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Role of Electrogastrography and Gastric Impedance Measurements in Evaluation of Gastric Emptying and Motility

A.J.P.M. SMOUT, MD, H.J.A. JEBBINK, MD, L.M.A. AKKERMANS, PhD, and P.P.M. BRUIJS

Electrogastrography records electrical potential variations brought about by myoelectrical activity of the stomach. Abnormal myoelectrical rhythms such as tachygastrias may also be detected. Electrogastrography provides little information on gastric motility and emptying. Impedance epigastrography is a technique that uses changes in epigastric impedance to evaluate gastric emptying of large-volume liquid meals. The results are inferior to those of tomographic impedance imaging. Phasic antral contractions may lead to phasic impedance changes recorded with nonimaging techniques and a phasic signal recorded with high-speed electrical impedance tomography. However, the relationship between phasic contractions and phasic variations in impedance do not appear consistent enough to allow clinical application of the technique.

KEY WORDS: electrogastrography; gastric impedance; gastric emptying.

In this paper, five techniques will be evaluated that have the common aim of deriving information about gastric motor functions (motility and emptying) from electrical signals recorded from the body surface. These techniques are electrogastrography and four different impedance measurement techniques.

ELECTROGASTROGRAPHY

EGG is the technique that records myoelectrical signals, generated by the stomach, from the body surface (skin). The EGG signal is a sinusoidal signal with a frequency of 3 cycles per minute (cpm) (0.05 Hz). The signal is always present regardless of the presence of (phasic) gastric contractions, but its amplitude usually increases when contractions occur (1). The amplitude increase seen after ingestion of a meal may be caused in part by a decreased distance between the gastric wall and the electrodes, but variations in electrode–source distance are an unlikely explanation for the contraction-associated amplitude variations observed in the interdigestive state. A model has been proposed in which dipole fronts generated by depolarization and repolarization of gastric smooth muscle are used to describe the latter (1).

It has been shown that EGG can be used to study normal gastric frequency and tachygastrias (1, 2). Uncoupled and irregular electrical activity cannot be detected (2). Attempts to use EGG as an indicator of the contractile activity of the stomach or gastric emptying have not yielded consistent or convincing results. As illustrated in Figure 1, EGG amplitude (or "power" of the 3 cpm component of the EGG power spectrum) and antral motility index are unrelated. The relationship with the rate of gastric emptying is too poor to be of clinical relevance. EGG is not a reliable tool to assess gastric motility and emptying. It appears unlikely that future developments will remove this limitation.

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From the Departments of Gastroenterology and Surgery, University Hospital, Utrecht, The Netherlands.
Address for reprint requests: Dr. A.J.P.M. Smout, Department of Gastroenterology, University Hospital Utrecht, PO Box 85500, 3508 GA Utrecht, The Netherlands.

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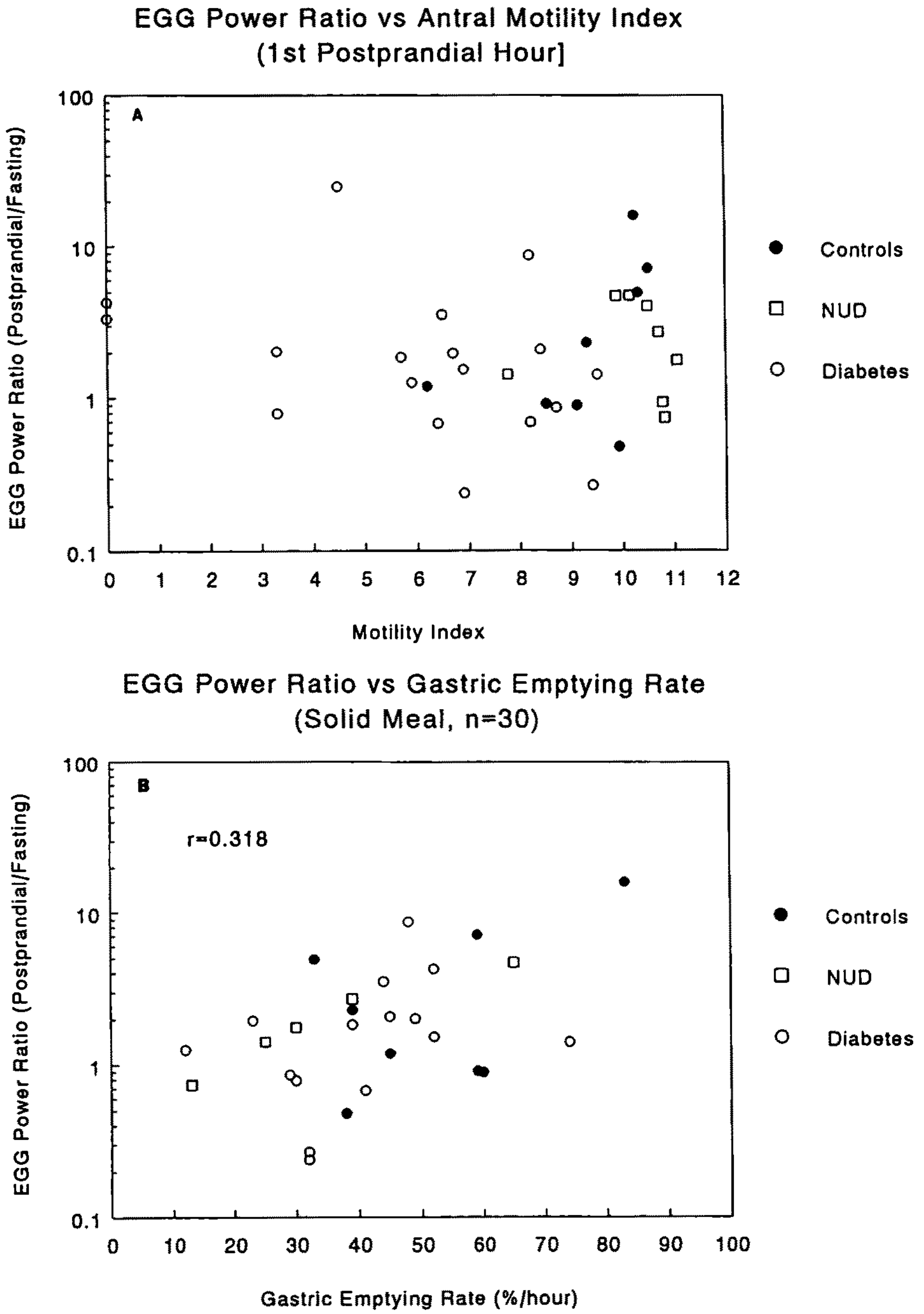

Fig 1. Relationships between EGG (postprandial/fasting ratio between power in the 3-cpm band), antral contractile activity (A) and gastric emptying rate (B). The test meal consisted of a pancake (271 kcal). No significant correlations were found.

ELECTRICAL IMPEDANCE MEASUREMENT TECHNIQUES

The electrical impedance of the human body, ie, the resistance to an alternating current, depends on the frequency of the current and on the ionic composition of the tissue between the measuring electrodes. Theoretically, impedance measurement could be used to study both gastric emptying and phasic (antral) contractions, provided the stomach is filled with material with a conductivity higher or lower than that of the body.

The presently available impedance techniques can be divided into conventional and tomographic imaging techniques. In conventional impedance measurements two or four electrodes are used. Usually a 50- to 100-kHz 3- to 5-mA current is used. In the two-electrode approach, potential variations are measured at the same electrodes through which current is injected. There are fewer artifacts associated with the four-electrode technique.

Conventional Techniques

Impedance Epigastrography. IE is a technique in which gastric emptying is assessed from impedance changes. Electrodes are positioned in the epigastric region and on the back to record the rapid impedance change induced by ingestion of 300–750 ml of water or orange juice and the subsequent slow return to baseline associated with emptying of the stomach. The correlation between emptying rates measured scintigraphically and those measured with IE are satisfactory (3). Inhibition of gastric secretion during IE is advisable, since acid secretion decreases the reproducibility of the results (5).

Two major drawbacks limit the usefulness of IE as a clinical tool. First, the results of IE measurement of gastric emptying are less reproducible than those of other techniques, in particular scintigraphy and tomographic impedance imaging techniques (3). Second, the technique is extremely artifact-sensitive. Minor body movements can render the tracing unreadable. In our hands, gastric emptying could not be assessed by means of IE in 50% of the subjects. Third, relatively large-volume unphysiological meals are required to produce a measurable impedance change. It is unlikely that IE will prove to be a suitable alternative to scintigraphy and tomographic impedance techniques.

Impedance Gastrography. IGG is a technique that uses conventional methods to record the phasic, 3/min impedance variations thought to be associated with gastric contractions. Cyclic impedance changes at a rate of 3/min can be easily detected after meals and distinguished in about 40% of the interdigestive recording time (4). We have developed a bedside system where EGG, IE, and EGG signals can be recorded simultaneously from the same set of epigastric electrodes. Cross-correlation analysis of EGG and IGG signals proved that these had identical repetition frequencies and a constant phase shift. There is little doubt that these IGG variations are of gastric origin (4).

We studied 12 healthy volunteers with combined EGG, IE, and IGG recording and simultaneous antroduodenal manometry. The subjects were studied for 4–5 hr fasting and for 2 hr after ingestion of a test meal. A rather disappointing finding was that the IGG recordings and their power spectra did not allow recognition of the interdigestive migrating motor complex (MMC). This was caused by an inconsistent relationship between IGG amplitude and antral pressure waves. In six of the 12 subjects clear-cut 3-cpm IGG activity was observed during the motor quiescence (phase I) of the MMC (Figure 2).

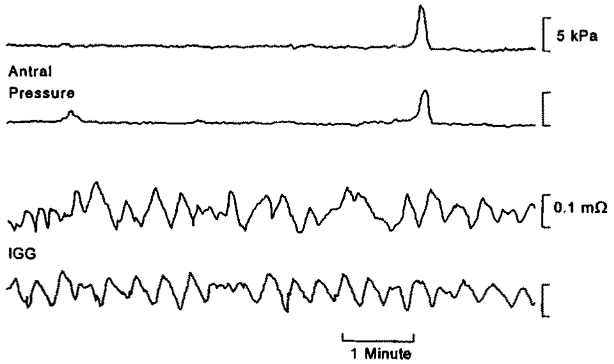

Fig 2. Example of dissociation between IGG and antral contractile activity, as measured by intraluminal manometry in healthy human subjects during phase II of the interdigestive migrating motor complex.

The conclusion to be drawn from these observations is that IGG does not simply reflect significant antral contractile activity. Perhaps the tiny contractions that have been reported to occur in association with electrical control activity give rise to detectable impedance variations. It is intuitively more likely, however, that the 3-cpm impedance variations observed during motor quiescence are caused by variations in cell membrane resistance associated with the depolarizations and repolarizations that underlie the electrical control activity of the stomach.

Tomographic Imaging Techniques

Electrical Impedance Tomography. EIT, also known as applied potential tomography (APT), is the technique that constructs cross-sectional "tomographic" images of the impedance relationships in the upper abdomen to assess gastric motor functions.

In EIT a circular array of electrodes around the upper abdomen is used. At any moment two of these electrodes are used for current injection (50 kHz, 5 mA peak-to-peak), the others measure potential differences caused by the current. Successively, neighboring electrode pairs take over the task of current injection. When EIT is used for measurement of gastric emptying, frames are collected at a rate of 1 frame/min, with each frame consisting of an average of 150 data cycles, collected over a period of 15 sec (5). Nowadays this technique should be referred to as low-speed EIT. The data are stored on a hard disk for later analysis.

Low-speed EIT can be used to follow gastric emptying of liquids such as conducting soup and nonconducting drinks such as 5% sucrose. There is a good correlation with the gastric emptying profile measured with a scintigraphic technique, which is better than that of EI (3). EIT can also be used to study the emptying of a semisolid meal, such as mashed potatoes, provided that the conductivity of the meal is either considerably higher or lower than that of the human body.

One limitation of the EIT technique is that it is necessary to inhibit gastric acid secretion (5). Another limitation is encountered in patients in whom gastric emptying has started before the meal is finished, eg, after partial gastric resection or vagotomy. In these cases, the 100% value cannot be derived and results cannot be expressed numerically as T1/2 or as percent per hour. Under these circumstances, it is only possible to extrapolate the emptying curve to the x axis and express the result as an expected time to complete emptying.

Recently, the first studies were conducted in which gastric motility (phasic contractions) was evaluated from EIT images. For this purpose frames were collected at a rate of 1 frame/sec, each frame being an average of six cycles. This technique is referred to as high-speed EIT.

Preliminary observations in infants and adults indicate that 3-cpm activity can be detected at a level of 1–10% of the impedance change induced by the test meal. Simultaneous recording of EGG and IET is possible, which would theoretically provide information about several aspects of gastric motility. However, the 3-cpm impedance variations recorded with high-speed EIT appear to show the same inconsistencies as those recorded by conventional IGG. A one-to-one relationship between gastric contractions and impedance variations appears to be lacking, casting doubt on the value of the technique as a contraction detector.

In conclusion, electrogastrography provides unreliable information about gastric motility and emptying. This technique should only be used to study the rhythm of gastric electrical control activity. Impedance measurement of gastric emptying with a conventional two- or four-electrode setup is inferior to tomographic imaging. The latter technique can be used, with certain provisos, to replace scintigraphy. Measurement of gastric contractions through impedance, either conventionally or with high-speed tomographic imaging, remains in the research domain. It is doubtful whether impedance changes measured at the body surface are reliable indicators of contractile activity.

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