Nuclear Scintigraphy and GER

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Abstract

Gastroesophageal reflux scintigraphy (also known as a milk scan) has been mainly used to measure gastric emptying, while the technique contributes also to the diagnosis of gastroesophageal reflux (GER). Milk scan provides information on gastric emptying, GER, pulmonary aspiration, and esophageal transit. The non-invasiveness is an additional advantage. The absence of normal ranges is a weakness, but that is valid for all diagnostic techniques in children. Milk scan is an underestimated diagnostic technique. If the impedance is not available and measurement of non-acid reflux may be of interest, nuclear scintigraphy should be more frequently considered.

Keywords

Gastroesophageal reflux scintigraphy · Nuclear scintigraphy · Milk scan · Gastric emptying · Aspiration · Gastroesophageal reflux

Radionuclide gastrointestinal motility studies are non-invasive, quantitative, and physiologic diagnostic tools for evaluating patients with gastrointestinal complaints [1]. Nuclear studies have been mainly used to measure gastric emptying, but this technique is also suitable to measure postprandial gastroesophageal reflux (GER) [2]. GER scintigraphy (also known as a milk scan) is most commonly performed in infants who have symptoms of sequelae of reflux disease, or when a patient's symptoms are not responding to standard therapies. The most common indications for

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performing esophageal transit scintigraphy include achalasia, dysphagia with negative barium swallow findings. Manometry measures pressure waves in the esophagus and sphincter. However, the procedure is invasive and may not be tolerated by patients. Manometry is much more difficult to perform in children than in a nuclear transit study. Esophageal transit scintigraphy also plays a role in the assessment of treatment response.

Esophageal transit scintigraphy is performed with water or milk with ^{99m}Tc-sulfur colloid (SC) or ^{99m}Tc-diethylenetriamine pentaacetic acid (DTPA). In older children, the study can be performed with orange juice. First, there are practice swallows with water or milk only. Then, the water or milk labeled with ^{99m}Tc-SC or ^{99m}Tc-DTPA is ingested as a bolus. The patient is instructed to swallow multiple times for complete clearance of the radiotracer from the oral cavity. The infant is first administered half the volume to be ingested mixed with ^{99m}Tc-SC, followed by the remainder of milk or formula without radiotracer. Dynamic 5- to 10-s frame images are then acquired for 60 min. The images are acquired in the posterior view of the chest including the oral cavity, with the older patient erect. The infant is in a supine position. Gamma camera images of the chest are obtained at time 0, 1, and 2 h for calculation of gastric emptying and to look for aspiration. Rapid frame imaging improves the sensitivity of the reflux study. Delayed static images can then be obtained as needed to detect aspiration. The study is then viewed in static and cine modes. If reflux is present, it may be graded according to the duration of the event, as well as the extent of cephalad reflux within the esophagus. Images are acquired at a rapid framing rate of less than 1 s per frame. After recording data, the esophagus is divided into three equal regions of interest, with further region around the stomach. Time activity curves from these regions allow the qualitative and quantitative evaluation of study. Quantification may include esophageal transit time, percentage clearance at a specified time point, or percentage retained within the esophagus at a specified time point. Transit time can be defined as time (seconds) from initial swallow to 90% clearance from peak activity. Percentage transit is quantified as the number of counts at peak minus the number of counts 10 s after peak counts divided by maximal counts. Esophageal transit time less than 15 s and esophageal percentage emptying greater than 83% were established as normal in healthy adult volunteers.

Esophageal transit scintigraphy can provide unique physiologic and quantitative information regarding esophageal motility and reflux to confirm or exclude the diagnosis of esophageal motility disorders and GERD [3]. Radionuclide gastroesophageal motor studies are well suited for identifying and characterizing disorders with impaired motor function affecting the esophagus and stomach semi-quantitatively and for monitoring the efficacy of therapy [4]. The most common indications for performing esophageal transit scintigraphy include achalasia, scleroderma, dysphagia with negative barium swallow findings, and patients who do not want manometry. Esophageal transit scintigraphy also plays a role in the assessment of treatment response where repeated invasive procedures may not be desirable, particularly in patients with achalasia.

Many years before impedance was technically possible, we showed that a milk scan was very useful to detect postprandial non-acid reflux: in 65 children, 123 reflux GER episodes were recorded with pH metry and scintiscanning, but only six occurred simultaneously [5]. Significantly more reflux episodes were recorded on scintigraphy ($n = 88$; $p < 0.05$), particularly during the first half-hour period ($n = 62$), if compared with the number of pH drops greater than 1 unit, even at pH levels higher than 4 ($n = 41$; $p < 0.05$) [5].

A major shortcoming to using nuclear scintigraphy to diagnose GER-(disease) in children is the lack of normal ranges in presumed healthy children, since GER is a normal physiologic occurring event. However, it must be admitted that the absence of normal values is valid for all techniques measuring GER in children, since for ethical reasons it has become impossible to perform these investigations in asymptomatic children. In veterinary medicine, detection of postprandial GER was demonstrated in each dog investigated [6]. As a consequence, it becomes difficult to distinguish pathologic from normal [6]. GER is common in preterm infants of less than 34 weeks gestation. The incidence of positive scintigraphy and grade of reflux is not significantly different in symptomatic vs. asymptomatic babies. Though radionuclide scintigraphy is a simple, quick, and non-invasive investigation in suspected cases of GER, positive scintigraphy has no correlation with symptoms [7]. By using histopathology as standard of comparison, the sensitivity and specificity of radionuclide scintigraphy was 78.54% and 81.25%, respectively. Because of its physiologic nature, low radiation exposure and convenience, milk scan is recommended as a suitable screening test for detecting GER where available [8]. The 5-s frame acquisition technique is more sensitive than the 60-s frame acquisition technique for detecting both high- and low-level GER [9]. Antegrade pulmonary aspiration can be demonstrated as an underlying cause for persistent/recurrent lower respiratory tract infection in developmentally normal children, with age being an important clinical predictor. Combined use of salivagram and milk scan is warranted to objectively evaluate pulmonary aspiration in children. Milk scan revealed GER in 38% of children and most commonly in those above the age of 2 years [10]. The percentage yield of a positive GER position-related technique was threefold that of conventional single supine position. These results may aid a better understanding of the pathophysiology of the disease and the design of preventive and therapeutic measures [11].

Kwatra et al. attempted to establish ranges for gastric emptying according to age, feeding, and other variables in a large retrospective series of 5136 children, but of course, all these investigations were done because of the presence of symptoms [12]. Nevertheless, they could show that gastric emptying was not different in children with or without GERD [12]. Although there are statistically significant differences in gastric emptying based on age, volume, and route of feeding, the data suggest that overall normal liquid gastric emptying in infants and children $\leq$5 years of age is $\geq$80% at 3 h. One-hour emptying measurements are not reliable for detecting delayed gastric emptying [11, 12]. Gastric emptying rate of milk was not significantly different between children with GER and healthy children. A wide range of

gastric emptying rates was observed in both groups [13]. This study has suggested that the number of reflux episodes was not related to the gastric emptying rate. However, reflux could be observed in a higher frequency before gastric emptying, which also suggested that a 30-min period may be sufficient when reflux is shown early. In negative cases, a 60-min acquisition time is recommended for the diagnosis of GER [14]. However, breath test are more appropriate to measure gastric emptying [15, 16].

The reasons for this lack of widespread use are likely multifactorial, including lack of familiarity of clinicians and nuclear medicine physicians with their utility and availability, limited understanding of how to perform and interpret these studies, and lack of a standard method [16]. If impedance is not available and measurement of non-acid reflux may be of interest, nuclear scintigraphy should be more frequently considered.

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