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LETTER

Scintigraphy vs. mechanical magnetogastrography: gastric emptying analysis

J. M. De la Roca-Chiapas · T. Córdova-Fraga · G. Reynaga · S. Solorio · M. Sosa · A. E. Rivera-Cisneros · J. J. Bernal · M. Vargas-Luna

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Abstract Scintigraphy technique is considered the gold standard for gastric emptying evaluations. Lately mechanical magnetogastrography (MMG) technique has emerged as an alternative for these assessments. This study presents the determination of reference values for MMG in order to validate this novel technique in gastric emptying measurements. Both methodologies were used in young and healthy subjects provided with a solid test meal. The measurements were performed with 2 days of difference. Bland–Altman analysis of the data was performed to conclude about the feasibility of MMG as a good alternative test for gastric emptying assessments. Using MMG, an average of the gastric emptying half-time of 57.6 ± 25.8 min was obtained, whereas the same parameter obtained by scintigraphy was 52.2 ± 12.9 min. In conclusion, the use of MMG technique is in concordance with the results using the gold standard technique for gastric emptying measurements.

Keywords Mechanical magnetogastrography · Scintigraphy · Gastric emptying

J. M. De la Roca-Chiapas (✉) · A. E. Rivera-Cisneros
Psychology Department, University of Guanajuato, Campus Leon, Av. De la Rosas 501, Jardines de Jerez, 37530 Leon, Gto., Mexico
e-mail: joseroca@fisica.ugto.mx

T. Córdova-Fraga · M. Sosa · J. J. Bernal · M. Vargas-Luna
Physical Engineering Department, University of Guanajuato, Campus Leon, 37150 Leon, Gto., Mexico

G. Reynaga
Medicine & Nutrition Department, University of Guanajuato, Campus Leon, 37000 Leon, Gto., Mexico

S. Solorio
Clinical Epidemiology Research Unit, UMAE No. 1, IMSS, 37000 Leon, Gto., Mexico

J. M. De la Roca-Chiapas
International Organization New Acropolis Mexico, Leon, Gto., Mexico

1 Introduction

Gastric emptying rate is used as an indicator for several gastrointestinal disorder diagnosis, such as diabetic gastroparesis [14], functional dyspepsia [12], among others. It is expressed as the emptying half-time, $\tau_{1/2}$ [18], indicating the time required to evacuate half of the luminal content. This parameter is evaluated using different methods; however, it is recommended the use of scintigraphy technique by the anterior/posterior method and 90 min of evaluation time [19], although there are protocols using different times for emptying liquid and/or solid material [8].

Several studies reported different emptying half-time values with their corresponding confidence interval. Of course these variations come from particular measurement conditions, sample size, and the characteristics of the population under study. As an example of natural difference of gastric emptying rates between two populations it can be mentioned the men versus women difference [10], probably related to hormone influence. Therefore, for women it is recommended to perform the evaluations during the first 10 days of the menstrual cycle [9].

Many methods exist for gastric emptying evaluation such as electrogastrography [4] which records gastric electrical activity through internal or cutaneous electrodes. The ultrasonography technique images the luminal content volume inside the stomach [15]. The 13C-octanoic acid

breath test measures the gastric emptying across percentage of total label excreted per unit time [16]. The MRI magnetic resonance imaging is another method of assessing the gastric emptying process [17] that allows the visualization of stomach and the luminal content. As also the scintigraphy which uses an isotopic marker $^{99m}T_c$ embedded in a standardized solid meal. This last technique is considered the reference one for gastric emptying evaluation [5].

All these techniques present advantages and disadvantages and it is important to choose the precise technique according to the particular characteristics of the study. Recently a new technique has emerged. The mechanical magnetogastrography (MMG) is a biomagnetic modality with the advantage of non-using ionizing radiation.

Since 70′s, biomagnetic techniques have been used for gastric emptying evaluation [11], detection of gastrointestinal motor activity [3], and esophageal transit time [6] among others.

In this study an evaluation was performed with solid test meal using MMG and comparing with scintigraphy to obtain the concordance of both techniques.

2 Materials and methods

2.1 Subjects

A group of nine of healthy subjects, five males and four females between 18 and 25 years old, mean 20.9 ± 2.7 years and Body Mass Index (BMI) < 27, mean 24.1 ± 2.2 kg/m^2 without history of gastrointestinal disease, who did not take any medication participated in this study.

2.2 Protocol

The study protocol was approved by the Bioethics Committee of the University of Guanajuato, which is in accordance with the Declaration of Helsinki for scientific research on humans. Subjects were evaluated in the morning after an overnight fast. All subjects ingested the same test meal in which the solid part has 160 kcal and the liquid part (to facilitate the ingestion) has 250 kcal. Each subject was evaluated with MMG and scintigraphy techniques, with 2 days of difference. The female were measured during the first 10 days of menstrual cycle in both test to avoid hormonal influence.

2.3 Scintigraphy examination procedure

The test meal was a well-cooked omelet made with an egg, labeled with 5 μCi of $^{99m}T_c$-Colloidal sulfur (TCK1 Scherring, Cis Bio), one slice of bread, and 250 ml peach juice. The voluntaries were in supine position during the evaluation which last 90 min. The recordings were taken the first 15 min and then 1 min was recorded every 15 min using the gamma-camera.

2.4 MMG examination procedure

All voluntaries ingested the same test meal as in the scintigraphy evaluation and were in prone position during this evaluation. In this case, the slice of bread was prepared like hot cake which was mixed with 4 g of magnetic tracer Byferrox (Fe_3O_4), to measure the magnetic relaxation of the tracers after an initial stimulation using a strong pulsed magnetic field (30 mT during 5 ms). The recordings were taken during 5 min every 10 min along 90 min, and after 10 min of being ingested the tracer.

2.5 Gastric emptying half-time calculation

There is no consensus regarding the best way to estimate the gastric emptying half-time ($t_{1/2}$) [7]. Different functions have been used to describe the emptying data [13]. Nevertheless, in our case, gastric emptying is well described by a simple decaying exponential function given as $y(t) = y_0 \exp^{-t/\tau}$, where $t_{1/2} = \tau \ln 2$ is the gastric emptying half-time. That is the time when $y(t)$ is half of the y_0 value.

3 Results and discussion

Five men and four women with a mean age of 20.9 ± 2.7 years and a mean BMI of 23.7 ± 2.3 kg/m^2 were evaluated. In particular the men have 21.6 ± 2.7 years old and a BMI of 23.1 ± 2.4 kg/m^2 on average, while the women have 20.2 ± 2.8 years old and a BMI of 25.0 ± 1.5 kg/m^2.

MMG configuration consists in two magnetic sensors located in parallel. One of the sensors was located near the fundus and the second one was at 7 cm below, corresponding roughly to the antrum position.

In principle, for each sensor, it can be used any of the three magnetic components B_x, B_y, B_z or its magnitude $B_s = \sqrt{B_x^2 + B_y^2 + B_z^2}$ to evaluate the gastric emptying time. If we do so, the average of the emptying time differences with respect to the scintigraphy varies according to the component used.

In particular, the B_x component gives higher emptying values for MMG technique, corresponding to the major differences with scintigraphy, although very similar for both sensors. This can be understood because sensors are located in a similar B_x coordinate, so independently of the position of the magnetized food the registers should

coincide. On the other hand, B_y recordings gives faster emptying values due to the high sensitivity to the distance of the magnetic sensors with the tracer and the fact that the food inside the stomach travel predominantly in y-direction. Finally, B_z—values gives the best results in terms of agreement with scintigraphy technique.

The standard deviation of the emptying time difference scintigraphy-MMG is roughly the same for all of the magnetization components, that is ±18.36 min (one SD), on average.

Now, we perform a Bland–Altman analysis [1] for the magnitude of the second sensor B_{s2}, as the best result for the magnitudes. Using MMG, the average of the gastric emptying half-time was 57.6 ± 25.8 min, whereas the same parameter obtained by scintigraphy has a value of 52.2 ± 12.9 min. The Bland–Altman test to compare the measurements between the scintigraphy and MGG-B_{s2} gives a decrease tendency, which means that MMG technique using B_{s2} parameter gives higher values for high average emptying times, but on the other hand it gives lower values for lower average emptying times. This is a general tendency for most of the magnetization component results. This tendency is not explained at the physiological level. So, if it is considered as an artifact of the technique, a straight line fitting of the result can be performed (figure not shown). Hence, ruling out this tendency and redefining the base line, the SD was significantly improved, from 18.36 to 11.23 min. This procedure was performed for the other components improving the agreement of both techniques.

4 Conclusions

According to the Brogna et al. study [2], the normal emptying time values are in the range from 30 to 76 min (53 ± 23 min), which suggests an agreement with those values obtained in this study by using both methods. Scintigraphy shows a better SD (12.9 min) than the 23 min reported, while the SD (25.8 min) for MMG is not far from the scintigraphy value. Hence, the dispersion values observed are in agreement with the 2-SD of the Bland–Altman analysis if the proper correction is performed to the MMG data.

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