

Gastric emptying test: A useful functional study rarely applied

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Abstract

Details about gastric physiology and pathophysiology are described. Other methods, some of them not used today, are also mentioned. Gastric emptying by radionuclides is important for checking normal function of the upper digestive system. The fried eggs etc. technique and not the liquid meal technique is preferred. *In conclusion*, gastric emptying by radionuclides, although other techniques have emerged, still has a diagnostic role in gastroplegia and in other mainly functional gastric disorders.

Introduction

Gastric emptying study is important for checking normal function of the upper digestive system. Nuclear medicine studies related to gastric emptying started in the 70s. Today, although medical societies of gastroenterology have met and tried for a consensus, there is no agreement as to the content of the radioactive meal to be given to the patients tested, the normal values of gastric emptying and the overall indications for this study. Ultrasound technique can easily examine gastric emptying but is not a quite sensitive technique.

We know that the fundus of the stomach is used as a storage place, when the stomach is overfilled [1]. The fundus of the stomach besides the usual longitudinal and cyclic muscular layers has also a third oblique layer, which allows greater elasticity and larger stretching. Contractions appearing at the upper part of the stomach push the content of the stomach towards its middle part and towards the pyloric antrum. Solid meals are emulsified or liquefied in the stomach in particles not larger than 2mm, so as to enter duodenum [2]. In fasting adults, the stomach only during the night remains quite empty, while during the day it may contain up to 20mL [3].

Muscular layers of the stomach wall are controlled by a basic electric rhythm at the greater curvature of the stomach produced by the so called "pace setter" [4]. Gastric neural plexuses of Meissner and Auerbach are related both with the vagus nerve and with other central nerves. Gastric movements and gastric emptying are influenced by the presence of food in the duodenum and the intestine. Several gastrointestinal hormones, like cholecystokinin, gastric inhibitory peptide and somatostatin, also influence gastric emptying [5].

Testing methods

Non radionuclidic methods have been used in the past to measure half time gastric emptying (HTGE). For historical reasons we mention the following methods, not any more used: a) *Gastric intubation*, so that consecutive measurements can be applied after inducing into the stomach a certain volume of a liquid solution, i.e. of a dye.

Intubation of the duodenum, so that one can measure over time, the volume of a liquid given per os, entering duodenum [6].

Radiation method. Emulsion of a contrast medium is given per os and the time it takes for this emulsion to leave the stomach is measured by radioscopy.

Contemporary non-radionuclidic methods

The magnetic resonance imaging (MRI), 1.5T for 60min measures accurately the volume of gastric content [7] and also the rate of excretion of liquids from gastric epithelium. By this technique we can also specifically measure the time, that water and/or lipids are emptied from the stomach [8].

Ultrasound with real time images. This is an easy method for measuring gastric emptying not administering radiation [9].

A special wireless capsule called: smart pile, which measures pH, temperature, intra-gastric pressure and pressure in the intestine. This method has great precision ($r=0.73$) and has been approved by Food and Drugs Administration, USA for measuring pH, gastric emptying and the overall transmission of a meal to the intestine for a period of 90min [8].

Gastric emptying by a respiratory test. The patient takes per os the non-radioactive ^{13}C -octreotate, which is a triglyceride, placed in a muffin or in spirulina, a proteinic alga. The ^{13}C is freed and absorbed in the small intestine and excreted by the lungs. This method also uses special technology, like the MRI method, needs special standardization technique and although its results are accurate, is not currently used [8].

The radionuclidic method

This method doesn't have many of the disadvantages of the above mentioned methods but needs to be applied in a department of Nuclear Medicine in order to measure HTGE. A test meal either liquid or solid, in which a radioactive solution has been added, is given per os. Griffith et al (1966) first applied this method [10]. This method has now been simplified

and improved, although still not widely used. The radioactive meal consists of 11MBq of radioactive technetium-99m sulfur colloid ($^{99m}\text{Tc-SC}$) mixed with two eggs, which are then fried or with another kind of proteinic solid meal. Sometimes ago, but not today, a chicken was labeled in vivo and used accordingly. *Normal values of HTGE are:* for liquid meals 30min and for solid meals, 120min. The curve indicating the rate of gastric emptying of solid meals is complex while for liquid meals this curve is mono-exponential [11].

It is understood that the patient must be fast, absolutely calm, have no outside pressure on his abdomen [12] and abstain for 3 days from any drugs, like opioids, analgetics or anticholinergics. His blood sugar must be less than 270mg/dL. All the above factors cause delay in HTGE. Smoking, also delays HTGE. Finally, the so called prokinetic drugs, like metoclopramide (raglan), tegaserod (zelnorm), erythromycin and domperidone (motilium) influence gastric emptying and increase HTGE [8]. Although antidiabetic drugs and insulin injections do not disturb the gastric emptying test, patients should inform the nuclear medicine physician before making any use of these drugs [13].

The kind of meal ingested, also determines the speed by which the meal will leave the stomach. Normal saline is emptied by a rhythm of 50-100mL/min, milk empties quite late, while a solid meal is usually emptied by a rhythm of only 2-6mL/min. It is obvious that meals activate specific duodenal osmotic receptors that delay HTGE [13]. Furthermore, the volume of the meal, its content in calories and the muscular tone of the stomach also influence HTGE [13].

Young women are advised to take the gastric emptying test during *the first 10 days of their menstrual period*, apart from the time they have the highest increase of estrogens and progesterone in the serum and apart from the time they are fertile [14].

The usual solid meal for measuring HTGE, as mentioned above, consists, in detail, of 2 fried eggs labelled with 18-37MBq ^{99m}Tc -pertechnetate with 2 slices of bread in a sandwich, marmalade, 30gr and tap water, 120mL. This meal has a caloric value of 255kcal and consists of 72% carbohydrates, 24% proteins, 2% lipids and 2% fibres. Eggs, after mixed with the radionuclide are fried for 3-5min. The whole meal must be eaten within 10min. The test is valid only if at least half the meal is ingested. The patient is in the standing position and anterior and posterior images are taken using a window for the 140keV of ^{99m}Tc . A low energy all purpose or a low energy high resolution collimator and a matrix 128X128 in word are used. Images are taken for 1min and the geometric mean is calculated as follows: $\sqrt{(\text{counts of the anterior} \times \text{counts of the posterior image})}$. A correction for radioactive decay is applied. If only one image is taken, the left anterior oblique (LAO) image is preferred. A region of interest (ROI) is drawn around the stomach avoiding inclusion of the intestine. In order to avoid counts from the intestine, lying behind the stomach, we may take this ROI from a LAO image or try to have exactly the same ROI for all measurements.

"Lag face" of the related gastric emptying curve starts from the time the meal is taken and ends by the time the meal appears in the duodenum. The "lag face" is considered of no special importance [14].

The liquid meal is not preferred because in case of gastroparesis the HTGE may be normal, while the solid meal will be well delayed. In case of nausea or vomiting, we may administer ondansetron, which is an antagonist to serotonin

receptors and does not influence or may influence very little, the HTGE [14].

It is important for the attending physician to know: a) the normal values of the test, b) the actual time of gastric emptying of his patient at 1, 2 and 4h, c) if his patient had taken any drugs before the test, d) the percentage of the actual radioactive meal taken and finally, e) the position of the patient during the study [14].

The gastric emptying test as described above gives to the patient a *whole body dose of 0.34-0.9mGy*. The large intestine is the "critical" organ accepting a dose up to 0.01Gy, since the radioactive meal remains in the intestine for about 30h [15].

Clinical applications of the radionuclidic method

The syndrome of gastroparesis is nowadays often diagnosed in clinical practice, like in cases of diabetes mellitus, neurogenic anorexia, amyloidosis, in patients taking sympatholytic drugs and in neurologic syndromes that influence gastric kinetics. Patients with gastroparesis besides the solid meal with fried eggs may, in special cases, be given a rather liquid meal having similar content of proteins, lipids and carbohydrates as the usual solid meal mentioned above [16]. In cases of gastroparesis the whole test must last more than 4h and the HTGE for both the solid and the liquid meals is considered the same [17].

Tachygastric, meaning increased gastric emptying is observed in dumping syndrome, in cases of partial gastrectomy or after taking certain drugs, like methanecoline or methoclopramide [3].

In diabetic patients, who are insulin treated, after taking the solid meal, a delay in HTGE of 25% was noticed, while in diabetics not treated with insulin this delay was only 17% [3]. *Functional dyspepsia* also induces an important delay in HTGE.

Patients with migraine but without functional dyspepsia have normal HTGE [18]. Patients with chronic renal insufficiency also have normal HTGE [19]. Laparoscopic cholecystectomy does not influence the HTGE that was tested before the operation [20].

After a surgical operation, patients usually suffer from their post-operation gastrointestinal atony due to increased secretion of norepinephrine, suspending gastric and intestinal contractions. Norepinephrine acts directly on the smooth muscles, suspending the vagal nerve activity and resulting gastric atony and HTGE delay. It is known that this syndrome subsides automatically within a few days.

Infusion of grelyn for 3h increases HTGE and acts therapeutically on the post operation ileus [21].

After vagotomy, ectopic gastric pace setters may appear at the area of the pyloric antrum and cause tachygastric.

In children younger than 8 years, with weight less than 30kg, the solid or the liquid gastric emptying test may be performed after taking only one image, the posterior one, for 1min. On the contrary, *in children older than 8 years, weighing more than 30kg* it is advised to be tested with a solid meal and calculate the geometric mean of an anterior and a posterior image-counts. In case these children are tested with a liquid meal, one only posterior image may be sufficient [22].

In conclusion, gastric emptying study is important for checking normal function of the upper digestive system. Gastric emptying by radionuclides better using a solid and not a liquid meal, although other techniques have emerged, still has a diagnostic role in gastroparesis and in other mainly functional, gastric disorders.

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