**Turk J Gastroenterol** *2016; 27: 415-20*

# Gastric myoelectrical activity abnormalities of electrogastrography in patients with functional dyspepsia

STOMACH

*Yusuf Kayar[1], Ahmet Danalıoğlu[1], Abdullah Al Kafee[2], Şükrü Okkesim[2], Hakan Şentürk[1]*

[1]Department of Internal Medicine, Division of Gastroenterology, Bezmialem Vakıf University School of Medicine, İstanbul, Turkey
[2]Department of Biomedical Engineering, Fatih University Institute of Biomedical Engineering, İstanbul, Turkey

Original Article

## ABSTRACT

**Background/Aims:** Pathogenesis of functional dyspepsia (FD) is unclear and not well documented. Some gastric motility abnormalities have been reported to be important factors. Transcutaneous electrogastrography (EGG) is an experimental method that is used to assess FD. We aimed to compare FD patients with control subjects in terms of motility abnormalities according to the EGG results.

**Materials and Methods:** Thirty patients with FD and thirty control subjects were included. EGG was preprandially and postprandially performed. The recordings were analyzed and compared between the two groups.

**Results:** Mean ages of the cases and controls were 31.4±9.3 and 32.58±7.6 years, respectively. Female subjects constituted 80% of the FD group and 76.67% of the control group. In terms of the preprandial dominant frequency (DF), the FD group demonstrated lower incidence of normal subjects than the control group [13 (43.3%) and 22 (73.3%), respectively] and a higher incidence of bradygastria than the control group [17 (56.7%) and 8 (26.6%), respectively]. In the FD group, the rate of cases with normal postprandial DF was lower than that in the control group [10 (33.3%) and 23 (76.7%), respectively], whereas the rates of bradygastria [18 (60%) and 7 (23.3%), respectively] and tachygastria [2 (6.7%) and 0 (0%), respectively] were higher in the FD group ($p<0.05$). Preprandial and postprandial DF values were statistically significant in both groups.

**Conclusion:** A high incidence of gastric motility and myoelectrical activity abnormalities was observed in patients with FD. EGG is an effective, reliable, and non-invasive method in differentiating the subgroups. After standardization of some parameters, EGG may be an essential and irreplaceable test to diagnose and follow-up FD patients with motor dysfunction.

**Keywords:** Functional dyspepsia, electrogastrography, gastric motility, myoelectrical activity

## INTRODUCTION

Functional dyspepsia (FD) is a clinical syndrome characterized by symptoms such as recurrent or persistent epigastric pain, abdominal discomfort, early satiety, abdominal fullness, nausea, and vomiting (1). Organic pathologies with similar symptoms should be excluded before diagnosing FD (2,3). Epidemiological studies have reported a similar incidence of functional gastrointestinal diseases in Europe and the United States of America (USA) and a lower incidence of such diseases in Asia (4). The pathogenesis of FD is not yet clearly known (5). Some genetic factors such as polymorphism or psychosocial factors or some other factors regarding bacterial flora are likely responsible for pathogenesis (2,5). Most of the patients with dyspeptic complaints of unknown cause were found to have various gastric and duodenal motility abnormalities leading to antral hypomotility (6,7), gastric motor abnormalities due to abnormal gastric myoelectrical activity, and delayed gastric emptying (8).

Transcutaneous electrogastrography (EGG) is a non-invasive technique that evaluates slow wave activity and peak potentials of the gastric contractions by measuring gastric myoelectrical activity (9). Cutaneous EGG recording of the myoelectrical signals are correlated

**Address for Correspondence:** Yusuf Kayar E-mail: ykayar@yahoo.com
**Received:** May 5, 2016 **Accepted:** August 29, 2016
 • Available online at www.turkjgastroenterol.org • DOI: 10.5152/tjg.2016.16281

Turk J Gastroenterol 2016; 27: 415-20



with serosal recording of the gastric myoelectrical activity (10). Gastric dysrhythmias can be detected by analyzing the EGG signal (1). Because it is more easily applicable than the other diagnostic techniques and is non-invasive, it is currently utilized in many fields for many conditions such as FD, pregnancy, anorexia nervosa, recurrent vomiting, and idiopathic and diabetic gastroparesis (5,9). Although much improvement has been made in the EGG field within the last twenty years, difficulties experienced in the recording of myoelectrical activity and analysis of the obtained signals still persist (9). Some studies have revealed statistically significant differences between the patients with FD and healthy control groups with respect to EGG parameters (6,11), while some others have not (12,13). On the other hand, Pfaffenbach et al. (14) have detected a significant difference only in preprandial dysrhythmia whereas no postprandial difference has been detected.

The purpose of our study was to identify the prevalence of EGG abnormalities in FD patients by evaluating the myoelectrical activity and to compare FD patients with healthy control groups with respect to preprandial and postprandial EGG abnormalities.

## MATERIALS AND METHODS

### Study subjects

Thirty patients between 18 and 60 with FD who applied between June 2014 and April 2015 were included. The study was a randomized, controlled, and prospective study.

### FD group

Functional dyspepsia was diagnosed according to the Rome III Diagnostic Criteria for functional gastrointestinal disorders (FGIDs) (1). Demographic characteristics were documented after physical examination. Body mass index (BMI) was calculated in all subjects. All the participants fasted after midnight, and their blood samples were obtained the next morning. The blood samples were tested for glucose, BUN, urea, creatinine, sodium, potassium, calcium, AST, ALT, ALP, GGT, LDH, HbA1c, TSH, FT4, and complete blood count. Abdominal ultrasonography (USG) was performed. Video esophagogastroduodenoscopy (EGD) was performed by an experienced gastroenterologist (AD) under conscious sedation following an 8-hour fasting period and intravenous midazolam injection. The presence of focal lesions, esophagitis, gastric or duodenal ulcerations, erosions, and malignancy were investigated. Biopsies were taken for *Helicobacter pylori* from the gastric antrum and corpus. The patients with relevant pathology detected by laboratory tests, USG, or EGD and the patients with cardiovascular, gastrointestinal, pulmonary, hepatic, renal, metabolic, neurological and psychiatric diseases, malignancy, type I and II diabetes mellitus, gastroesophageal reflux disease, irritable bowel disease, pregnancy, history of major abdominal surgery, and on therapy that affects gastric motility were excluded.

### Control group

Thirty people without any disease or clinical complaint and a history of gastric dysrhythmic diseases were enrolled into the control group. None of the subjects were taking medications that might affect gastrointestinal motility. Similar lab tests, USG, and EGD were performed for participants, and only the subjects who had all their test results in a normal range were included.

### Ethics statement

All participants provided written informed consent for participation in the study. Ethics approval for conducting this study was obtained from the Ethical Committee of Bezmialem Vakıf University. All procedures were in accordance with the ethical standards of the committee on human experimentation of our institution and with the Declaration of Helsinki.

### Study protocol

EGG was performed in the morning following 8 hours of fasting. Initially, EGG recordings were obtained in the supine position for 30 minutes. Afterwards, the participants were given a standard meal (Standard test meal included 500 kcal of protein, fat, and carbohydrate. The meal consisted of two slices of toasted bread, one fried egg, and 330 mL of sour cherry juice) and EGG recordings were obtained in the supine position for 60 minutes.

### Analysis of gastric myoelectrical activity

The skin of the body site where the electrodes would be placed was shaved to remove abdominal hair and cleaned. A special gel was applied to reduce impedance of the skin–electrode interface. The first electrode was placed in the midline between the xiphoid and umbilicus and the second one on the left side of the body between the lower rib and the first electrode. The reference electrode was placed in the left lower quadrant at the left costal edge (15). Noise artifacts originating from motion, respiration, electrocardiography, and other gastrointestinal organs are an important problem in the evaluation of the EGG signals. Consequently, the signal/noise ratio of the EEG was significantly lower compared to our biological indices. Since visual analysis of EGG signals are very difficult because of this issue, computer-based signal analysis techniques were applied. The EGG recordings of all the participants were obtained in a silent room. The participants were told not to talk, not to read, and not to change their position in order to avoid motion artifacts. All EGG signals were recorded by a device of the 3 CPM Company that had approval from the Food and Drug Administration (FDA).

The obtained recordings were analyzed in the institute of Biomedical Engineering, Fatih University. The EGG signals were analyzed with an FFT (The Fast Fourier Transform)-based method called running spectral analysis (RSA). The RSA method, being frequently used for EGG analysis in literature, gives information about the frequency spectrum and its change in time. In this method, the signal is divided into predefined segments and FFT is performed on each segment. The frequency at which the power spectrum of a total recording had a peak power in the range of 0.5 to 9.0 cpm was defined as the dominant frequency (DF). In our study, DF was computed for pre- and post-feeding states. Gastric DF is nearly 3 cpm in healthy subjects; therefore, 2.5–3.5 cpm was accepted as normal (16,17). DF of EGG signals smaller than 2.4 cpm were called bradygastria, which results from a decreased number of antral contractions and reduced contractile effectiveness of the stomach. If DF was more than 3.6 cpm, it was called tachygastria, and it develops when an ectopic pacemaker occurs, in which the stomach is usually atonic (18). Gastric frequency more than 9 cpm was considered to be noise or electrical activity that originated from the large or small intestine (19).

### Statistical analysis

The statistical analysis of the data was performed using the SPSS 22.0 (IBM Corp.; Armonk, NY, USA) software package. The descriptive statistical methods (average, percentile±standard deviation, frequency, mean, and median) were used in the evaluation of the study data. The Mann–Whitney U test was used with intergroup comparisons for the parameters without normal distribution. The Chi-square test and Fisher's exact test were used in the comparison of qualitative data. The Wilcoxon Test was used to test the distribution for two variables. In the analyses, $p<0.05$ was accepted as statistically significant.

## RESULTS

The study included a total of 60 subjects including 30 patients with FD and 30 control subjects.

### The demographic characteristics of the groups

Mean ages of the patient group and the control group were 31.4±9.3 and 32.58±7.6 years, respectively. The female patients constituted 80% of the FD group, whereas the control group had 76.67% female subjects. Mean height, weight, and BMI value of the FD group were 163.4±6.4, 66.6±12.9, and 24.8±4.3, respectively; whereas those of the control group were 165.6±6.3, 66.8±14.4, and 23.7±2.8, respectively. The number of the female subjects was significantly higher in both FD and the control groups, and the mean height was significantly lower in the FD group. However, no significant relationship between age, weight, and BMI was detected. The demographic characteristics of the groups are presented in Table 1.

### The evaluation with respect to preprandial DF

Although the FD group demonstrated a lower incidence of normogastria than the control group [13 (43.3%) and 22 (73.3%), respectively] and higher incidence of bradygastria than the control group [17 (56.7%) and 8 (26.6%), respectively], no statistically significant difference was found. The DF value of the FD group was lower than that of the control group, and a statistically significant difference was found (Table 2, Figure 1).

**Table 1.** Demographics of the FD and control groups

| | FD group Mean±SD | Control group Mean±SD | p |
|---|---|---|---|
| Age | 31.4±9.3 | 32.58±7.6 | 0.8169 |
| Gender | 24 (80%) | 23 (76.67%) | 0.7450 |
| Height | 163.4±6.4 | 165.63±7.3 | 0.074 |
| Weight | 66.6±12.9 | 66.8±14.4 | 0.9457 |
| BMI | 24.8±4.3 | 23.7±2.8 | 0.21 |

FD: functional dyspepsia; BMI: body mass index; SD: standard deviation

**Table 2.** Comparison between the groups with respect to preprandial and postprandial EGG parameters

| | EGG | FD gastroparesis (n=30) | Control group (n=30) | p |
|---|---|---|---|---|
| Preprandial | Normal n (%) | 13 (43.3%) | 22 (73.3%) | 0.47 |
| | Bradygastria n (%) | 17 (56.7%) | 8 (26.6%) | |
| | Tachygastria n (%) | 0 | 0 | |
| | DF (cpm) | 2.04±0.61 | 2.41±0.276 | |
| | | (Median=1.94; Min=1.16, Max=3.57) | (Median=2.48; Min=1.78, Max=2.83) | 0.0155* |
| Postprandial | Normal n (%) | 10 (33.3%) | 23 (76.6%) | 0.028* |
| | Bradygastria n (%) | 18 (60%) | 7 (23.3%) | |
| | Tachygastria n (%) | 2 (6.7 %) | 0 | |
| | DF (cpm) | 2.14±0.62 Median=2.10; Min=1.15, Max=3.64) | 2.50±0.339 (Median=2.49; Min=1.74, Max=3.08) | 0.0234* |

EGG: electrogastrography; FD: functional dyspepsia; DF: dominant frequency; cpm: cycles per minute
*p<0.05

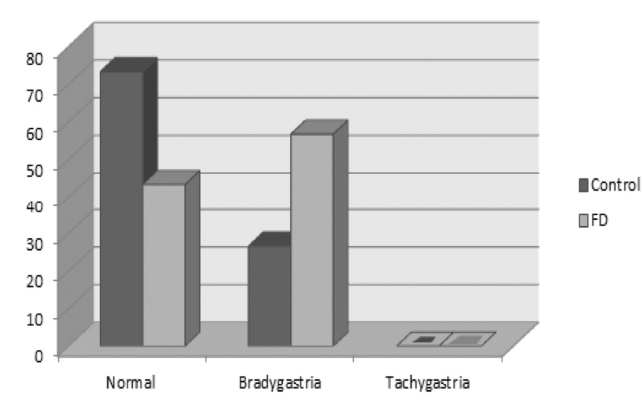


**Figure 1.** Preprandial EGG analysis in FD and control groups

### The evaluation with respect to postprandial DF

It was detected that, in terms of postprandial DF, the rate of the normal patients in the FD group was lower than in the control group [10 (33.3%) and 23 (76.6%), respectively), whereas the rate of bradygastria (18 (60%) and 7 (23.3%), respectively] and



Original Article

tachygastria [2 (6.7%) and 0 (0%), respectively] were higher in the FD group. These differences were found to be statistically significant (p<0.05). The FD group showed statistically significant lower incidence of DF than the control group (Table 2, Figure 2).

### The comparison between the groups with respect to preprandial and postprandial DF

An increase in postprandial DF value was noticed in both groups. However, this difference was not statistically significant (p values were 0.181 and 0.462, respectively; p>0.05) (Table 3).

## DISCUSSION

Some studies have shown that EGG is a reliable and precise technique for the measurement of gastric myoelectrical activity and is an effective method for subgroup analysis of functional gastrointestinal diseases accompanied by gastric motility abnormalities. These studies have suggested that 36%–60% of the patients with FD have EEG abnormalities and that EGG can detect gastric motility disorders in 93% of the cases. As a result, it has been shown that EGG is capable of performing a diagnostic analysis in the FD subgroups with abnormal myoelectrical rhythm (6,9).

However, controversial outcomes have been reported in the studies that used EGG parameters to compare patients with FD to healthy control groups. Leahy et al. (5) have detected

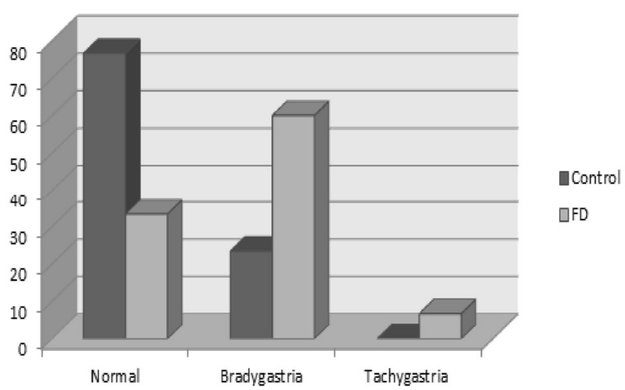


**Figure 2.** Postprandial EGG analysis in the FD and control groups

**Table 3.** Comparison between groups with respect to preprandial and postprandial DF

| | EGG | Preprandial | Postprandial | p |
|---|---|---|---|---|
| FD gastroparesis (n=30) | DF (cpm) | 2.04±0.61 (Median=1.94; Min=1.16, Max=3.57) | 2.14±0.62 (Median=2.10; Min=1.15, Max=3.64) | 0.181 |
| Control (n=30) | DF (cpm) | 2.41±0.276 (Median=2.48; Min=1.78, Max=2.83) | 2.50±0.339 (Median=2.49; Min=1.74, Max=3.08) | 0.462 |

EGG: electrogastrography; FD: functional dyspepsia; DF: dominant frequency; cpm: cycles per minute

gastric arrhythmias in 36% of the FD patients and have shown that this ratio is significantly higher than the control group. Lin et al. (6) have encountered an abnormal gastric myoelectrical activity in 9 (60%) of the 15 patients with FD and reported dysrhythmia in gastric slow waves and no increase in postprandial dominant power in most of the cases. Chey et al. (20) have reported the rate of gastric dysrhythmias to be 50% in the patients with unexplained dyspeptic complaints, whereas they have found no dysrhythmia in the control group. Geldof et al. (21) have demonstrated the presence of gastric dysrhythmia in 48% of the patients with unexplained nausea and vomiting while reporting no increase in postprandial amplitude in most of these patients. Cucchiara et al. (11) have also detected a high rate of gastric dysrhythmia in 14 pediatric patients with upper gastrointestinal symptoms. Also, studies have reported that patients with gastroparesis have high rate of gastric dysrhythmia similar to FD patients (8,22). Like the previous studies in the literature, we encountered a significantly higher rate of dysrhythmia in the FD patients compared to the control group subjects. However, Jebbink et al. (12) found no significant difference between the patients in FD and the control groups with respect to the incidence of dysrhythmia. Similarly, Oba-Kuniyoshi et al. (13) in their study on the dysmotility-like FD patients, reported no significant difference between the FD patients and the control subjects in terms of dysrhythmia. Inconsistency among the results of the studies may be caused by the fact that they have been conducted on patients with different diagnoses and that the diagnostic criteria for FD may vary. Additionally, variety in the content and the volume of the standard test meal, body positions of the patients during the recording, the recording environment, and movement of the patient during the recording, length of the recording, and changes in the analysis methods may play a role in obtaining different results (23).

The role of gastric electrical dysrhythmia and delayed gastric emptying has not been clearly identified yet. Also, there is limited information about the origin of the postprandial symptoms in patients with dysmotility-like FD (12,14). Although physiological abnormalities have been well documented in these studies, their relationship with the symptoms was not clearly described (5,12,24). However, studies on FD patients utilizing manometer and EGG have reported that antral hypomotility, changes in the electrical activity, and delayed gastric emptying are important mechanisms (6,8,12). Absence of fundal relaxation increases intragastric pressure and causes the displacement of food from the proximal end to the distal end. This leads to antral overdistention and causes the development of upper abdominal discomfort, distention, and nausea (12,25). Also, increased sensitivity to gastric distention due to visceral hyperalgesia plays a role in the development of these symptoms (26). On the other hand, animal studies have shown that tachygastria, an important factor leading to FD, develops in the absence of antral motility (27), and is correlated with levels of vasopressin and epinephrine and the quantitative nausea score (9,14).

Studies have demonstrated that 30%–80% of the patients with FD have delayed gastric emptying (6). Although radioscintigraphy may be helpful in the detection of delayed gastric emptying, it cannot provide information about the etiology (28). The reasons of delayed gastric emptying in FD patients can be gastric hypomotility and non-coordinated gastric contractions, which occur due to irregular gastric slow waves and also insufficient increase in the amplitude of postprandial gastric slow waves. These kinds of factors can be evaluated with gastric myoelectrical activity (6,8). Therefore, gastric myoelectrical activity is an important factor in the pathophysiology of FD.

Abnormalities of gastric myoelectrical activity, mainly dysrhythmia, are not found in all FD patients. This fact shows that there are several mechanisms apart from myoelectrical activity. Therefore, patients with FD constitute a heterogeneous population in terms of the underlying mechanism. EGG may differentiate FD patients with dysrhythmia from those having normal rhythm. Treatment regimens should primarily target the underlying pathophysiology (29). It has been demonstrated that prokinetic agents improve EGG abnormalities in the patients with gastroparesis (30). Thus, EGG outcomes may be helpful in the treatment selection in some cases. Also elimination of the gastric arrhythmogenic focus may contribute to clinical improvement (31). Additionally, EGG is not only effective in differentiating normal and dysrhythmic patients, but also useful to evaluate the effectivity of the given treatment.

As a conclusion, a high incidence of gastric motility and myoelectrical activity abnormalities were observed in patients with FD. EGG is an effective, reliable and non-invasive method in differentiating the subgroups. However, the test meal, localization of the electrodes, EGG recording duration, and analysis of the obtained recordings has not yet been standardized. Additionally, analysis of the data is based on various reference values for normal intervals. Therefore, widely accepted reference values remain to be determined. The studies of our center as well as other centers continue. The solution of the current problems will allow EGG to be an irreplaceable test in diagnosing FD with motor dysfunction as well as monitoring the efficacy of the selected treatment.

**Ethics Committee Approval:** Ethics committee approval was received for this study from the ethics committee of Bezmialem Vakıf University.

**Informed Consent:** Written informed consent was obtained from patients who participated in this study.

**Peer-review:** Externally peer-reviewed.

**Author Contributions**: Concept - A.D., S.O.; Design - A.D., S.O.; Supervision - A.D., S.O.; Materials - S.O., A.K.; Data Collection and/or Processing - S.O., A.K., Y.K.; Analysis and/or Interpretation - H.S.; Writer - Y.K., H.S., A.D.

**Acknowledgements:** Authors would like to thank The Scientific and Technological Research Council of Turkey – TÜBİTAK for the grant under construction 113E605.

**Conflict of Interest:** No conflict of interest was declared by the authors.

**Financial Disclosure:** The authors declare that this study has been supported by The Scientific and Technological Research Council of Turkey - TÜBİTAK.

## REFERENCES

1. Drossman DA, Dumitrascu DL. Rome III: New standard for functional gastrointestinal disorders. J Gastrointestin Liver Dis 2006; 15: 237.
2. Babara L, Camilleri M, Corinaldesi R, et al. Definition and investigation of dyspepsia: Consensus of an international ad hoc working party. Dig Dis Sci 1989; 34: 1272-6. **[CrossRef]**
3. Dobrek Ł, Thor PJ. Pathophysiological concepts of functional dyspepsia and irritable bowel syndrome future pharmacotherapy. Acta Pol Pharm 2009; 66: 447-60.
4. Mahadeva S, Goh KL. Epidemiology of functional dyspepsia: A global perspective. World J Gastroenterol 2006; 12: 2661-6. **[CrossRef]**
5. Leahy A, Besherdas K, Clayman C, Mason I, Epstein O. Abnormalities of the electrogastrogram in functional gastrointestinal disorders. Am J Gastroenterol 1999; 94: 1023-8. **[CrossRef]**
6. Lin Z, Eaker EY, Sarosiek I, McCallum RW. Gastric myoelectrical activity and gastric emptying in patients with functional dyspepsia. Am J Gastroenterol 1999; 94: 2384-9. **[CrossRef]**
7. Waldron B, Cullen PT, Kumar R, Smith D, Jankowski J, Hopwood D, et al. Evidence for hypomotility in non-ulcer dyspepsia: A prospective multifactorial study. Gut 199; 32: 246-51. **[CrossRef]**
8. Chen JD, Lin Z, Pan J, McCallum RW. Abnormal gastric myoelectrical activity and delayed gastric emptying in patients withsymptoms suggestive of gastroparesis. Dig Dis Sci 1996; 41: 1538-45. **[CrossRef]**
9. Riezzo G, Russo F, Indrio F. Electrogastrography in adults and children: the strength, pitfalls, and clinical significance of the cutaneous recording of the gastric electrical activity. Biomed Res Int 2013; 2013: 282757. **[CrossRef]**
10. Lin Z, Chen JD, Schirmer BD, McCallum RW. Postprandial response of gastric slow waves: correlation of serosal recordings with the electrogastrogram. Dig Dis Sci 2000; 45: 645-51. **[CrossRef]**
11. Cucchiara S, Riezzo G, Minella R, Pezzolla F, Giorgio I, Auricchio S.Electrogastrography in non-ulcer dyspepsia. Arch Dis Child 1992; 67: 613-7. **[CrossRef]**
12. Jebbink HJ, Van Berg-Henegouwen GP, Bruijs PP, Akkermans L, Smout AJ. Gastric myoelectrical activity and gastrointestinal motility in patients with functional dyspepsia. Eur J Clin Invest 1995; 25: 429-37. **[CrossRef]**
13. Oba-Kuniyoshi AS, Oliveira Jr JA, Moraes ER, Troncon LE. Postprandial symptoms in dysmotility-like functional dyspepsia are not related to disturbances of gastric myoelectrical activity. Braz J Med Biol Res 2004; 37: 47-53. **[CrossRef]**
14. Pfaffenbach B, Adamek RJ, Bartholomäus C, Wegener M. Gastric dysrhythmias and delayed gastric emptying in patients with functional dyspepsia. Dig Dis Sci 1997; 42: 2094-9. **[CrossRef]**
15. Brzana RJ, Koch KL, Bingaman S. Gastric Myoelectrical Activity in Patients With Gastric Outlet Obstruction and Idiopathic Gastroparesis. Am J Gastroenterol 1998; 93: 1803-9. **[CrossRef]**
16. Parkman HP, Hasler WL, Barnett JL, Eaker EY. Electrogastrography: a document prepared by the gastric section of the American Mo-

Original Article

tility Society Clinical GI Motility Testing Task Force. Neurogastroenterol Motil 2003; 15: 89-102. [CrossRef]

17. Morello R, Capua CD, Lamonaca F. "Diagnosis of Gastric Disorders by Non-invasive Myoelectrical Measurements". DIIES, University Mediterranea of Reggio Calabria, Italy. IEEE 6th International Workshop on Medical Measurement and Applications, 30-31 May, Bari, Italy, 2011: 261-6.
18. Kara S, Dirgenali F, Okkesim S. Estimating Gastric Rhythm Differences Using a Wavelet Method from the Electrogastrograms of Normal and Diabetic Subjects. Instrum Sci Technol 2005; 33: 519-32. [CrossRef]
19. Chang FY. Electrogastrography: Basic knowledge, recording, processing and its clinical applications. J Gastroenterol Hepatol 2005; 20: 502-16. [CrossRef]
20. Chey WY, You CH, Lee KY, Menguy R. Gastric dysrhythmias: Clinical aspects. In: Chey WY, ed. Functional dyspepsias of the digestive tract. New York: Raven Press, 1983: 175-81.
21. Geldof H, van der Schee EJ, van Blankenstein M, Grashuis JL. Electrogastrographic study of gastric myoelectrical activity in patients with unexplained nausea and vomiting. Gut 1986; 27: 799-808. [CrossRef]
22. Rothstein RD, Alavi A, Reynolds JC. Electrogastrography in patients with gastroparesis and effect of long-term cisapride. Dig Dis Sci 1993; 38: 1518-24. [CrossRef]
23. Levanon D, Zhang M, Chen JDZ. Efficiency and efficacy of the electrogastrogram. Dig Dis Sci 1998; 40: 1445-50.
24. van der Voort IR, Osmanoglou E, Seybold M, et al. Electrogastrography as a diagnostic tool for delayed gastric emptying in functional dyspepsia and irritable bowel syndrome. Neurogastroenterol Motil 2003; 15: 467-73. [CrossRef]
25. Troncon LE, Thompson DG, Ahluwalia NK, Barlow J, Heggie LJ. Relations between upper abdominal symptoms and gastric distension abnormalities in dysmotility like functional dyspepsia and after vagotomy. Gut 1995; 37: 17-22. [CrossRef]
26. Lémann M, Dederding JP, Flourié B, Franchisseur C, Ramband JC, Jian R. Abnormal perception of visceral pain in response to gastric distension in chronic idiopathic dyspepsia. Dig Dis Sci 1991; 36: 1249-54. [CrossRef]
27. Edelbroek M, Schuurkes J, De Ridder W, Horowitz M, Dent J, Akkermans L. Effect of cisapride on myoelectrical and motor responses of antropyloroduodenal region during intraduodenal lipid and antral tachygastria in conscious dog. Dig Dis Sci 1995; 40: 901-11. [CrossRef]
28. Jian R, Ducrot F, Ruskone A, et al. Symptomatic, radionuclide and therapeutic assessment of chronic idiopathic dyspepsia. Dig Dis Sci 1989; 34: 657-64. [CrossRef]
29. Talley NJ. Review article: functional dyspepsia--should treatment be targeted on disturbed physiology? Aliment Pharmacol Ther 1995; 9: 107-15. [CrossRef]
30. McCallum RW. Cisapride: A new class of prokinetic agent. Am J Gastroenterol 1991; 86: 135-49.
31. Rothstein RD, Alavi A, Reynolds JC. Electrogastrography in patients with gastroparesis and effect of long-term cisapride. Dig Dis Sci 1993; 38: 1518-24.[CrossRef]