A NOVEL APPROACH FOR DETECTION OF DIGESTIVE SYSTEM DISORDERS

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ABSTRACT

Digestive system is one of the most important systems in the human body, which plays major role directly or indirectly for the normal function of human body. Most of the people around the world have the digestive system disorders due to improper digestion of food due to inefficient performance of stomach activity. The main objective of this paper is to propose a novel method of finding the digestive system disorders using Electrogastrogram [EGG], which is a non-invasive, cheap and painless method. By detecting the electrical signal from the stomach cutaneously, EGG acts as a preliminary investigation without a need for Endoscopy which is painful investigation. The recording setup explained in this proposed system includes LabVIEW software and hardware which is used to record the EGG for more than hundred patients, nearly 75% of the patients suffered from digestive system disorders, such as Dyspepsia, Stomach ulcer, nausea, cyclic vomiting syndrome, etc. For the above said digestive system disorders, dissimilarity found in its frequency and amplitude is compared with its normal individual parameter (3cpm) at a fair amount of accuracy.

Keywords: digestive system, electrogastrogram, dyspepsia, nausea.

1. INTRODUCTION

An Electrogastrogram (EGG) is a non-invasive test used to measure gastric myoelectrical activity [2, 18]. The normal gastric myoelectrical activity consists of a slow wave and spike potential. The abnormality arises due to recurrent nausea, vomiting, Dyspepsia, Stomach ulcer, Cyclic vomiting syndrome, *etc* which signals that the stomach is not emptying food normally. If the electrogastrogram is abnormal, it confirms that the problem probably is with the stomach's muscles or the nerves that control the muscles. This paper deals with the novel approach of recording the electrical signals that travel through the muscles of the stomach and control the muscle's contraction. The EGG can be considered as an experimental procedure since its exact role in the diagnosis of digestive disorders of the stomach has not been defined yet.

2. ELECTROGASTROGRAM

An electrogastrogram is similar to an electrocardiogram of the heart. It is a recording of the electrical signals that travel through the muscles of the stomach and control the muscle's contraction. It is used when there is a suspicion that the muscles of the stomach or the nerves controlling the muscles are not working normally. It is done by placing the electrode cutaneously over the stomach and the electrical signals coming from the stomach's muscles are sensed by the electrode and recorded on a computer for analysis by the patient lying down without movement. In normal individuals, the electrogastrogram is a regular electrical rhythm generated by the muscles of the stomach and the power (voltage) of the electrical current increases after the meal. In patients with abnormalities of the muscles or nerves of the stomach, the rhythm often is irregular or there is no post-meal increase in electric power. This method will not have any side effects and it is a painless study.

3. PROPOSED EGG RECORDING SET UP

The Ag/Agcl electrodes [5, 12] are used as sensors to record the electrical activity of the stomach's muscle cutaneously. The electrical signals generated are usually of very low amplitude ranging from 0.01 to 0.5 mV which is given to signal conditioning unit (SCU) because proper conditioning of signals is necessary to produce analog signal without noise before giving it to the ADC. The SCU consist of instrumentation amplifier and low pass filter. The instrumentation amplifier has a gain of 1000 to 10,000. The amplified signals are input to a second order low pass Butterworth filter to remove the noises and ripples. The analog output of the filtered signal is converted to digital through Analog to Digital Converter (ADC). These outputs are then applied to a microcontroller circuit which transfers the digital outputs to the PC via RS232 to view the recorded signal in a readable form. The LabVIEW software which uses the graphical data flow programming technique for the purpose of recording EGG for the investigation of digestive system disorders is shown in Figure-1.

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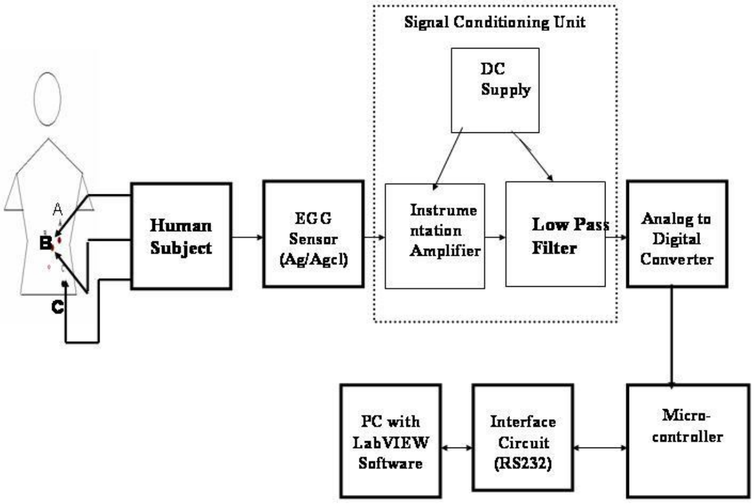

Figure-1. General block diagram for recording EGG.

4. THE ANATOMY OF THE STOMACH

The main function of the stomach is to process and transport food [2]. After feeding, the contractile activity of the stomach helps to mix, grind and eventually evacuate small portions of chyme into the small bowel, while the rest of the chyme is mixed and ground. Anatomically, the stomach can be divided into three major regions: fundus (the most proximal), corpus and antrum. Histologically, the fundus and corpus are hardly separable. In the antral area, the density of the smooth muscle cells increases. The area in the corpus around the greater curvature, where the split of the longitudinal layers takes place, is considered to be anatomically correlated with the origin of gastric electrical activity. The stomach wall, like the wall of most other parts of the digestive canal, consists of three layers: the mucosal (the innermost), the muscularis and the serosal (the outermost). The mucosal layer itself can be divided into three layers: the mucosa (the epithelial lining of the gastric cavity), the muscularis mucosae (low density smooth muscle cells) and the submucosal layer (consisting of connective tissue interlaced with plexi of the enteric nervous system). The second gastric layer, the muscularis, can also be divided into three layers: the longitudinal (the most superficial), the circular and the oblique. The longitudinal layer of the muscularis can be separated into two different categories: a longitudinal layer that is common with the esophagus and ends in the corpus, and a longitudinal layer that originates in the corpus and spreads into the duodenum as shown in Figure-2.

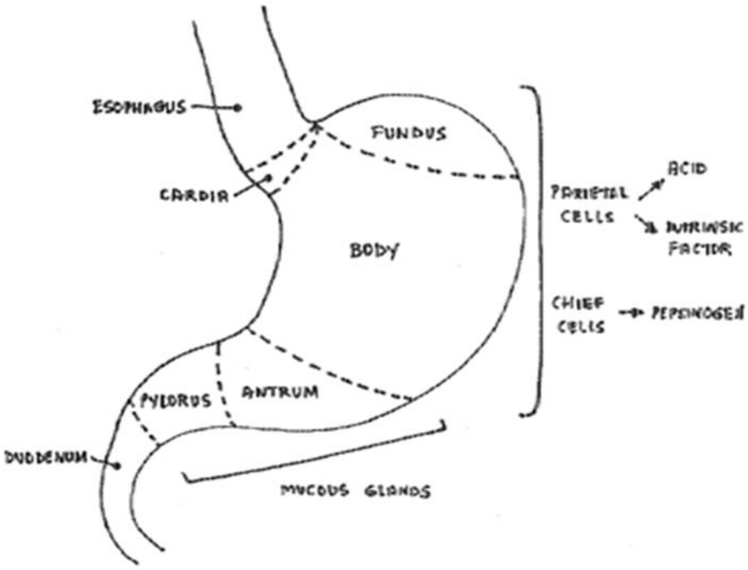

Figure-2. The anatomy of the stomach.

5. ELECTRODES POSITIONING

The electrical signals are generally produced in the mid-corpus of the stomach where the electrical activity takes place. The positioning of the Ag/ Agcl electrodes for tapping of these signals is as shown Figure-3. Two electrodes A and B are placed in the fundus and the mid corpus of the stomach. The third electrode C is placed as ground at the end of the stomach region for patient safety [4].

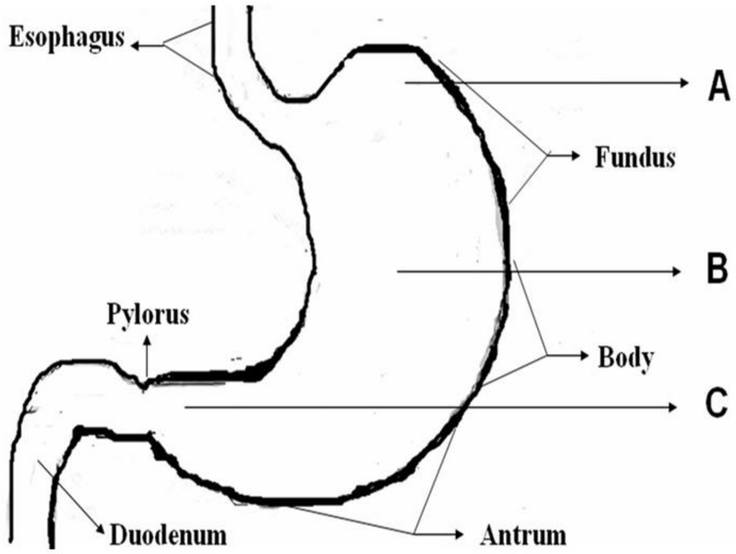

Figure-3. Electrode positioning for recording EGG.

5. MATERIALS AND METHODS

Patients consecutively attending a hospital outpatient's gastroenterology clinic were studied. All patients were considered by their general practitioner to have significant symptoms to merit referral to a specialist clinic for further evaluation and investigation. The patients included 50 with Dyspepsia, 40 with Stomach ulcer, and 25 with Nausea (Table 1). Hematological and biochemical profiles were normal in all patients.

Table-1. Sex and age distribution of patient groups.

Disorders	Mean Age (Years)	Male	Female
Dyspepsia (D) (N=50)	42	28	22
Stomach Ulcer (SU) (N=40)	31	19	31
Nausea (N) (N=25)	45	25	20

A gastrointestinal symptom profile was recorded on all patients immediately before the EGG [3, 7]. This profile detailed the presence or absence of the following dyspeptic symptoms in the previous 2 weeks: Dyspepsia (D), Stomach ulcer (SU), Nausea (N) and Cyclic vomiting syndrome. The EGG was performed after a 6 hours fasting. All medication with the potential affect to gastric function was discontinued for more than 48 hours before the recording. Patients were studied in a semireclaining position and requested to avoid any major movements. The skin was lightly abraded with gauze before placement of adhesive gel EGG electrodes. Two bipolar skin electrodes were placed on the abdomen, one on the fundus and the other on the mid-corpus. A reference electrode was placed on the right side of the abdomen. The electrodes were connected to a signal conditioning unit (SCU). The EGG recording included a 1 hour fasting study, after which the patient ate a sandwich (575 kcal, 50% carbohydrate, 25% protein, 25% fat) and drank 200ml of water. This was immediately followed by another 1 hour recording. Visual inspection of the waveform detected any obvious major movement artifacts. These were defined as abnormally large positive or negative peaks in the tracing and were detected from the analysis. The EGG data was observed by the LabVIEW software running on a personal computer. The EGG frequency ,amplitude are recorded and its respective values are stored for further analysis of the same to investigate the digestive system disorders as shown in Figure-4.

A sampling frequency of 4Hz was used. The EGG analysis is based on the frequency and amplitude of the signals. For the periods before and after the test meal, the frequency and amplitude values are observed. Normal electrical activity was defined as a frequency between: 2-4 cycles/minute [9, 17, and 20]. Activity of 0-2 cycles / minute was termed bradygastria, and 4-9 cycles / minute as tachygastria. The percentage of normal electrical activity, bradygastria, and tachygastria were calculated both before and after the test meal. The amplitude of the dominant frequency was measured both before and after

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the test meal. The electrical frequency is stable and does not change significantly after a standard test meal.

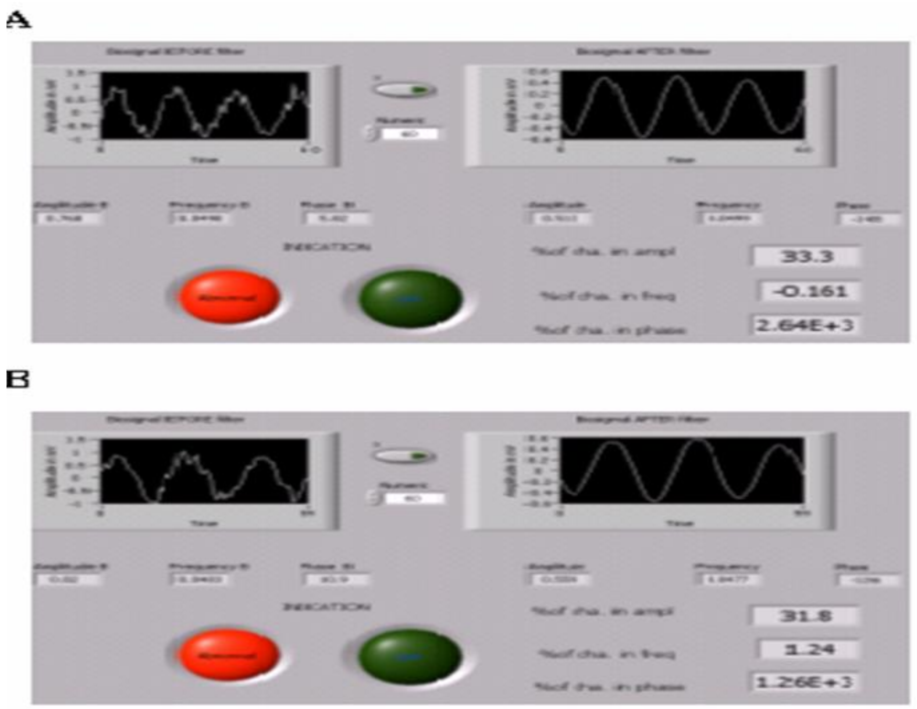

Figure-4. A and B are recorded EGG from dyspepsia and nausea patients, respectively.

6. ALGORITHM

The steps for the proposed EGG signal recording is given below:

i. Initialization of Analog to Digital Converter.
ii. Enable Serial Port to transmit data.
iii. Initialization of Timer.
iv. ADC values are read for amplitude.
v. Timer values are read for cycles.
vi. Conversion of values in to decimal.
vii. Data are sent to PC through serial port.
viii. Lab VIEW software is used to observe and Record.
ix. Continue from step iv.

7. RESULTS AND DISCUSSIONS

The effectiveness of the proposed methodology is illustrated and the Table-2 shows the range of frequencies and amplitudes for various abnormalities at preprandial and postprandial condition as observed from the recording setup in consultation of physician. The variation in frequency and amplitude values are observed between preprandial and postprandial condition as shown in Figure-6.

Table-2. Frequency and amplitude ranges of various disorders of stomach.

Conditions	Frequency (cpm)	Amplitude (V)
Preprandial		
Dyspepsia	4-5	0.65-0.95
Nausea	3.5-5.8	0.4-0.6
Vomiting	5.5-6.3	0.54-0.0.72
Stomach Ulcer	6-9	0.6 -0.78
Postprandial		
Dyspepsia	1-2.8	0.5-0.7
Nausea	2-3	0.3-0.8
Vomiting	2-3.5	0.42-0.67
Stomach Ulcer	1.3-2.5	0.3-0.5.5

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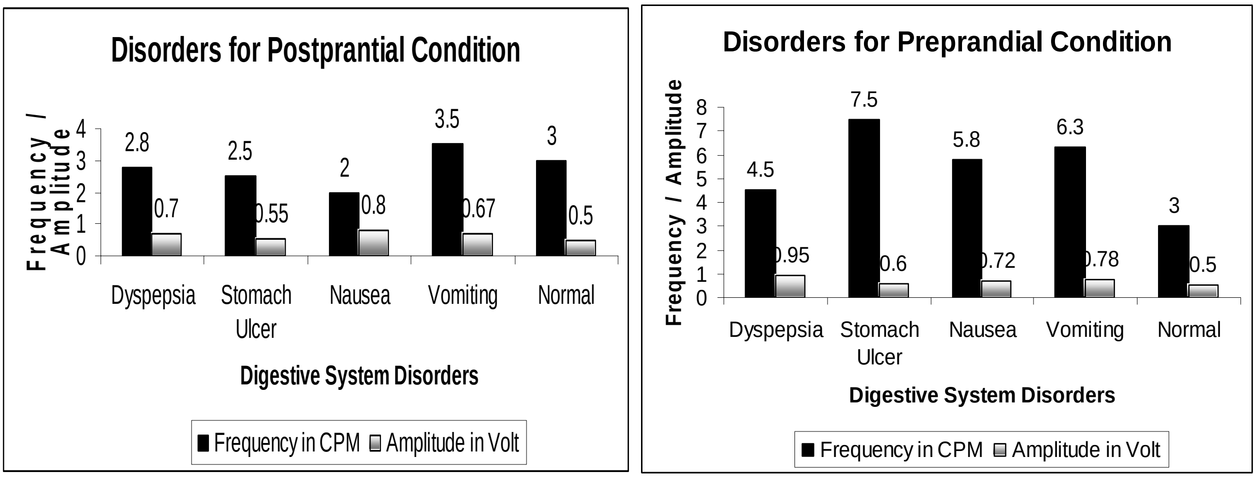

Figure-6. Bar chart represents the variation in frequency and amplitude for the digestive system disorder for preprandial and postprandial condition.

In this study, we have used the EGG to record myoelectrical activity for the patients suffering from Dyspepsia, Stomach ulcer, and Nausea. The abnormal EGG has a high specificity for the detection of abnormal myoelectrical activity [15, 16]. The observation that the test meal can worsen or correct the EGG reflects the interaction between fasting, feeding, and electrical activity. The effect of fasting or feeding indicates both an abnormality and change in the EGG recording. A postprandial power reduction has been proposed as an EGG abnormality, and correlated with gastroparesis [11]. However, in this study, eight controls demonstrated a postprandial power reduction, indicating that power reduction is an unreliable sign. The significance of power reduction after meals has also been questioned by a recent study comparing internal gastric electrical activity with the EGG [6]. There are important practical implications stemming from this study. In the absence of readily available tests in functional dyspepsia, there has been an assumption that patients with functional dyspepsia entered into clinical trials represent a homogeneous group. This study indicates that it is possible to identify a subgroup of patients with EGG evidence of abnormal gastric myoelectrical activity that is likely to have antral hypomotility. The EGG could help distinguish stomach ulcer from dyspepsia in clinical trials. The treatment of dyspepsia should be aimed at correcting physiological abnormalities [8]. A normal or abnormal EGG will not only help distinguish patient heterogeneity in clinical studies but might also provide a useful objective marker of treatment effect [10,13,14,19]. Further studies of statistical analysis, power spectrum and by using LabVIEW software in dyspepsia patients, with and without an abnormal EGG will help to determine whether these other abnormalities define more coherent or overlapping subtypes of disorder.

The Figure-7. shows the various waveforms obtained for various diseases. It is plotted between Amplitude and Time period.

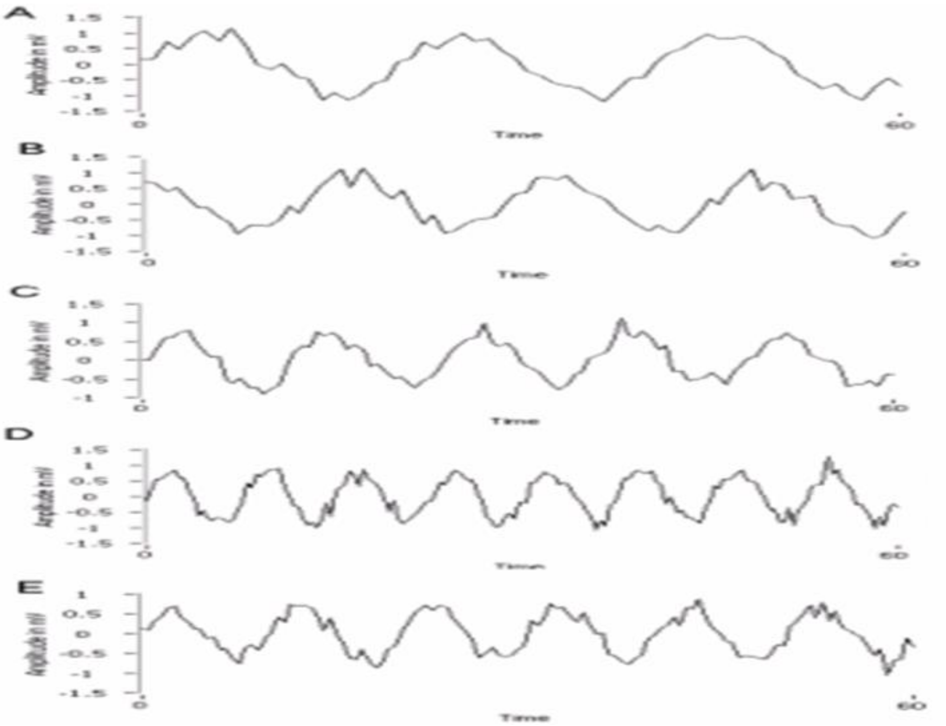

Figure-7. Waveforms for different disorders. Normal individual Waveform with 3 cycles per minute as frequency (recording A). A dyspepsia patient wave pattern (recording B). A Nausea patient wave pattern (recording C). A Vomiting patient wave pattern (recording D). An Ulcer patient wave pattern (recording E).

8. CONCLUSIONS

A simplified novel approach is proposed in this paper for recording of gastro electrical activity. The EGG setup is used to record the activity of patients suffering from digestive disorders like Dyspepsia (D), Stomach ulcer (SU), Nausea (N) and Cyclic vomiting syndrome. About more than 100 patients were tested using this setup and the results are summarized based on the observation. In future, NI based LabVIEW with Data Acquisition Card (DAC) can be used to perform the recording of EGG to the fair amount of accuracy for further analysis using wavelet transform, statistical analysis ,etc which may improve the accuracy of diagnosis.

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