Rehabilitation Tool for Gastroparesis by the Analysis of Interstitial Cells of Cajal (The External Gastric Pacmaker with a Feedback of Gastric Potential)

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Received date: **Accepted date:** **Published date:**

Abstract

Physiology of Stomach

T e physiology of the stomach and the electrical properties are important in assessing about the health.

Interstitial cells of cajal–natural gastric pacemaker

T e entire stomach wall is interiorly coated by interstitial cells of Cajal (ICC). T e ICCs are the pacemaker cells, the cells that spontaneously depolarize and repolarize and set the myoelectrical rhythmicity of the stomach and other areas of the gastrointestinal tract. T e interstitial cells are electrically coupled with the circular muscle cells (Figure 2).

Low-amplitude rhythmic circular contractions occur at the pacemaker rhythm. Rhythmicity and contractility of the circular muscle layer are modulated by ongoing activity excitatory and inhibitory of myenteric neurons that synapse with the interstitial cells [5].

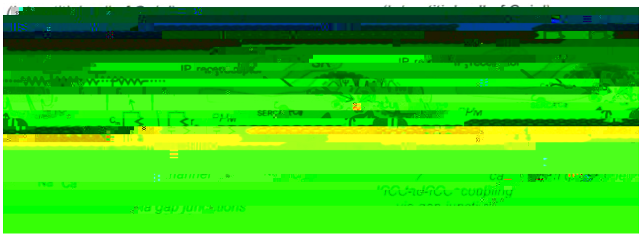

Figure 2: Coupling of interstitial cells of cajal.

Electrical activity of the stomach

T e electrical activity of the stomach that is initiated by the ICC is the essential component in the gastric functions. T is can be captured and reconstructed into useful diagnostic functional information. T e electrogastrogram is a function of intensity of the gastric actions per unit time. It varies depending upon the area which is considered based on its activity. Figure 3 shows the electrical activity at di ferent regions of the stomach [5].

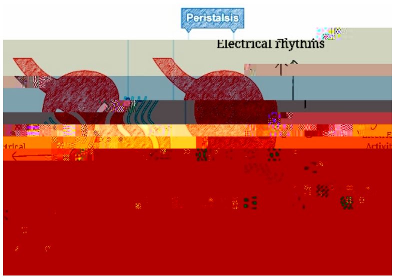

Figure 3: Electrical activity of the stomach.

T ese gastric potentials are very sensitive. To get a good quality signal, one active electrode should be placed approximately 10 cm from the umbilicus and 6 cm to the patient's lef. T e second active electrode should be placed approximately 4 cm above the umbilicus on the midline of the abdomen.

T e reference electrode is placed 10 to 15 cm to the right of the midline electrode, usually along the mid clavicular line and 2 to 3 below the lowest anterior rib on the right side (Figure 4) [5].

Figure 4: Standard electrode placement for EGG signal.

Signal acquisition

T e electrodes placed on the abdomen captures the electrical signal and provide the functional information of the GI tract. T e signal acquired will be feedback to the PIC microcontroller which serves as the reference for gastric stimulator [6-8].

Responsiveness of the Stomach

T e Stomach will produce a movement in response to the stimulus from the ICC. T is gastric motility is the important in the phase of digestion. T e delayed gastric emptying has been a resultant from many causes such as from an accidental damage to vagus nerve and some idiopathic causes. T e diabetic and Par]pᵐe sÅ oathent ss aun s

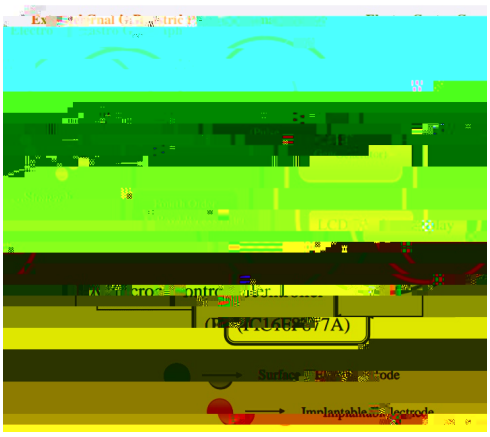

Figure 5: Delineative diagram.

Electrogastrograph

Electrogastrograph can provide a real-time diagnosis helps in improving the treatment through the Stimulator by using it as a biofeedback. T e electrogastrogram replicates the stomach activity at every instance which is recorded and used to provide synchronous and regulated stimulation.

EGG is an integral unit of electrodes, amplifer, flter unit and a processor to record the electrical activity of the gastric cells. T is is the only method that exactly reproduces the functional information of the gastro-intestinal organs which can help in diagnosing the gastric diseases. T e Figure 6 shows the electrogastrogram of a normal person.

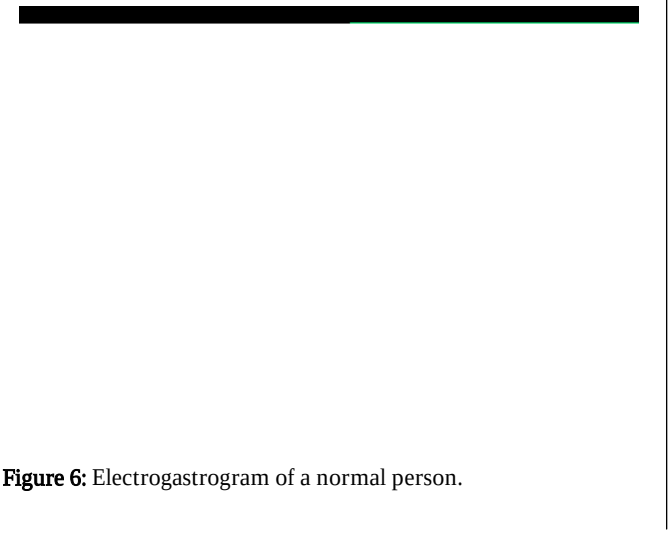

Figure 6: Electrogastrogram of a normal person.

Figure 10 shows the pulses that are delivered to the stomach which is affected by gastroparesis.

Figure 9: Filter characteristics of EGG signal.

Gastric Pacemaker

It will provide the gastric electrical stimulation to the gastric muscles via the feedback from electrogastrograph [11].

Stimulator (Pulse Generator): Gastric pacemaker is solely works with the help of pulse generator, which is programmed to deliver different frequencies depends on the patient risk. Generally, gastroparesis patient needs 10 to 14 Hz frequency for gastric muscle stimulation.

LCD Display: LCDs are available to display the frequency which is delivered to the patient when the trigger is ON. It is interfaced with PIC microcontroller to get the trigger pulse from the pulse generator.

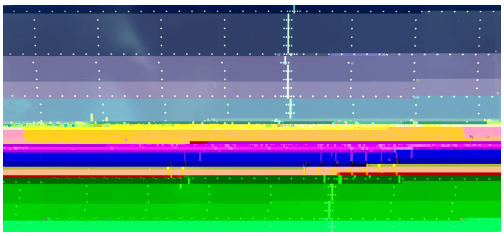

Figure 10: High frequency pulses (10 to 14 Hz) used for gastric stimulation.

Integration

The electrogastrograph will record the gastric potential using normal surface electrode on the abdomen. The

- The signal which satisfes this will be proceeded to further evaluation (Conditional check 2) and the signal that fails in this check will be declared as abnormal and proceeded to make a decision (Conditional check 3) of which kind of treatment is advisable to the patient.

Condition 2: The signal is checked here for the normal gastric rate (should be less than 3 cpm) and also examines whether there is any kind of hyper-actions.

- The signal that falls under the former condition will be declared as completely normal and the latter will be declared as abnormal and they are advised to take up a medical examination.

Condition 3: The signal is checked here to make a decision between which kind of treatment is recommended to the patient.

- The patient with mild efect (i.e., who have around 2 cpm) will be advised to take up a doctor's advice and who have severe efect (i.e., who have less than 1 cpm) will be advised to take up a treatment through our gastric stimulator.

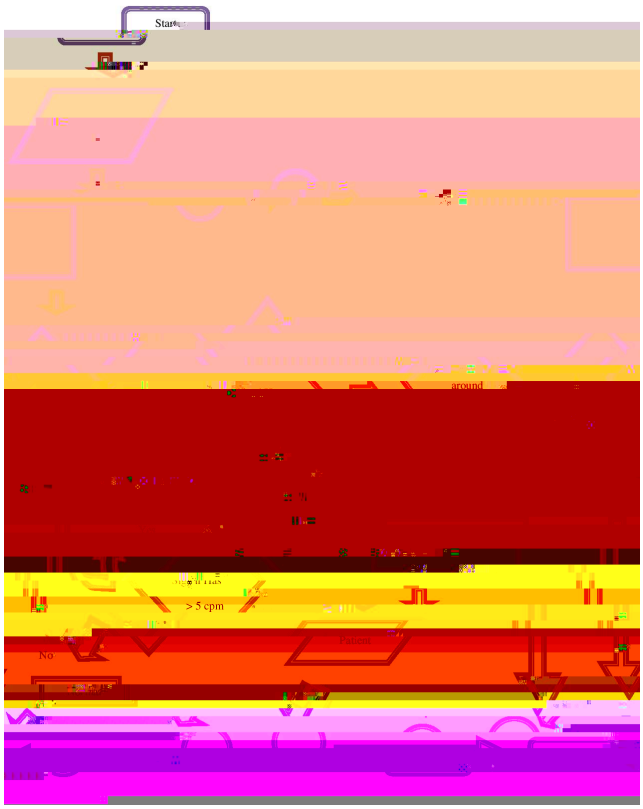

Figure 12: The working fow of complete system.

Result

The outcome of the proposed methodology provides the synchronous stimulation to the stomach. Thus the device provides an efective

is connected to it. The following Figures 15 and 16 show the type of stimulation provided according to the status of the microcontroller. This is helps in keeping the stimulator as ON or OFF.

Figure 15: The state of a stimulator is OFF.

The stimulator is kept OFF by the PIC microcontroller, if the gastric motility is normal when examining through the electrogastrograph. The stimulator remains intact and leaves the natural functions undisturbed rather providing unwanted stimulation and resulting in an irreversible damage.

Figure 16: The state of a stimulator is ON.

The stimulator is kept ON and provides appropriate stimulation, if gastric delayed emptying is detected when examining through the electrogastrograph. The stimulation can be provided with the current of frequency of 14 Hz through the stimulating electrode for that instance of a particular period of 1 minute [18,19]. The high frequency stimulation offers the stimulus to the stomach when the natural stimulus is not so effective for the proper functioning of the stomach. The competitive stimulation is completely eliminated with the help of the feedback by the analysis of the electrical activity of the interstitial cells of cajal with respect to the responsiveness of the stomach at every instant in real time [20].

Inference

The plot in the Figure 6 is an electrogastrogram in the digital values showing the recording over a period of 4 minutes and 15 seconds.

The stimulator provides the stimulation of 14 Hz with an onset of the trigger from EGG module. The Stimulation is not produced when the diagnostic module finds the normal gastric actions i.e., the electrogastrogram obtained is having more than 2 cpm. This is depicted in Figure 15. The stimulation is produced only when the diagnostic module finds it necessary.

The stimulation can be provided with the current of frequency of 14 Hz through the stimulating electrode at that particular period of 1 minute. This is depicted in Figure 16.

Conclusion

The Project provides an effective treatment to the Gastroparesis. The Gastric Electrical Stimulation is a method that compensates the effect of the disease by providing a high frequency over the surface of the stomach through the implanted electrodes. Gastroparesis is a disease which paralyzes the stomach; the sufferers cannot digest the food properly due to the delayed gastric emptying. The stimulation can only be provided when the Gastric emptying is required which promotes synchronous stimulation. Rather the existing stimulator provides continuous stimulation once it's triggered after a bolus feedback that

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