Electrode Control Activity (ECA) and Electrical Response Activity (ERA). It has been demonstrated\(^4,5\) that intracellular electrical depolarization due to spontaneous ionic exchange through the membrane precedes contraction of the gastric smooth muscle fibers. However, not all depolarizations are followed by contractile activity and this is the main difference between gastric and cardia muscles. Weber and Kohatsu\(^6\), Kelly and Code\(^7\) showed as possible origin of gastric electrical activity an area of the corpus along the greater curvature where begin the longitudinal muscle fibers that continue into the duodenum. The mechanism of propagation of gastric electrical activity is still unknown but there are well definite temporal and spatial rules that regulate the propagation.

ECA is considered to be the initial rapid depolarization of the cell and is a necessary condition, even if not sufficient, so that the contraction could happen. It is periodic in nature, with a period of about 20 seconds (frequency of 3 cycles per minute). Only the appearance of the plateau of the ERA, and eventually the second component of the ERA, the spikes that are superimposed over the plateau, indicate that the contraction will follow.

During the fasting state the GEA can show the patterns of the so called Migrating Myoelectrical Complex (MMC)\(^8\) and it can be separated into four phases: (1) quiescent phase 1, when only ECA is present; (2) transitional phase 2 when cycle of ECA are mixed with cycles in which both ECA and ERA are present; (3) phase 3 during which ECA is always followed by ERA with its two components; (4) transitional phase 4, very similar to phase 2. The total duration of the 4 phases is 1.5-2.0 hours.

Mirizzi and Scafoglieri\(^9\), Mirizzi et al\(^10,11\) have modelled the electrical field produced...
by the human stomach and demonstrated that the optimal position for the EGG electrodes is along the projection of the stomach axis on the abdomen wall, as shown in Figure 1.

Many authors\cite{12-20} have tried to use electrogastrography for clinical assessment of gastric motility disorders. Unfortunately, only qualitative methods (and therefore subjective) of evaluation of the EGG were suggested. Myntchev et al\cite{21} have tried to produce an objective quantitative method of evaluation of gastric electrical activity, including EGG. They demonstrated that the most reliable EGG parameter is gastric electrical frequency. It shows a good level of stability in all conditions when registered maintaining standard modalities. A further parameter that seems to be of interest is the variation of signal amplitude after meal.

The ECA (slow waves) is responsible for controlling the maximum frequency and the aboral propagation of distal gastric contractions. As reported above, the normal gastric slow waves frequency is approximately 3 cpm. Meal ingestion increases the amplitude of the EGG signal which is believed to result either from increased antral contractility or from mechanical distension of the stomach.

The more common procedure of evaluation of the electrogastrographic recording is the spectral analysis that uses the “Fast Fourier Transform” (FFT) to convert the temporal signal in its components of frequency (Figure 2). According to the theory of Fourier every periodic signal can be considered as constituted by a series of sinusoidal waves. The application of the FFT to the signal over time determines the decomposition of the signal in its components of frequency producing a spectrum of frequencies.” The amplitude of every component of frequency points out the contribution of that component in the original signal. The energy of a component of frequency is calculated as the square of the amplitude.

The graph obtained by the spectrum analysis shows the mean contribution of a date frequency on the whole signal expressed as energy of that frequency. The dominant mean frequency is 3.0 cpm and the corresponding energy it is express in nV2. Such representation doesn't allow following the variations of frequency and energy over time. This problem has been overcome with the introduction of the analysis Running Spectra (Figure 3). The graphic representation mostly used for the analysis Running Spectra is pseudo-three-dimensional that is able to show the variations of frequency and amplitude in the time.

**Clinical Application**

The cutaneous registration of the electrical activity of the stomach allows to quantify the dominant frequency, the regularity of myoelectrical activity, the percentage of time in which abnormal slow or fast wave rhythms...
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**Figure 3.** Running Spectra analysis allows to visualize the components of gastric signal over time. From Van der Schee ET, Grashuis JT. Med Biol Eng Comput 1987; 25:57-62.

are present during fasting and postprandially, and to assess the increase in amplitude after meal\textsuperscript{22} (Figures 4 and 5).

Using the same terminology of the electrocardiography it is possible to describe the gastric dysrhythmias as tachygastria and bradigastria. Normally the 3 cpm frequency represents the 70% of the recorded cycles. When this percentage is reduced the electrical activity of the stomach is altered. The tachygastria and the bradigastria and the abnormal low amplitude of the signal after meal ingestion have been defined in patients with idiopathic or diabetic gastroparesis\textsuperscript{23} (Figure 6). Camilleri et al\textsuperscript{22} described also abnormalities in patients with unexplained nausea and vomiting, motion sickness, and nausea and vomiting of pregnancy. Parkman et al\textsuperscript{24} showed EGG abnormalities in 75% of patients with gastroparesis versus 25% of symptomatic patients with normal gastric emptying. EGG abnormalities and delayed gastric emptying may define different patient populations with dyspeptic symptoms\textsuperscript{25} (Figures 7 and 8). Koch et al\textsuperscript{26} showed that the symptomatic response to antiemetic or prokinetic drug treatments correlated better with resolution of gastric dysrhythmias than acceleration of delayed emptying in some groups of patients. Even hyperglycaemia may provoke dysrhythmias in diabetic patients\textsuperscript{27}.

**Figure 4.** Healthy subject. The dominant frequency in the fasting state and after the meal ingestion is 3 cpm.
In clinical practice EGG has been used to demonstrate gastric myoelectrical abnormalities in patients with unexplained nausea and vomiting or functional dyspepsia. It seems correct to consider the EGG, joined to scintigraphy, as a tool of a general evaluation of patients with symptoms suggestive of an upper gastrointestinal motility disorder 22,23. To date there have been little investigation to demonstrate the utility of EGG in the management of patients with suspected gastric motility abnormalities.

Figure 5. Healthy subject. Normal increase of the gastric signal after meal ingestion with dominant 3 cpm frequency.

Figure 6. Diabetic not compensated patient with dominant bradigastria before meal. After meal ingestion irregular increase of frequency of the gastric electric activity.
Perspective

Gastric emptying scintigraphy of a solid-phase meal is considered the gold standard for the study of gastroparesis. Breath test using the non radioactive isotope $^{13}$C bound to digestible substance have been validated for measuring gastric emptying. Most commonly, $^{13}$C-labeled octanoate, a medium chain triglyceride, is bound into a solid meal (eggs with ham, butter, bread). After ingestion and stomach emptying, $^{13}$C-octanoate is absorbed in the small intestine and metabolized to $^{13}$CO$_2$, which is then expelled from the lungs. The limiting step is the rate of gastric emptying.
Octanoate breath testing provide a measure of solid phase emptying and its results are reproducible and correlate with findings on gastric emptying scintigraphy. \textsuperscript{21,29,30} \textsuperscript{13}C breath test do not use ionizing radiation and can be used to test patients in the community or even at the bedside where the gamma camera facilities are not available. Breath samples can be preserved and shipped to a laboratory for analysis by means a mass spectrometer. This possibility can make easy to perform a double test: EGG registration in the laboratory for analysis by means a mass spectrometer. This possibility can make easy to perform a double test: EGG registration in the laboratory for analysis by means a mass spectrometer. This possibility can make easy to perform a double test: EGG registration in the laboratory for analysis by means a mass spectrometer. This possibility can make easy to perform a double test: EGG registration in the laboratory for analysis by means a mass spectrometer. This possibility can make easy to perform a double test: EGG registration in the laboratory for analysis by means a mass spectrometer. This possibility can make easy to perform a double test: EGG registration in the laboratory for analysis by means a mass spectrometer.

Electrogastrography has the potential to become a routine clinical procedure in the near future.

References


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