35	PD	1 050	10	19	Recovery
35	M	45	PD	1 250	11	Death on d 16 for complications	Death
36	F	48	PD	1 050	11	17	Recovery
37	M	56	PD	1 450	16	21	Recovery
38	M	60	PD	1 400	14	20	Recovery
39	F	65	PD	1 500	15	20	Reoperation at 16th d
40	M	47	PD	1 250	13	18	Recovery
41	M	63	PD	1 600	16	21	Recovery
mean±SD		53.8±13		1 180±310	15.5±6	23.1±9	

A: Gastroenteroanastomosis; B: Cholecystojejunostomy; C: Choledochojejunostomy; D: Chemical splanchnicectomies. [1]Discharged on request by the patient.

study of the resected specimen showed hypoganglionosis, neuronal dysplasia, and marked reduction in both myenteric and intramuscular interstitial cells of Cajal in patients with idiopathic gastroparesis.

Certainly, PGS after gastric surgery also can be due to muscular, neural, or humoral abnormalities. Hypothyroidism and diabetes[4] have been identified as contributing factors to gastroparesis in some patients. In patients without an identified cause, the gastroparesis is labeled as idiopathic. The mechanisms of PGS following PD is similar to that after gastrectomy.

Table 2 Correlation between multiple factors and PGS after PCC

Group	Age (yr)		Gender		Hypoproteinemia		Jaundice		Surgical procedure		Tumor location		Outlet obstruction	
	60	<60	M	F	Y	N	Y	N	PCC+A (or B, C, D)	PCC	Head and uncinate	Body and tail	Y	N
PGS	15	16	21	10	2	29	22	9	27	4	29	2	5	26
NO PGS	7	8	10	5	4	11	12	3	12	3	7	8	3	12
P	NS		NS		NS		NS		NS		<0.05		NS	

NS: No-significant.

The results of our observations suggest no significant direct relation of PGS following PCC with the types of gastric operations or the loss of gastric parasympathetic control, nor was it related to the patients' age or presence of hypoproteinemia or preoperative gastric outlet obstruction (Table 2), which, however, might be the factors contributing to PGS after gastrectomy or PD[1-5]. We therefore suggest that the mechanism of PGS after PCC may differ, at least partially, from that underlying the PGS following gastrectomy or PD.

Patients with tumors located in the pancreatic head and uncinate process are at higher risk to develop PGS following PCC than those with tumors in the pancreatic body and tail (Table 2). The interstitial cells of Cajal in the muscular wall of the gastric corpus and antrum are exposed to likely damage during the freezing of the pancreatico-duodenal area, which offers a possible explanation for the pathogenesis of PGS after PCC.

Pylorus-preserving pancreatoduodenectomy (PPPD) frequently results in gastric stasis[12,16], which occurs in 20% to 50% of the patients during the early postoperative period. As the duodenum has proved to be important in the initiation and consolidation of phase III activity of the migrating motor complex (MMC) of the stomach, its removal severely undermines the gastric phase III, hence gastric stasis may occur. On the basis of their findings that patients undergoing PPPD had slower recovery of gastric phase III and lower plasma motilin concentrations than those undergoing duodenum-preserving pancreatic head resection, Matsunaga *et al*.[16] concluded that PGS after PPPD might be attributed, at least in part, to delayed recovery of gastric phase III activity due to lowered concentrations of plasma motilin after resection of the duodenum. However, resection of the pancreas does not seem to affect gastrointestinal motility. Malfertheiner and Sarr[17] reported that even a total pancreatectomy failed to obviously affect the motor activity of the entire upper gastrointestinal tract in dogs.

We found in this study that PGS developed in 67% of all patients after PCC through multifactorial mechanisms, which could be at least partially in common with those underlying the PGS resulted from PPPD. The possible factors responsible for PGS after PCC include ischemic and neural injury to the antropyloric muscles and the duodenum after freezing of the pancreatico-duodenal area (but not to direct freezing of the duodenal pacemaker) and reduced circulating levels of motilin originally produced by the enterochromaffin cells in the duodenum and proximal jejunum. The peak plasma motilin concentration occurs in line with phase III activity of the interdigestive MMC in the stomach and duodenum. The phase III starts in the gastroduodenal region and migrates downward along the small intestine, hence its nickname the "housekeeper". The housekeeper function of phase III may be important to empty the gastric juice in the postoperative period after PCC. As the duodenum plays a role in the initiation and consolidation of gastric phase III, the injury of the duodenum by freezing -and thus the interruption of gastric phase III- may be one of the several possible causes of PGS after PCC. But still, the above hypotheses currently have to remain hypothetical, and the exact mechanisms of PGS caused by PCC must await further investigation.

Patients with PGS have non-specific symptoms of early satiety, postprandial bloating, nausea, and vomiting, and the volume of gastric juice suction in most of them can increase gradually during early postoperative period. The diagnosis of PGS is often difficult to confirm. In the absence of identifiable anatomic problems such as anastomotic stricture, efferent limb obstruction, or jejunogastric intussusception, other causes of gastric dystonia must be carefully examined. Hypothyroidism has been identified as a contributing factor to gastroparesis in some patients. Gastroparesis can also occur in patients with diabetes[18,19]. Several complementary diagnostic modalities may be used to confirm the diagnosis of PGS. Fiberoptic endoscopy or radiography of the upper gastrointestinal tract should be performed routinely to exclude anatomical causes of gastric outlet obstruction. Radionuclide GESs can also be necessary, for clinical evaluation and conventional radiographic studies are often unreliable. If endoscopy and radionuclide scintigraphy are inconclusive, a small bowel contrast study should be performed to rule out possible mechanical lesions and/or generalized gut hypomotility. Although not routinely available[20], electromyography of the gastrointestinal tract may provide valuable assistance in the diagnosis of patients with complex motility disturbances.

As the treatment of gastroparesis is far from ideal, nonconventional approaches and nonstandard medications might be of use. Traditional medical therapy consists of behavioral and diet modification, nasogastric tube suction and the use of prokinetic drugs such as bethanecol, metoclopramide, erythromycin and the more recent cisapride[10]. Dietary measures and prokinetic drugs may help relieve the symptoms in most patients, while some patients with severe nausea and vomiting require antiemetic medications. A few patients fail medical therapy and continue to have debilitating symptoms of gastroparesis, who may benefit from a venting gastrostomy[18] or jejunostomy performed surgically, endoscopically, or fluoroscopically[20]. Near-completion gastrectomy (NCG) has proved useful in small series of patients[21], but data on long-term follow-up has been lacking. Gastric electrical stimulation can be of value in the management of gastroparesis[22-24], in which the patients with PGS received continuous high-frequency/low-energy gastric electrical stimulation via electrodes deposited in the muscular wall of the antrum and connected to a neurostimulator in an abdominal wall pocket. This method produced entrainment of the intrinsic slow wave and promoted contractions in phase III with the normal slow wave. This is why a suitable stimulation to the stomach during gastroscopic examination is also helpful for the remission of PGS[3-5]. In this study, 5 patients received gastroscopic examination and the symptoms were markedly relieved. Ten patients with PGS were treated with acupuncture, and the effects were satisfactory.

According to our experience, all patients of PGS caused by PD or PCC need to undergo a long period of nasogastric suction till the clinical symptom relief or recovery occurs. The patients may experience epigastric fullness, nausea, or even vomiting, if

the nasogastric tube is withdrawn too early. Therefore, almost all of the patients with PGS in this study received the gastric juice suction over an average period of 2.2 wk, with the longest exceeding 8 wk. Because of long-term absence of food intake, these patients required nutritional support with a feeding jejunostomy tube or underwent a period of parenteral nutrition. The jejunostomy tube, as we believe, is safe, economic and practical for nutrition support in such patients, because their small intestinal peristaltic contractions and absorption function were normal in spite of PGS. Clinically, almost all of the patients had a concurrent jejunostomy during cryosurgery, considering the likeliness of these patients to develop delayed gastric emptying and for administration of postoperative enteral nutrition support. We consider that the non-operative treatments are effective for PGS after PCC or PD, and gastric reoperations should be avoided.

REFERENCES

1 **Naritomi G,** Tanaka M, Matsunaga H, Yokohata K, Ogawa Y, Chijiiwa K, Yamaguchi K. Pancreatic head resection with and without preservation of the duodenum: Different postoperative gastric motility. *Surgery* 1996; **120**: 831-837

2 **Toyota N,** Takada T, Yasuda H, Amano H, Yoshida M, Isaka T, Hijikata H, Takada K. The effects of omeprazole, a proton pump inhibitor, on early gastric stagnation after a pylorus-preserving pancreaticoduodenectomy: results of a randomized study. *Hepatogastroenterology* 1998; **45**: 1005-1010

3 **Cai YT**, Qin XY. Clinical, analysis of 15 cases with gastroparesis after radicalgastrectomy. *Zhongguo Shiyong Waike Zazhi* 1999; **19**: 338-340

4 **Qin XY**, Lei Y. Functional delayed gastric emptying after gastrectomy. *Zhongguo Weichang Waike Zazhi* 2000; **3**: 7-9

5 **Lui FL**, Qin XY. Clinical analysis of 20 cases with postsurgical gastroparesis syndrome after radical subtotal gastrectomy. *Zhonghua Weichang Waike Zazhi* 2002; **5**: 245-248

6 **Kovach SJ,** Hendrickson RJ, Cappadona CR, Schmidt CM, Groen K, Koniaris LG, Sitzmann JV. Cryoablation of unresectable pancreatic cancer. *Surgery* 2002; **131**: 463-464

7 **Patiutko IuI,** Barkanov AI, Kholikov TK, Lagoshnyi AT, Li LI, Samoilenko VM, Afrikian MN, Savel'eva EV. The combined treatment of locally disseminated pancreatic cancer using cryosurgery. *Vopr Onkol* 1991; **37**: 695-700

8 **Li B**. the current status of combined treatment for pancreatic carcinoma. *Zhongguo Puwai Jichu Yu Linchuang Zazhi* 2000; **7**: 390-392

9 **Chen XL,** Wang D, Yan LN, Li B, Wang XY, Yang BY. Experimental study of cryosurgery for isolated pancreano-duodinal area: a possible therapy for pancreano-duodinal neoplasm. *Zhongguo Puwai Jichu Yu Linchuang Zazhi* 1998; **5:** 324-325

10 **Stanciu GO.** Gastroparesis and its management. *Rev Med Chir Soc Med Nat Iasi* 2001; **105**: 451-456

11 **Donahue PE,** Bombeck CT, Condon RE, Nyhus LM. Proximal gastric vagotomy *versus* selective vagotomy with antrectomy: Results of a prospective, randomized clinical trial after four to twelve years. *Surgery* 1984; **96**: 585-590

12 **Horowitz M,** Dent J, Fraser R, Sun W, Hebbard G. Role and integrationt mechanisms controlling gastric emptying. *Dig Dis Sci* 1994; **39**(Suppl 12): 7S-13S

13 **Schirmer BD.** Gastric atony and the Roux syndrome. *Gastroenterol Clin North Am* 1994; **23**: 327-343

14 **Ordog T,** Takayama I, Cheung WK, Ward SM, Sanders KM. Remodeling of networks of interstitial cells of Cajal in a murine model of diabetic gastroparesis. *Diabetes* 2000; **49**: 1731-1739

15 **Zarate N,** Mearin F, Wang XY, Hewlett B, Huizinga JD, Malagelada JR. Severe idiopathic gastroparesis due to neuronal and interstitial cells of Cajal degeneration: pathological findings and management. *Gut* 2003; **52**: 966-970

16 **Matsunaga H,** Tanaka M, Takahata S, Ogawa Y, Naritomi G, Yokohata K, Yamaguchi K, Chijiiwa K. Manometric evidence of improved early gastric stasis by erythromycin after pylorus-preserving pancreatoduodenectomy. *World J Surg* 2000; **24**: 1236-1242

17 **Malfertheiner P,** Sarr MG, Dimagno EP. Role of the pancreas in the control of interdigestive gastrointestinal motility. *Gastroenterology* 1989; **96**: 200-205

18 **Watkins PJ,** Buxton-Thomas MS, Howard ER. Long-term outcome after gastrectomy for intractable diabetic gastroparesis. *Diabet Med* 2003; **20**: 58-63

19 **Lehmann R,** Honegger RA, Feinle C, Fried M, Spinas GA, Schwizer W. Glucose control is not improved by accelerating gastric emptying in patients with type 1 diabetes mellitus and gastroparesis. A pilot study with cisapride as a model drug. *Exp Clin Endocrinol Diabetes* 2003; **111**: 255-261

20 **Koch KL.** Electrogastrography: physiological basis and clinical application in diabetic gastropathy. *Diabetes Technol Ther* 2001; **3**: 51-62

21 **Jones MP,** Maganti K. A systematic review of surgical therapy for gastroparesis. *Am J Gastroenterol* 2003; **98**: 2122-2129

22 **Abell T**, Lou J, Tabbaa M, Batista O, Malinowski S, Al-Juburi A. Gastric electrical stimulation for gastroparesis improves nutritional parameters at short, intermediate, and long-term follow-up. *J Parenter Enteral Nutr* 2003; **27**: 277-281

23 **Lin Z,** Forster J, Sarosiek I, McCallum RW. Treatment of gastroparesis with electrical stimulation. *Dig Dis Sci* 2003; **48**: 837-848

24 **Lawlor PM,** McCullough JA, Byrne PJ, Reynolds JV. Electrogastrography: a non-invasive measurement of gastric function. *Ir J Med Sci* 2001; **170**: 126-131

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