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Outpatient vs. Inpatient Gastric Emptying Studies: Does Admission Status Influence Findings?

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Abstract

Objectives: Gastric emptying studies are performed in both outpatient and inpatient settings. Although there is no data on the prevalence of positive and negative testing between inpatient and outpatient studies, some feel inpatient testing is inappropriate secondary to potential false positives. We aim to identify the incidence and determinants of abnormal studies for inpatient versus outpatient gastric emptying studies.

Methods: A retrospective chart review of scintigraphic gastric emptying studies was performed between June 1, 2012 and April 11, 2014. Demographics, clinical information, and procedure details were collected. Descriptive statistics were used to report findings with categorical variables analyzed using Pearson Chi-Square test and continuous variables analyzed with independent samples t-test. All statistical analyses were performed using IBM SPSS Statistics version 21.0 software.

Results: 107 GE studies were reviewed (34 inpatient, 73 outpatient). Six incomplete studies were excluded. Mean patient age was 51 years (64% female, 60% Caucasian). There were more women than men in the outpatient population (p=0.04). The inpatient studies had a higher percentage of African Americans while the outpatient studies were mostly Caucasian (p=0.002). There were no other demographic differences between the inpatient and outpatient groups. The most common indication for testing was nausea and/or vomiting (44%). 42 (22 inpatient, 20 outpatient) tests were positive and 59 (8 inpatient, 51 outpatient) were negative for impaired gastric emptying. Inpatient GE testing was abnormal 73% of the time, while outpatient GE testing was abnormal 28% of the time (p<0.01). Review of inpatient GE studies revealed 97% patients received a medication known to alter gastric motility and 67% received opioid narcotics within 72 hours of testing. Patients with diabetes were 2.28 times more likely to have a positive test than patients without diabetes. Half of the abnormal tests were found in patients with diabetes.

Conclusions: Abnormal gastric emptying studies are more commonly found in inpatient studies. A majority of inpatient studies are performed on patients who have received medications known to delay gastric motility and may be at an increased risk for false positives.

Keywords: Gastroparesis; Medication-induced gastroparesis; Delayed gastric emptying

Introduction

The diagnosis and burden of gastroparesis has exponentially increased over the last decade. A United States Medicare-based data collection on hospitalizations from 1995 to 2004 showed a 158% increase in hospitalizations with gastroparesis as the primary diagnosis over this time period [1]. The increased rate of hospitalizations may be attributed to the introduction of gastric electrical stimulation as treatment for gastroparesis [2]. Increased diagnosis of gastroparesis may also be related to better recognition of this complication in patients with diabetes [3,4]. The true population prevalence of gastroparesis is largely unknown. Most studies have come from large tertiary academic centers or have focused solely on diabetic gastroparesis. These studies estimate the prevalence to be 50-65% among diabetic patients [5-7]. The first large population community-based study was done in Olmsted County, Minnesota. This study estimated impaired gastric emptying to affect 24.2 per 100,000 persons [7].

The outcome and natural history of gastroparesis is also not well understood due to few studies with small numbers and short follow up [1]. One study showed no correlation with delayed gastric emptying and increased mortality after adjustment for comorbidities [5]. Other studies have shown an increase in morbidity, mortality, emergency room use, doctor's visits and hospitalizations in patients with documented gastroparesis as compared to the general population [7-9]. Patients with uncontrolled gastroparesis are known to have significant impairment in their quality of life as well as significant health care costs [10,11]. Using a validated quality of life questionnaire,

a reduction in scores across all domains (physical, emotional, vitality, mental, social, bodily pain, and general health) has been found in patients with gastroparesis [10]. Another study showed poor quality of life was independent of other comorbid factors including age, gender, smoking, alcohol use and type of diabetes [11].

The documentation of delayed gastric emptying can be accomplished by several tests but the gold standard is a scintigraphic gastric emptying (GE) study that demonstrates gastric retention of solids [12,13]. Patient factors including medications, tobacco use, presence of pain, immobility, hyperglycemia, and gender can all affect study outcomes [6,13]. Two broad classes of medication are known to affect gastric motility; prokinetic agents accelerate gastric transit whereas another group of medications slow gastric transit times. Known prokinetic medications include metoclopramide, domperidone, erythromycin and cholinergic medications such as bethanechol [14-20]. Medications known to slow gastric emptying include opioid narcotics, tramadol, tricyclic antidepressants, calcium channel blockers, dopamine agonists, octreotide, anticholinergics, clonidine, and phenothiazines [14,21-33]. Nicotine has also been shown to slow gastric emptying [13,34,35]. Acute changes in blood sugar impact gastric motility. Gastric emptying is slower with hyperglycemia and accelerated during hypoglycemia [6,36-38]. Painful stimuli may also slow gastric emptying as the human body releases noradrenaline in response to painful stimuli which inhibits gastric emptying and tone [34,39].

GE studies are currently performed in both the outpatient and inpatient setting; however, there is no data on the prevalence of positive and negative testing between these two populations. Inpatients are more likely to be immobile, experiencing painful stimuli, and, most importantly, receive medications known to alter gastric motility. Therefore, we hypothesize that inpatient studies will have a higher rate of positive tests. Our aim was to identify the incidence and determinants of abnormal GE studies in the outpatient and inpatient setting.

Materials and Methods

After obtaining approval from the Institution Review Board of Saint Louis University a retrospective chart review was performed. All scintigraphic GE studies done between June 1, 2012 and April 11, 2014 at Saint Louis University hospital were identified through our radiological database and via CPT codes. The start date was chosen as it coincided with the first day our electronic health record was initiated. Data collected included demographics, details of the gastric emptying study, medications and past medical history. Labs and imaging performed within one year prior to the gastric emptying study date were also collected. Descriptive statistics were used to report findings with categorical variables analyzed using Pearson Chi-Square test and continuous variables analyzed with independent sample t-test. All statistical analyses were performed using IBM SPSS Statistics version 21.0 software [40].

Results

A total of 122 GE studies were identified; 107 (34 inpatient, 73 outpatient) were analyzed. Thirteen studies were excluded because the subjects were less than eighteen years of age and two because the studies were not performed at our institution. Six other studies were deemed incomplete and excluded from the analysis (Two patients vomited prior to completing the study. One patient refused to finish the study. Two studies included either duodenal or esophageal activity. One study was done with tube feeds and only T1/2 was recorded).

42 (22 inpatient, 20 outpatient) tests were positive and 59 (8 inpatient, 51 outpatient) tests were negative for impaired gastric emptying. Inpatient GE testing was abnormal in 73% of the cases as compared to outpatient GE testing at 28% ($p<0.01$). The study flow is shown in Figure 1. Nearly all, 97%, inpatients received a medication known to alter gastric motility within 72 hours of testing. In comparison, 70% of outpatients were prescribed a medication known to alter gastric motility. 67% of inpatients received opioid narcotics within 72 hours of testing compared to 28% prescribed as an outpatient ($p<0.001$). 23% of inpatients received tramadol within 72 hours of testing compared to 13% of outpatients (Table 1).

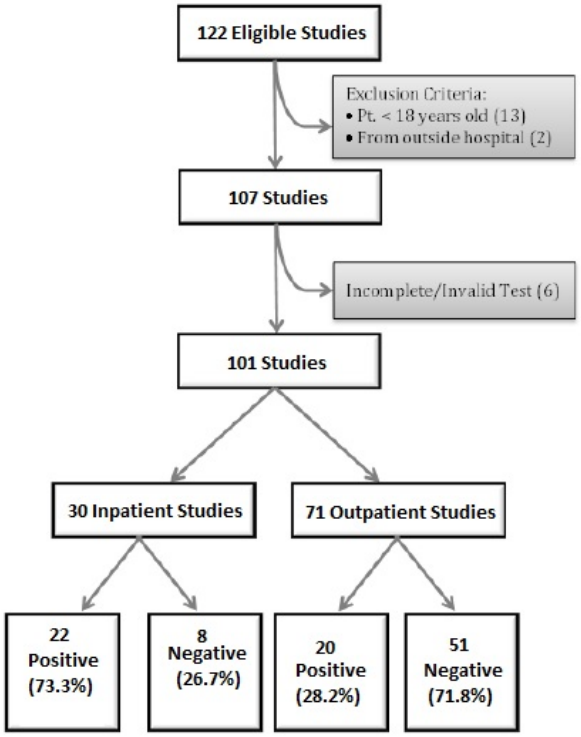

Figure 1: Study flow of inpatient and outpatient gastric emptying testing.

	Inpatient (n=30)	Outpatient (n=71)	p-value[a]
Medications, n (%)			
Decrease gastric motility 1	25 (83.3)	49 (69.0)	0.14
Increase gastric motility 2	17 (56.7)	12 (16.9)	<0.001*
Opioids	20 (66.7)	20 (28.2)	<0.001*
Tramadol	7 (23.3)	9 (12.7)	0.23[a]
Tricyclic Antidepressants	0 (0)	14 (19.7)	0.005*[a]
Calcium Channel Blockers	8 (26.7)	16 (22.5)	0.66

Dopamine Agonist	0 (0)	4 (5.6)	0.31[a]
Anticholinergics	3 (10.0)	9 (12.7)	1.00[a]
Clonidine	3 (10.0)	4 (5.6)	0.42[a]
Phenothiazine	8 (26.7)	10 (14.1)	0.13
Erythromycin	2 (6.7)	1 (1.4)	0.21[a]
Domperidone	1 (3.3)	1 (1.4)	0.51[a]
Metoclopramide	15 (50.0)	10 (14.1)	<0.001*

[a] Fisher's Exact test reported due to small cell sizes.

*Significant at p<0.05

1 Metoclopramide, Domperidone, Erythromycin

2 Opioids, Tramadol, Tricyclic Antidepressants, Calcium Channel Blockers, Dopamine agonists, Anticholinergics, Clonidine, and Phenothiazines

Table 1: Medications – Inpatient vs. Outpatient

Mean patient age was 51 years (64% female, 60% Caucasian). There were more women in the outpatient population (p=0.04). Inpatient GE studies were performed more often in African Americans, while the outpatient population was mostly Caucasian (p=0.002). The mean BMI for inpatients was 25.90 compared to 29.49 for the outpatients (p=0.02). Table 2 highlights demographics of the study. However, when comparing age, sex, race, ethnicity and BMI there was no statistically significant difference between positive and negative tests (data not shown).

	Inpatient (n=30)	**Outpatient (n=71)**	**p-value**
Age in years, mean (SD)	53.77 (18.6)	50.08 (16.9)	0.33
Sex, n (%)			
Male	15 (50.0)	20 (28.2)	<0.04*
Female	15 (50.0)	51 (71.8)	
Race, n (%)			
Caucasian	12 (40.0)	52 (73.2)	0.002*
African American	18 (60.0)	19 (26.8)	
Ethnicity			
Hispanic	1 (3.3)	5 (7.0)	0.67[a]
Non-Hispanic	29 (96.7)	66 (93.0)	
BMI, mean (SD)	25.90 (6.3)	29.49 (7.0)	0.02*

[a] Fisher's Exact test reported due to small cell sizes.

*Significant at p<0.05

Table 2: Demographics – Inpatient vs. Outpatient.

The indications most commonly documented by providers for testing were nausea and/or vomiting (44%) followed by abdominal pain (25%) and early satiety (8%). Similarly, patients reported nausea and/or vomiting (84%), abdominal pain (68%), and gastroesophageal reflux disease (GERD) symptoms (51%) prior to testing. These are patient reported symptoms as documented in admission history or the clinic progress note. Nausea and vomiting were associated with positive tests (p=0.03) and the presence of classic GERD symptoms was associated with negative tests (p=0.01) across both inpatient and outpatient populations (Table 3).

Symptoms	**Positive (n=42)**	**Negative (n=59)**	**P- valuea**
Nausea &/Or Vomiting			
Neither	6 (14.3)	10 (16.9)	
Nausea Only	7 (16.7)	20 (33.9)	0.03*
Vomiting Only	0 (0)	4 (6.8)	
Both Nausea & Vomiting	29 (69.0)	25 (42.4)	
Abdominal Pain			
No Pain	14 (33.3)	18 (30.5)	
Chronic (>6 months)	18 (14.9)	36 (61.0)	0.06
Acute/Sub-acute (<6 months)	10 (23.8)	5 (8.5)	
GERD	15 (35.7)	36 (61.0)	0.01*
Early Satiety	6 (14.3)	9 (15.3)	0.89
Post-Prandial Fullness	7 (16.7)	7 (11.9)	0.49
Weight Loss			
None	30 (71.4)	41 (69.5)	0.72
>10 pounds in last year	7 (16.7)	13 (22.0)	
<10 pounds in last year	5 (11.9)	5 (8.5)	
Delayed Emesis	0 (0)	3 (5.1)	0.26[a]
Diarrhea	11 (26.2)	16 (27.1)	0.92
Constipation	8 (19.0)	21 (35.6)	0.07
Chest Pain	5 (11.9)	8 (13.6)	0.81
Other Pain (not abdominal/chest)	4 (9.5)	8 (13.6)	0.76[a]

[a] Fisher's Exact test reported due to small cell sizes.

*Significant at p<0.05

Table 3: Patient reported symptoms – Positive vs. Negative Test.

When comparing negative versus positive tests there was no statistical difference between patients with a prior cholecystectomy or total abdominal hysterectomy, however 41% of all patients undergoing GE studies had a hysterectomy prior to testing and 40% of patients had a cholecystectomy.

Patients with diabetes (type 1 or 2) were 2.28 (95% CI 1.00-5.17), times more likely to have a positive test than patients without diabetes. Half of the abnormal tests were found in patients with diabetes.

There was no association between duration of diabetes and increasing prevalence of positive tests. The frequency of all other

disease states was too infrequent to assess any association with positive vs. negative tests (Table 4).

	Positive (n=42)	Negative (n=59)	p-value[a]
Medical History, n (%)			
Diabetes	21 (50.0)	18 (30.5)	0.05*
Post Viral Syndrome	0 (0)	1 (1.7)	1.00[a]
Other Connective Tissue Disease	1 (2.4)	1 (1.7)	1.00[a]
Surgical History, n (%)			
Any Abdominal Surgery	19 (45.2)	21 (35.6)	0.33
Any Thoracic Surgery	5 (11.9)	4 (6.8)	0.48[a]
Cholecystectomy	16 (38.1)	24 (40.7)	0.79
Total Abdominal Hysterectomy	13 (48.1)	14 (34.1)	0.15

[a] Fisher's Exact test reported due to small cell sizes.

*Significant at p<0.05

Table 4: PMH and PSH – Positive vs. Negative Test.

The majority of diabetic subjects (72%) had a hemoglobin A1c recorded and the average hemoglobin A1c was 7.9%. There was no association between increased A1c levels and increased prevalence of positive tests. Nearly all the inpatients (93%) had a morning fasting glucose documented on the day of testing. The mean glucose was 131 with a maximum of 267 and a minimum of 55. Subjects with a positive GE test had statistically significant lower mean albumin level (3.38) compared to those with a negative test (3.81), p=0.007.

Discussion

The impact admission status has on GE studies had not been reported in the literature previously. Our retrospective study found a statistically significant association between an increase in positive tests and inpatient status. This may be due to the effect of medications received as an inpatient as nearly all inpatients (97%) received medications known to alter gastric motility and a majority received opioid narcotics within 72 hours of testing. In addition, there was a statistically significant difference in inpatient (66.7%) versus outpatient (28.2%) opioid use (p<0.001). Given opioids strong anti-motility properties this may play a key role in the increased rate of positive tests in the inpatient setting.

Pro-motility agents were given to 56.7% of inpatients prior to testing whereas clinical records indicated just 16.9% of outpatients had previously been prescribed such medication (p<0.001). Metoclopramide was the most commonly prescribed pro-motility medication (88% of the inpatients and 83% of the outpatients). The most common indication for admission was nausea and/or vomiting and metoclopramide is often used for its anti-emetic properties in the inpatient setting as well as empirically to treat presumed gastroparesis. Despite the high number of patients receiving such medications there was still a very high number of abnormal gastric emptying studies in the inpatient population. A possible explanation for this could be that the combination of opioid medications, immobility and general pain/discomfort these inpatients are experiencing is a stronger factor in modifying gastric motility then metoclopramide. In the outpatient setting the use of metoclopramide as a therapeutic agent for impaired gastric motility might be successful, therefore decreasing the number of positive tests seen in the outpatient setting.

The correlation between subjective symptoms and objective findings of impaired gastric motility is poor and symptoms are generally poor markers of gastroparesis [41,42]. However, in our study there was a statistically significant association between an increased risk of a positive test and the symptoms of nausea and/or vomiting (p=0.03). Nausea and vomiting symptoms were also the most common indication for testing (44%) and the most common patient reported symptoms (84%).

Current guidelines recommend that patient's with classic symptoms of GERD undergo a trial of proton pump inhibitors as an initial diagnostic and therapeutic intervention [43]. In our study, classic GERD symptoms were associated with a negative test (p=0.01). This finding seems to validate current guidelines, thus illustrating the need for thorough history taking and thoughtful decisions on differential diagnosis and further testing.

A high percentage of patients had either a prior cholecystectomy (40%) or total abdominal hysterectomy (41%) prior to testing for gastroparesis. Given the relative difficulty in making a diagnosis of gastroparesis due to poor correlation between clinical symptoms and documented gastroparesis, the high prevalence of abdominal surgeries may be related to misdiagnosis. This can be seen in other abdominal pain syndromes. For example, the numbers of abdominal and pelvic surgeries are disproportionately high despite normal pathology and histology in surgically resected tissue in IBS patients [44]. In the setting of visceral pain syndromes, patients may be inappropriately exposed to procedures that place unnecessary financial burdens, with increased morbidity and mortality.

Not surprisingly, patients with diabetes mellitus were more likely to have a positive test than patients without diabetes. In addition, the majority of the abnormal tests were found in patients with diabetes. Longer duration of disease and poorer glycemic control are potential risk factors for developing gastroparesis [12]. However, in our study these associations were not seen. Because of the retrospective study, we had limited data on glycemic control and duration of diabetes mellitus.

As stated earlier, elevated blood glucose at the time of testing can slow gastric motility. In our study nearly all the inpatients (93%) had a fasting morning glucose documented on the day of testing. They were all fairly well controlled as the mean glucose was 131 with a maximum of 267 and a minimum of 55. Given this data, it is unlikely that elevated glucose levels are the driving force behind the increased number of positive tests seen in the inpatient population.

As albumin is a marker of general nutrition, it is not surprising that patients with delayed gastric emptying have significantly lower markers of nutrition. In fact, one prospective study of 146 patients with gastroparesis showed that as many as 21% required nutritional support with either a feeding tube or parenteral nutrition [8].

This study had several limitations inherent to a retrospective chart review. Data was collected using electronic medical records retrospectively through charts subject to incomplete records and missing data. Although there was a statistically significant increase in positive studies done as an inpatient and many of these patients received medication known to alter gastric motility, this only establishes association and not causality. In addition, our patient

population was comprised of African Americans and Caucasians which limits the ability to generalize our findings to the general population.

Our documentation of outpatient medications was limited to clinic visits closest to the gastric emptying study as our radiology department does not collect medication history at the time of the study. Although this is a limitation of our study, it also provides an avenue for improving patient care and physician practices. Guidelines suggest that ordering providers counsel patients on the discontinuation of appropriate medications prior to testing [45]. In addition, documentation that these medications have been stopped prior to testing regardless of the study location (inpatient or outpatient) is imperative to ensuring the validity of the GE study as symptoms of gastroparesis are non-specific and may correlate poorly with documented gastroparesis. However, providers may forget to counsel patients and/or patients may forget to discontinue medications. Creating an intake form to be completed by the patient prior to testing will allow the physicians to more accurately interpret the study and will provide valuable information to the physician when deciding on a diagnosis and treatment plan.

Optimizing diagnosis and management of patients with gastroparesis is further heightened as it appears that the prevalence of gastroparesis is increasing with significant impact on morbidity, mortality, quality of life and an increased burden on health care systems [1,46]. It is well documented that certain patient factors can greatly affect gastric motility and many of these factors are different between inpatient and outpatient populations. Our study demonstrates a statistically significant increased proportion of abnormal GE studies in inpatient studies when comparing inpatient to outpatient studies. However, a majority of these inpatient studies are being done with patients who have received medications known to alter gastric motility and therefore may be at an increased risk for false positives. Data from this study may help to improve the sensitivity and specificity of GE studies.

References

1. Wang YR, Fisher RS, Parkman HP (2008) Gastroparesis-related hospitalizations in the United States: trends, characteristics, and outcomes, 1995-2004. Am J Gastroenterol 103: 313-322.
2. Camilleri M, Bharucha AE, Farrugia G (2011) Epidemiology, mechanisms, and management of diabetic gastroparesis. Clin Gastroenterol Hepatol 9: 5-12.
3. Kassander P (1958) Asymptomatic gastric retention in diabetics (gastroparesis diabeticorum). Ann Intern Med 48: 797-812.
4. Keshavarzian A, Iber FL, Vaeth J (1987) Gastric emptying in patients with insulin-requiring diabetes mellitus. Am J Gastroenterol 82: 29-35.
5. Kong MF, Horowitz M, Jones KL, Wishart JM, Harding PE (1999) Natural history of diabetic gastroparesis. Diabetes Care 22: 503-507.
6. Jones KL, Russo A, Stevens JE, Wishart JM, Berry MK, et al. (2001) Predictors of delayed gastric emptying in diabetes. Diabetes Care 24: 1264-1269.
7. Jung HK, Choung RS, Locke GR 3rd, Schleck CD, Zinsmeister AR, et al. (2009) The incidence, prevalence, and outcomes of patients with gastroparesis in Olmsted County, Minnesota, from 1996 to 2006. Gastroenterology 136: 1225-1233.
8. Soykan I, Sivri B, Sarosiek I, Kiernan B, McCallum RW (1998) Demography, clinical characteristics, psychological and abuse profiles, treatment, and long term follow-up of patients with gastroparesis. Dig Dis Sci 43: 2398-2404.
9. Hyett B, Martinez FJ, Gill BM, Mehra S, Lembo A, Kelly CP, et al. (2009) Delayed radionucleotide gastric emptying studies predict morbidity in diabetics with symptoms of gastroparesis. Gastroenterology 137: 445-452.
10. Punkkinen J, Färkkilä M, Mätzke S, Korppi-Tommola T, Sane T, et al. (2008) Upper abdominal symptoms in patients with Type 1 diabetes: unrelated to impairment in gastric emptying caused by autonomic neuropathy. Diabet Med 25: 570-577.
11. Talley NJ, Young L, Bytzer P, Hammer J, Leemon M, et al. (2001) Impact of chronic gastrointestinal symptoms in diabetes mellitus on health-related quality of life. Am J Gastroenterol 96: 71-76.
12. Camilleri M (2007) Clinical practice. Diabetic gastroparesis. N Engl J Med 356: 820-829.
13. Abell TL, Camilleri M, Donohoe K, Hasler WL, Lin HC, et al. (2008) Consensus recommendations for gastric emptying scintigraphy: a joint report of the American Neurogastroenterology and Motility Society and the Society of Nuclear Medicine. Am J Gastroenterol 103: 753-763.
14. Parkman HP, Trate DM, Knight LC, Brown KL, Maurer AH, et al. (1999) Cholinergic effects on human gastric motility. Gut 45: 346-354.
15. McCallum RW, Ricci DA, Rakatansky H, Behar J, Rhodes JB, et al. (1983) A multicenter placebo-controlled clinical trial of oral metoclopramide in diabetic gastroparesis. Diabetes Care 6: 463-467.
16. Patterson D, Abell T, Rothstein R, Koch K, Barnett J (1999) A double-blind multicenter comparison of domperidone and metoclopramide in the treatment of diabetic patients with symptoms of gastroparesis. Am J Gastroenterol 94: 1230-1234.
17. Coulie B, Tack J, Peeters T, Janssens J (1998) Involvement of two different pathways in the motor effects of erythromycin on the gastric antrum in humans. Gut 43: 395-400.
18. Janssens J, Peeters TL, Vantrappen G, Tack J, Urbain JL, et al. (1990) Improvement of gastric emptying in diabetic gastroparesis by erythromycin. Preliminary studies. N Engl J Med 322: 1028-1031.
19. Richards RD, Davenport K, McCallum RW (1993) The treatment of idiopathic and diabetic gastroparesis with acute intravenous and chronic oral erythromycin. Am J Gastroenterol 88: 203-207.
20. Rowbotham DJ, Bamber PA, Nimmo WS (1988) Comparison of the effect of cisapride and metoclopramide on morphine-induced delay in gastric emptying. Br J Clin Pharmacol 26: 741-746.
21. Nimmo WS, Heading RC, Wilson J, Tothill P, Prescott LF (1975) Inhibition of gastric emptying and drug absorption by narcotic analgesics. Br J Clin Pharmacol 2: 509-513.
22. Crighton IM, Martin PH, Hobbs GJ, Cobby TF, Fletcher AJ, et al. (1998) A comparison of the effects of intravenous tramadol, codeine, and morphine on gastric emptying in human volunteers. Anesth Analg 87: 445-449.
23. Maurer AH, Krevsky B, Knight LC, Brown K (1996) Opioid and opioid-like drug effects on whole-gut transit measured by scintigraphy. J Nucl Med 37: 818-822.
24. Mittal RK, Frank EB, Lange RC, McCallum RW (1986) Effects of morphine and naloxone on esophageal motility and gastric emptying in man. Dig Dis Sci 31: 936-942.
25. Jeong ID, Camilleri M, Shin A, Iturrino J, Boldingh A, et al. (2012) A randomised, placebo-controlled trial comparing the effects of tapentadol and oxycodone on gastrointestinal and colonic transit in healthy humans. Aliment Pharmacol Ther 35: 1088-1096.
26. Vella A, Lee JS, Camilleri M, Szarka LA, Burton DD, et al. (2002) Effects of pramlintide, an amylin analogue, on gastric emptying in type 1 and 2 diabetes mellitus. Neurogastroenterol Motil 14: 123-131.
27. Ratner RE, Dickey R, Fineman M, Maggs DG, Shen L, et al. Amylin replacement with pramlintide as an adjunct to insulin therapy improves long-term glycemic and weight control in Type 1 diabetes mellitus: a 1-year, randomized controlled trial. Diabet Med 21: 1204-1212.
28. Foxx-Orenstein A, Camilleri M, Stephens D, Burton D (2003) Effect of a somatostatin analogue on gastric motor and sensory functions in healthy humans. Gut 52: 1555-1561.

29. Parkman HP, Hasler WL, Fisher RS (2004) American Gastroenterological Association technical review on the diagnosis and treatment of gastroparesis. Gastroenterology 127: 1592.
30. Bouras EP, Talley NJ, Camilleri M, Burton DD, Heckman MG, et al. (2008) Effects of amitriptyline on gastric sensorimotor function and postprandial symptoms in healthy individuals: a randomized, double-blind, placebo-controlled trial. Am J Gastroenterol 103: 2043.
31. Foxx-Orenstein A, Camilleri M, Stephens D, Burton D (2003) Effect of a somatostatin analogue on gastric motor and sensory functions in healthy humans. Gut 52: 1555-1561.
32. Linnebjerg H, Park S, Kothare PA, Trautmann ME, Mace K, et al. (2008) Effect of exenatide on gastric emptying and relationship to postprandial glycemia in type 2 diabetes. Regul Pept 151: 123-129.
33. Wright AB, McKelvey GM, Wood AK, Post EJ (1999) Effects of promethazine on porcine gastroduodenal function: a sonographic study. Ultrasound Med Biol 25: 241-247.
34. Nowak A, Jonderko K, Kaczor R, Nowak S, Skrzypek D (1987) Cigarette smoking delays gastric emptying of a radiolabelled solid food in healthy smokers. Scand J Gastroenterol 22: 54-58.
35. Miller G, Palmer KR, Smith B, Ferrington C, Merrick MV (1989) Smoking delays gastric emptying of solids. Gut 30: 50-53.
36. Fraser RJ, Horowitz M, Maddox AF, Harding PE, Chatterton BE, et al. (1990) Hyperglycaemia slows gastric emptying in type 1 (insulin-dependent) diabetes mellitus. Diabetologia 33: 675-680.
37. Samsom M, Akkermans LM, Jebbink RJ, van Isselt H, vanBerge-Henegouwen GP, et al. (1997) Gastrointestinal motor mechanisms in hyperglycaemia induced delayed gastric emptying in type I diabetes mellitus. Gut 40: 641-646.
38. Schvarcz E, Palmér M, Aman J, Lindkvist B, Beckman KW (1993) Hypoglycaemia increases the gastric emptying rate in patients with type 1 diabetes mellitus. Diabet Med 10: 660-663.
39. Bojö L, Cassuto J, Nellgård P (1992) Pain-induced inhibition of gastric motility is mediated by adrenergic and vagal non-adrenergic reflexes in the rat. Acta Physiol Scand 146: 377-383.
40. IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.
41. Talley NJ, Locke GR 3rd, Lahr BD, Zinsmeister AR, Tougas G, et al. (2006) Functional dyspepsia, delayed gastric emptying, and impaired quality of life. Gut 55: 933-939.
42. Jones KL, Russo A, Berry MK, Stevens JE, Wishart JM, et al. (2002) A longitudinal study of gastric emptying and upper gastrointestinal symptoms in patients with diabetes mellitus. Am J Med 113: 449-455.
43. Katz P, Gerson L, Vela M. Philip O (2013) Diagnosis and Management of Gastroesophageal Reflux Disease. Am J Gastroenterol 108: 308-328.
44. Hasler WL, Schoenfeld P (2003) Systematic review: Abdominal and pelvic surgery in patients with irritable bowel syndrome. Aliment Pharmacol Ther 17: 997-1005.
45. Camilleri M, Parkman HP, Shafi MA, Abell TL, Gerson L (2013) Clinical guideline: management of gastroparesis. Am J Gastroenterol 108: 18-37.
46. Bell RA, Jones-Vessey K, Summerson JH (2002) Hospitalizations and outcomes for diabetic gastroparesis in North Carolina. South Med J 95: 1297-1299.