Ultrasound Measurement in M Mode of Peristalsis and Gastric Emptying

Teodoro Cordova-Fraga[*1, 2], Martha Alicia Hernandez-Gonzalez[3], Angelica Hernandez-Rayas[1], Jos é Francisco G ómez-Aguilar[1], Modesto Sosa-Aquino[1], Miguel Vargas-Luna[1], Sergio Solorio-Meza[3], Jesus Bernal-Alvarado[1], Carlos Ricardo Contreras-Gaytan[2], Jos é Mar ía de la Roca-Chiapas[4]

[1]Departamento de Ingenier ía F ísica, Universidad de Guanajuato, Campus Le ón, Loma del Bosque No. 103, Lomas del Campestre, 37150 Le ón GTO, M éxico
[2]Facultad de Ingenieria en Computacion y Electronica, Universidad De La Salle Bajio, Av. Universidad No. 602, Lomas del Campestre, 37150 Le ón GTO, M éxico
[3]Unidad M édica de Alta Especialidad, Cl ínica T1-Le ón, Instituto Mexicano del Seguro Social, Blvd. A. L ópez Mateos y Paseo de los Insurgentes s/n, Los Para ísos, 37320 Le ón, GTO, M éxico
Departamento de Psicolog ía, Universidad de Guanajuato, Campus Le ón, Av. de las Rosas 501, Jardines de Jerez, 37530 Le ón GTO, M éxico
[*1,2]theo@fisica.ugto.mx; [3]martha.hernandezg@imss.gob.mx; [1]angelicahr@fisica.ugto.mx; [1]jfga@fisica.ugto.mx; [1]modesto@ugto.mx; [1]mvargas@fisica.ugto.mx; [3]sergio.solorio@imss.gob.mx; [1]bernal@fisica.ugto.mx; [2]crcontreras@delasalle.edu.mx; [4]joseroca@fisica.ugto.mx

***Abstract*- The use of ultrasound equipment in routine clinical evaluation of the gastrointestinal tract is still standby. Objective: to show an alternative application of ultrasound technique for monitoring peristalsis and gastric emptying through an executable routine implemented in LabVIEW. Methods: an ultrasound equipment (Medison SONACE 800 SE) was used in ten healthy subjects and four patients; dominant peristalsis frequency and gastric emptying were measured after fasting nights of the patients; subjects ingested, first 300 mL of water and then a solid meal (240 kCal). Results: the video acquisition in M mode and imaging processing were performed in a LabVIEW platform, as long as digital signal processing was carried out in matlab 2008a; peristaltic frequency of 2.4 cpm (cycles per minute) and a half time of the gastric emptying around 35 s were found. Discussion: these findings are congruent with similar evaluations of GI tract obtained by using the gold standard technique. So, ultrasound technique is now an alternative procedure for gastric evaluation with the advantage that patients are free of ionizing radiation, and these equipments are amply available in the world hospitals.**

Keywords- Digital Images Processing; Digital Signal Analysis; Gastroparesis

I. INTRODUCTION

In the evaluation and diagnosis of gastrointestinal (GI) tract, a variety of techniques are used around the world, such as endoscopy, electrogastrography, radiography, scintigraphy, echography, etc. (Odunsi *et al*. 1999, Bateman *et al*. 1982, Gilja *et al*. 1999, Kenneth *et al*. 2001, Vantrappen *et al*. 1994), these assessments are used both in diagnosis and in the localization and monitoring of some GI problems (Mangnall *et al*. 1991, Mariani *et al*. 2004).

Clinical trans-abdominal ultrasound (US) studies have been used in hepatobiliary–pancreatic and liver examination, and recently in bowel inflammation (Dietrich *et al*. 2009), nevertheless, for GI tract assessments; the use of US technique is still controversial. Fortunately, technology advances and recent results obtained by echography in a wide variety of GI ills (Kusunoki et al. 2010), this suggest that the US technique is a powerful diagnostic tool for carrying out gastric studies and monitoring the GI tract (Newell *et al*. 1993).

Peristaltic waves due to gastric activity (GA) are suddenly initialized in the stomach wall corpus (Holt *et al*. 1980). They have a rate average frequency of 3 cpm (cycles per minute), this is 0.05 Hz, in healthy subjects (Kenneth *et al*. 2001). This GA first moves part of the lumen content from fundus to antrum that contributes to digestion and formation of chyme, then it also pushes the chyme from antrum to duodenum through pylorus (Kenneth *et al*. 2001). LabVIEW is a system design platform and development environment for a visual programming language from National Instruments. The graphical language is named “G” (dataflow programming language). LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms. Execution is determined by the structure of a graphical block diagram (the LV-source code) on which the programmer connects different function-nodes by drawing wires (Blume *et al*. 2007).

In order to identify when patients present either a normal clinical or some pathology such as bradygastria or tachygastria, a measurement modality of GA by using ultrasound images in M mode is presented in this work. In (C órdova *et al*. 2011), a digital image processing of gastric ultrasound is presented, whole automated routine and implemented filters are described in order to use this procedure in gastric peristalsis and gastric emptying evaluations. The acquisition and images processing are implemented in a LabVIEW platform and they are also presented.

II. MATERIALS AND METHODS

An ultrasound equipment model Medison SONACE 800 SE, complemented with Doppler and a curved array

DOI: 10.5963/LSMR0203002

transducer C3-7ED, from 3 MHz to 7 MHz, was used in this work.

This study was performed according to Helsinki agreement for scientific human studies. Furthermore, all participants were widely informed about the study protocol, and a written consent was obtained from each one of them prior to examination.

Ten healthy volunteers (males and females, the mean age is 20 years old) with no history of GI diseases and four patients (males and females, the mean age is 40 years old) under treatment of gastroparesis were examined. All subjects attended the study with an overnight fast. So, five minutes previous to auscultation, each volunteer swallowed 300 mL of water in order to enhance the stomach wall and perform the peristaltic evaluation. The patient stomach was localized when they were in a supine position, and then an US image as it is shown in (Figure 1) was in the equipment screen.

After that, the abdominal ultrasound transducer was fixed for 90 seconds, and then it was recording an ultrasound video with 2610 frames identical to picture shown in Figure 1.

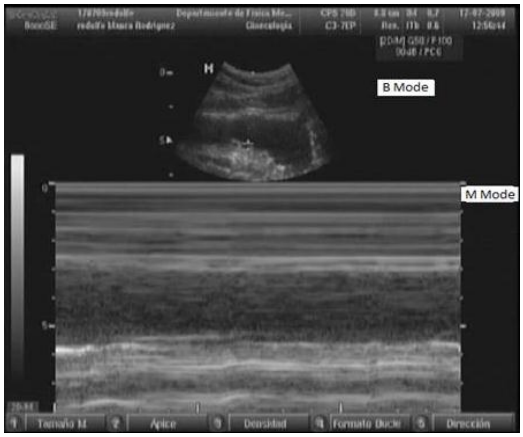

Figure 1 A whole ultrasound screen image is shown. The top image is in B mode, while in the bottom, it is shown a dynamic image in M mode

An automatic routine for images processing implemented in LabVIEW platform, as an executable, was implemented and used for getting individual frames. First it is selected the stomach area, as it is shown in Figure 2.

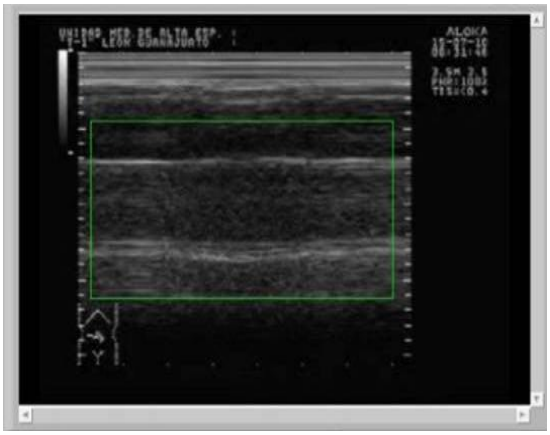

Figure 2 It is shown the selection of the interest area according to stomach of the patient

Then, a series of filtering process was implemented in order to enhance and have an exact definition of the stomach wall, see Figure 3.

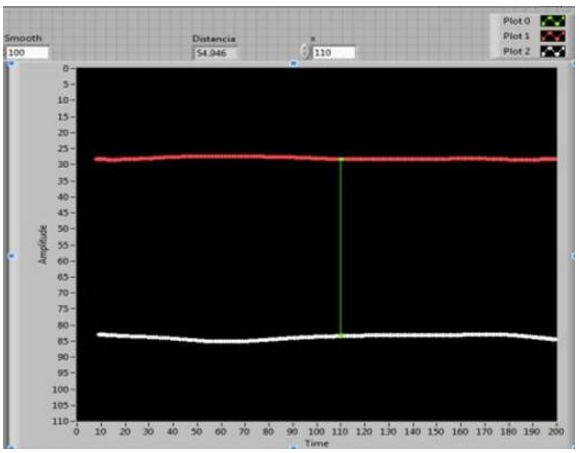

Figure 3 Graphic schematization of the stomach width measured in each frame

It is important to note that only one measurement of the difference in the length between the superior and inferior walls of the stomach was registered from each frame, such that a unique point was gotten always in the same position in each frame, see Figure 3. Therefore, 2610 points were recorded per minute, which are plotted in a graph, see Figure 4. They represent the changes in the width that the stomach undergone during 90 seconds. Such is equivalent to have a sampling frequency of 29 Hz, and this means that there are enough points for a FFT (Fast Fourier Transform) without Nyquist frequency problems and enough time to have a power spectral density according to Bradshaw *et al* algorithm (Bradshaw *et al*. 1995).

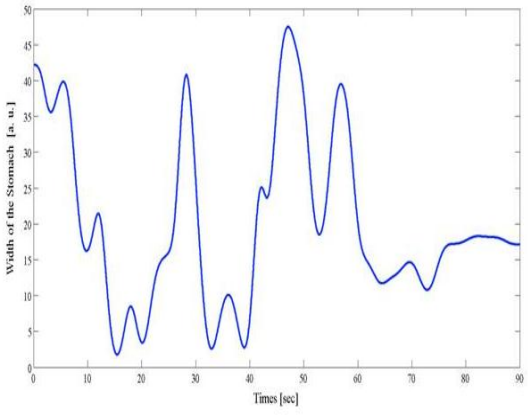

Figure 4 Variations of the stomach wall's difference recorded in a patient for 90 seconds.

On the other hand, for an estimation of the gastric emptying and continue with gastric peristalsis assessments, after the first measurement, subjects ingested a solid meal with 240 kCal, and then a series of four posterior measurements with intervals of 15 minutes were performed in each one. Then, if the area under the curve in Figure 4 is assessed, it can obtain an average of the lumen content of the stomach. Then five average lengths were estimated in order to know the gastric emptying associated with each patient.

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III. RESULTS AND DISCUSSION

The peristaltic gastric activity for a patient is shown in Figure 4. This figure shows the variations of the stomach wall's difference in time for one and half minutes. Nevertheless, exact dominant gastric frequency is not explicit, so a Fourier transform according to Bradshaw *et al.* (Bradshaw *et al*. 1995) algorithm was performed with this data, see Figure 5, and there is found a dominant frequency of 2.4 cpm.

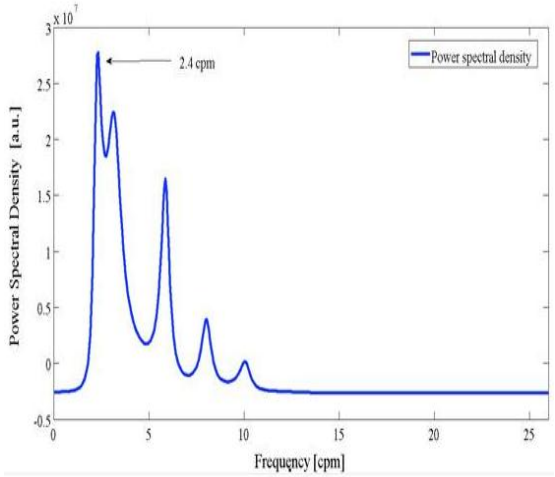

Figure 5 Power spectral density of previous data plotted in order to find the gastric dominant frequency

The gastric emptying behavior for a healthy volunteer is shown in Figure 6, where the 5 steps of the protocol (with intervals of 15 minutes) are shown. The first one represents the fasting measurement, when the subject swallowed 300 mL of water. Then, the next four bars represent the same stomach width with lumen content at 15, 30, 45 and 60 minutes, respectively, after the patient swallowed the solid test meal. A first-order exponential could be fit for the half time gastric emptying. While Figure 7 has a similar behavior to Figure 6, these data corresponded to a patient with gastroparesis.

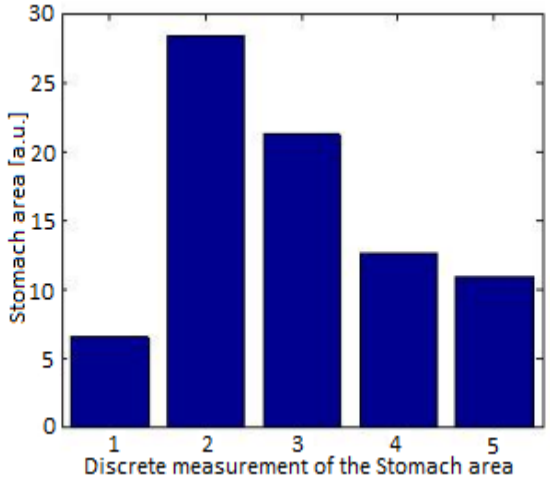

Figure 6 It is shown the behavior of the gastric emptying in a healthy subject. The first bar is in fasting measurement, when the subject swallowed 300 ml of water. Then, the next four bars represent the same stomach width after swallowing the solid test meal. This is with lumen content at 15, 30, 45 and 60 minutes.

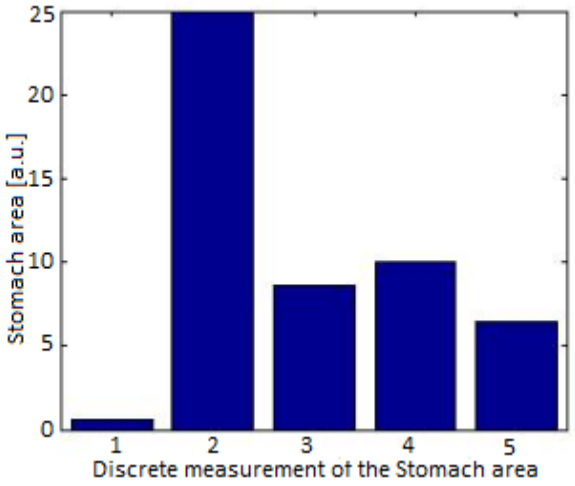

Figure 7 Here is shown the behavior of the gastric emptying in a diabetic patient with gastroparesis. The first bar means the fasting measurement, when the subject swallowed 300 ml of water. The next four bars represent the same stomach width after swallowing the solid test meal; this is with lumen content at 15, 30, 45 and 60 minutes.

The gastric emptying of chyme is, arguably, the most important function of the stomach, just as the ejection of blood is the most important function of the heart. Although a number of methods have been used to assess gastric emptying in humans, many of these have technical limitations or are complex to perform (Szarka *et al.* 2009, Hveem *et al.* 1996). Many techniques for direct assessment of gastric emptying involve exposure of the subject to ionizing radiation. There is thus a need for a non-invasive method for the measurement of gastric emptying. Ultrasound is considered to be safe, and the technique we describe is non-invasive and readily repeatable.

IV. CONCLUSION

Then, evaluation of GI tract by ultrasound modality through video acquisition and imaging processing in LabVIEW platform is a powerful tool relatively easy to be implemented in any hospital around the world. It gives a direct evaluation of the gastric peristalsis and gastric emptying in a very short time with a high precision. The results obtained for the dominant gastric frequency are in agreement with the expected values and reported data in similar works (Kenneth *et al.* 2001). Furthermore, patients may be evaluated as many times as required by medical treatments, essentially because the method has the benefit of non using ionizing radiation, so side effects due to ionizing radiation will not be presented. Although gastric emptying scintigraphy is the most widely used test for the assessment of gastric emptying, radiation exposure is an important consideration in this method while the advantages of US techniques are widely available equipment, modest running costs, and no radiation exposure.

ACKNOWLEDGEMENTS

Authors thank DAIP, Universidad de Guanajuato, grant number 0017/2010, and Universidad De La Salle Bajio projects of 2011 for financial support. The authors also thank all the volunteers and patients for their generous collaboration.

DOI: 10.5963/LSMR0203002

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Bachelor in Physics-Mathematics (1996) México, Ms. S. in Physics (2000) México; Ph.D. in Physics (2003) México; Research Fellow: (August, 2004- July, 2005) Vanderbilt University. Nashville, Tennessee, USA Sponsor: *Dr. Alan Leonard Bradshaw*

DOI: 10.5963/LSMR0203002