A new method for evaluating the esophageal transit time with external approach by ultrasonography*

Um novo método de avaliação do "tempo esofágico" com ultra-sonografia por abordagem externa

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Abstract **OBJECTIVE: To utilize ultrasonography for evaluating the esophageal transit time as well as the esophagus capability of differentiating among non-solid substances ingested (water and yoghurt). MATERIALS AND METHODS: Twenty-two young adults of both sexes with no gastric or esophageal complaint were evaluated, with a B-mode 3.5 MHz, convex transducer placed over the epigastric area. The esophageal transit time was determined by means of a chronometer activated when the deglutition was initiated (glottic movement), and stopped upon visualization of the bolus through the intra-abdominal esophagus. RESULTS: The mean esophageal transit time for water was 6.64 ± 1.83 sec, and 8.59 ± 2.70 sec for yoghurt. The comparative statistical analysis by a *t*-paired test has demonstrated statistically significant differences between the mean esophageal transit times for the two substances. CONCLUSION: This new experimental method for evaluating the esophageal transit time by ultrasonography demonstrates significant differences in the time required for a determined liquid or pasty food passing through the esophagus, elucidating clinical suspicions and allowing a more precise indication for further, more complex clinical studies.**

Keywords: Ultrasonography; Esophageal transit time; Abdominal esophagus.

Resumo **OBJETIVO: Utilizar a ultra-sonografia como método de avaliação do "tempo esofágico" e sua capacidade de discriminação entre as substâncias não-sólidas ingeridas (água e iogurte). MATERIAIS E MÉTODOS: Foram estudados 22 adultos jovens, sem queixa gástrica e esofágica, de ambos os sexos. Foi utilizado transdutor de ultra-som de 3,5 MHz, convexo, em modo B, colocado na região epigástrica. O intervalo de tempo esofágico foi determinado utilizando-se um cronômetro que foi acionado no momento da movimentação da glote (início da deglutição) e interrompido ao se visualizar a passagem do conteúdo deglutido no esôfago intra-abdominal. RESULTADOS: O tempo médio de trânsito para a água foi de 6,64 ± 1,83 segundos e para o iogurte foi de 8,59 ± 2,70 segundos. A análise estatística comparativa pelo teste *t* pareado mostrou que as médias apresentaram diferenças significativas entre as substâncias. CONCLUSÃO: O novo método experimental de avaliar o "tempo esofágico" com ultra-som é capaz de propiciar diferenças significativas do tempo necessário para um determinado alimento (líquido ou pastoso) percorrer o esôfago, esclarecendo as suspeitas clínicas e possibilitando a indicação mais precisa de exames clínicos mais complexos.**

Unitermos: Ultra-sonografia; Tempo esofágico; Esôfago intra-abdominal.

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INTRODUCTION

Over the last decades, huge development in medicine have led to the introduction of increasingly complex imaging methods which, however, are hardly accessible by the general population because of the high costs involved in the utilization of these techniques. Imaging methods such as chest radiography have been routinely performed in hospitals and, considering the high incidence of normal results (70%[1] to 77%[2]), it is suggested that a more careful selection of cases is made in order to avoid unnecessary procedures. A study has been developed with other complementary diagnostic methods such as the technique of gastric emptying by means of ultrasonography[3], to avoid that patients are excessively exposed to ionizing radiation.

In the case of esophageal complaints, contrast-enhanced esophageal radiography, esophageal manometry, scintigraphy, intraesophageal ultrasonography are routinely performed, all of them with precise indications[4–8]. Radioscopy and scintigraphy are the methods indicated for evaluating the

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esophageal transit[9–11]. However, these methods involve either a higher or lower degree of radiation exposure to the patients, despite routine implementation of quality control and guarantee systems[12].

Manometry, endoscopy and intra-esophageal ultrasonography have been utilized as a means for reducing ionizing radiation exposure. These techniques, although invasive, allow the investigation of peristalsis, mucosal lesions and diseases affecting the thickness of esophageal wall and adjacent structures.

There is a concern in finding other faster methods for preliminary evaluation in cases of mild esophageal complaints in order to optimize the indication for more complex complementary studies.

"Esophageal transit time" corresponds to the time interval required for the swallowed content to pass through the esophagus into the stomach. Esophageal transit time, in the present study was measured by means of ultrasonography, from the moment of the glottis movement (entry of the bolus into the esophagus) up to the visualization of the swallowed bolus passing through the intra-abdominal esophagus. No similar study involving the utilization of ultrasonography for this purpose has been found in the literature.

The first objective of the present experimental study was utilizing ultrasonography as a method for evaluating the esophageal transit time, and the second, estimating the esophagus capability of differentiating between liquid (water) and pasty (yoghurt) substances ingested.

MATERIALS AND METHODS

The sample of the present study included 22 young, healthy volunteers of both sexes, with ages ranging between 19 and 26 years (mean 21.64 ± 2.08 years), heights ranging between 155 and 184 cm (mean 167 ± 8.89 cm) and weighting between 48 and 82 kg (mean 62.18 ± 8.84 kg). Exclusion criteria were the following: symptoms associated with the high digestive tract and diseases that could interfere with the data collection.

A Toshiba Sonolyer series SSH 140 A/G (Toshiba; Tokio, Japan) US unit with a semi-convex 3.5 MHz transducer, maintained at a controlled temperature of 22ºC was utilized in the present study. Also a Seiko 3 BAR stopwatch (Seiko; Tokio, Japan) with a resolution of up to 1/100 seconds was utilized.

Mineral water maintained at room temperature (approximately 20 ml/volunteer) and yoghurt (approximately 20 ml or 20 g/volunteer) maintained in a refrigerator at 5º, were administered during the examinations.

After fasting for three hours, every volunteer, received water in the oral cavity, and was positioned in dorsal decubitus on the examination table, with the epigastric region exposed. Subsequently, the investigator, holding the stopwatch with the left hand, positioned the fifth finger of this hand on the epiglottis of the patient and the right hand holding the US probe positioned on the left lateral region of the xiphoid appendix.

The ultrasound beam was cranially directed until the intra-abdominal esophagus was visualized. At this moment, the volunteer was asked to swallow the water, so the investigator could feel the glottis movement and immediately activate the stopwatch that was deactivated upon visualization, by means of US, of the passage of the liquid bolus through the intra-abdominal esophagus.

The esophageal transit time for water was recorded and, after a 30-minute interval, the same volunteer was given yoghurt and, again, positioned in dorsal decubitus; and the procedure was repeated (Figures 1 and 2).

The 44 values for esophageal transit time were obtained, constituting paired treatments, with every of the 22 volunteers forming a pair of values for esophageal transit time after receiving water and yoghurt.

The present study was approved by the Committee for Ethics in Research of the Institution where the study was developed. All of the volunteers were given an explanation about the methodology utilized and signed a term of free and informed consent.

The experiment homogeneity was evaluated by means of a comparison between mean esophageal transit times ac-

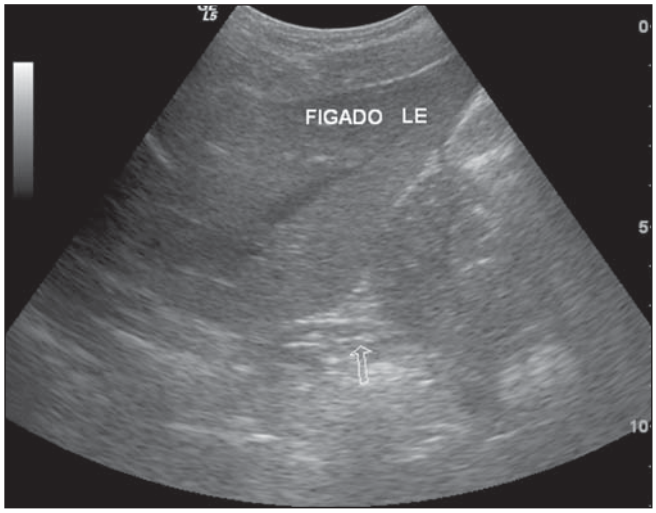

Figure 1. US scan at the level of the liver showing the intra-abdominal esophagus (arrow).

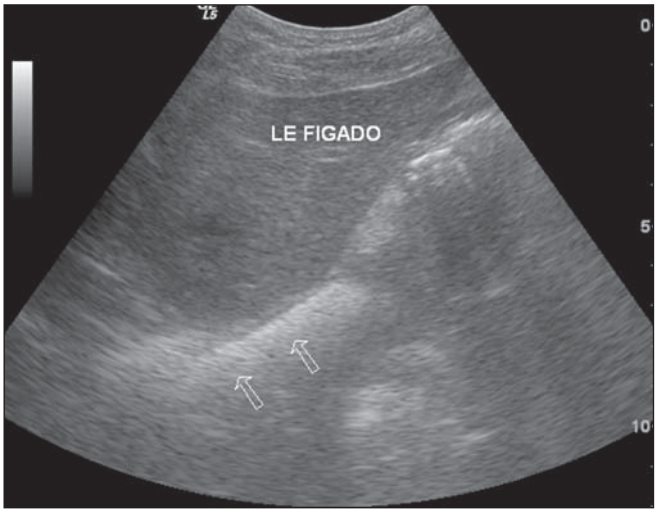

Figure 2. US scan at the level of the liver showing the intra-abdominal esophagus during the passage of the bolus (arrows).

cording to sex, separately for water and yoghurt, utilizing the two-tailed t-test, considering the impossibility of anticipating the significance of the difference.

The comparison between esophageal transit time with water and yoghurt was made through the one-tailed t-test[13], considering the hypothesis that the swallowing of less fluid substances results in a longer esophageal transit time. For the purposes of statistical analysis, the significance level was fixed in 5%, and the confidence interval in 95% for mean esophageal transit time with both water and yoghurt.

Table 1 Mean, standard deviation and variation coefficient in percentage of the variables height, age, weight and esophageal transit times with water and yoghurt.

Variables	Mean	Standard deviation	Variation coefficient (%)
Height (cm)	167.30	8.89	5.31
Age (anos)	21.64	2.08	9.61
Weight (kg)	62.18	8.84	14.22
Esophageal transit time (s) water	6.64	1.83	27.56
Esophageal transit time (s) ioghurt	8.59	2.70	31.43

RESULTS

The lowest value obtained for esophageal transit time with water was 3.74 seconds, and with yoghurt, 4.71 seconds; and the highest values were, respectively 9.85 seconds and 16.6 seconds. In four cases, the esophageal transit time was longer with water ingestion.

No significant difference was observed as regards esophageal transit time in male and female volunteers ($t_{water} = 0.8576$, gl = 20, $p = 0.4012$; $t_{yoghurt} = 0.6031$, gl = 20, $p = 0.5532$).

The mean esophageal transit time for water was 6.64 ± 1.83 seconds, and for yoghurt, 8.59 ± 2.70 seconds (Table 1).

The analysis of the difference (yoghurt-water) between esophageal transit times has indicated that the mean esophageal transit time with water ingestion was statistically lower as compared with yoghurt ingestion (t = 2.9905, gl = 21, $p = 0.0039$).

DISCUSSION

In the present experiment, the volunteers had no difficulty keeping water or yoghurt in the oral cavity. All the steps of the investigation could be accomplished in a calm environment for all the individuals inside the examination room. The intra-abdominal esophagus could be easily accessed and identified at US, allowing the visualization of the progression of the water/yoghurt bolus through this region.

The esophageal transit time could be determined with the aid of the stopwatch in all the volunteers, by measuring the time interval between the moment where the device was activated once the deglutition of water or yoghurt was initiated, up to the visualization of the bolus transit through the intra-abdominal esophagus. All the examinations could be easily and simply performed, with the patients comfortably positioned and taking a short time to be completed.

The method could differentiate the esophageal transit time for water that was statistically shorter than for yoghurt ($p < 0.0039$), demonstrating that both substances present a defined time for passing through the esophagus, and that both can be utilized in an initial screening for conditions affecting the peristalsis of this organ and, consequently, the delay in the bolus transit through the esophagus.

The evaluation of the thoracic esophagus with external approach by ultrasonography is impaired by the access difficulty, both through the anterior and the posterior mediastinum because of the presence of air in the lungs and bone tissue in the dorsal spine through which sound waves cannot be transmitted, with the exception of the segment posterior to the aorta and the heart[14]. The cervical esophagus can be evaluated by ultrasonography, considering its lateral location in relation to the trachea, proximity with the surface and interposition of soft tissue such as the left thyroid lobe[15]. Given its posterior positioning in relation to the left hepatic lobe, the intra-abdominal segment of the esophagus is easily accessible by ultrasonography, acting as an access window for ultrasound imaging (a relatively homogeneous organ that displaces the bowel loops with gas)[16–19].

With the advent of new technologies, new method have been introduced for evaluating the esophagus such as nuclear medicine, optic fiber endoscopy, manometry with pH-metry, and endoscopic ultrasonography. All these methods demonstrate the location and anatomical and functional aspects of the esophagus[20–22], but are invasive or utilize ionizing radiation with highly expensive equipment.

Therefore, the method evaluated in the present study has allowed a less invasive, a cost-effective and probably more easily available technique for the patients as compared with esophageal radiography or scintigraphy, considering that this method requires only a conventional ultrasonography unit and a stopwatch to be reproduced.

CONCLUSION

The new experimental method for evaluating the esophageal transit time with external approach by ultrasonography is a simple, non-invasive technique that provides significant information without requiring ionizing radiation. This method gives us information on the differences between the esophageal transit time for liquid and pasty food. It is widely available and can be simply performed, with no contraindication and playing a significant role in the initial evaluation of conditions that may affect the esophagus. It is a safe, reliable and discriminative method including bedside capability (suitable for utilization in residences, hospitals and infirmaries), allowing the obtention of fast results with a good cost-benefit ratio.

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