Barium Contrast Radiography and Scintigraphy

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Introduction

Several tests have been advocated to evaluate patients with suspected gastroesophageal reflux disease (GERD), including endoscopy, manometry, barium contrast radiography, scintigraphy, 24-h pH monitoring, and combined pH-metry and multichannel intraluminal impedance [51]. Barium contrast radiography was proposed in the investigation of GER in order to document the retrograde flow of gastric content. This technique has been proposed to be useful for the evaluation of motility and for morphologic abnormalities of the esophagus. Scintigraphy utilizes milk or liquid-labeled ^{99m} technetium feeds to evaluate gastric emptying and possible microaspiration. This nuclear scan evaluates only postprandial reflux and is not able to correlate refluxes with gastric pH. A lack of standardized technique and the absence of age-specific values reduce the accuracy of this test. According to the last NASPGHAN and ESPGHAN guidelines on GERD, both techniques are not useful in the routine diagnosis of GERD. The main reasons are:

– The small duration of the exam may show only an isolated episode of reflux which cannot be considered significant [54].
– The sensitivity and the specificity of barium contrast radiography and scintigraphy are 29 % and 15 %, and 21 % and 83 %, respectively. These values are definitely very low compared with pH-metry sensitivity (86 %) and specificity (100 %) [25, 50, 54].

Barium Contrast Radiography

Barium contrast radiography, or gastrointestinal series (GI series), is a noninvasive technique used for the evaluation of upper gastrointestinal disorders. This technique is usually executed as a multiphase examination that includes various steps such as the timed barium swallow, the oropharyngeal phase, the motility phase, the distended or single-contrast phase, and then an attempt at reflux identification. The upper GI series can be performed in different views:

1. Double-contrast view using a high-density barium suspension.
2. Single-contrast view using low-density barium suspension.
3. Mucosal relief view using higher or low density of barium suspension [29, 30].

These different techniques are associated with different positions, allowing the radiologist the ability to detect specific abnormalities or disease processes. With barium contrast radiography, it is only possible to evaluate malformations in the GI tract. Historically it has been used to

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try to demonstrate the presence of ulcers, strictures, or other abnormalities of the mucosa. At the same time, it can monitor a retrograde flow of the barium from the stomach to the esophagus that could indicate a reflux of gastric content (Fig. 80.1). Bilious vomiting, protracted vomiting, feeding difficulty or dysphagia, poor weight gain or weight loss, and assessment of the status of previous fundoplication are the major indications of barium contrast radiography in children. The upper GI series is also utilized for assessing swallowing disorders and oropharyngeal aspiration in children and is usually termed a "videofluoroscopy" in these situations [4].

Use of the Upper GI Series in Diagnosis of GERD

The effectiveness and importance of reflux identification during barium studies have been questioned by many authors [35]. An upper GI series can identify a single reflux event (Figs. 80.2 and 80.3), but conflicting data exist about the possible correlation between the size and height of reflux detected by barium contrast radiography and the presence of GER/GERD. Christiansen et al. found a positive correlation between the level of reflux on barium studies and the proximal extent of reflux esophagitis on microscopic examination of endoscopic biopsy specimens from the esophagus [11]. Moreover, Pan et al. comparing the findings on 24-h pH-metry, with those of barium contrast radiography of 28 patients, observed that patients with massive reflux episodes on barium contrast radiography had pathologic acid reflux on pH monitoring [37]. On the other hand, it has been recently established that no correlation exists between the height of reflux and esophageal/extraesophageal symptoms, prognosis, or the natural history of GERD [6]. Indeed, reviewing various data reported in the literature, we noted a broad agreement not to consider barium contrast radiography as a useful tool in the diagnosis of GERD because of its low sensitivity and specificity. In a review of ten previously published studies, Ott found that only 204 (35 %) of 587 patients with proven reflux had a GERD detected on GI series, showing a lower sensitivity of this technique compared to 24-h pH-metry [35]. In the literature, several studies, concerning the attempt to demonstrate higher barium contrast radiography sensitivity and specificity, are reported. Thompson

Fig. 80.1 A retrograde flow of barium in pharynx due to an incoordination of swallowing evaluate trough barium contrast radiography (Photographs made available by Department of Radiology, University of Naples Federico II, courtesy of Hana Dolenzalova, M.D.)

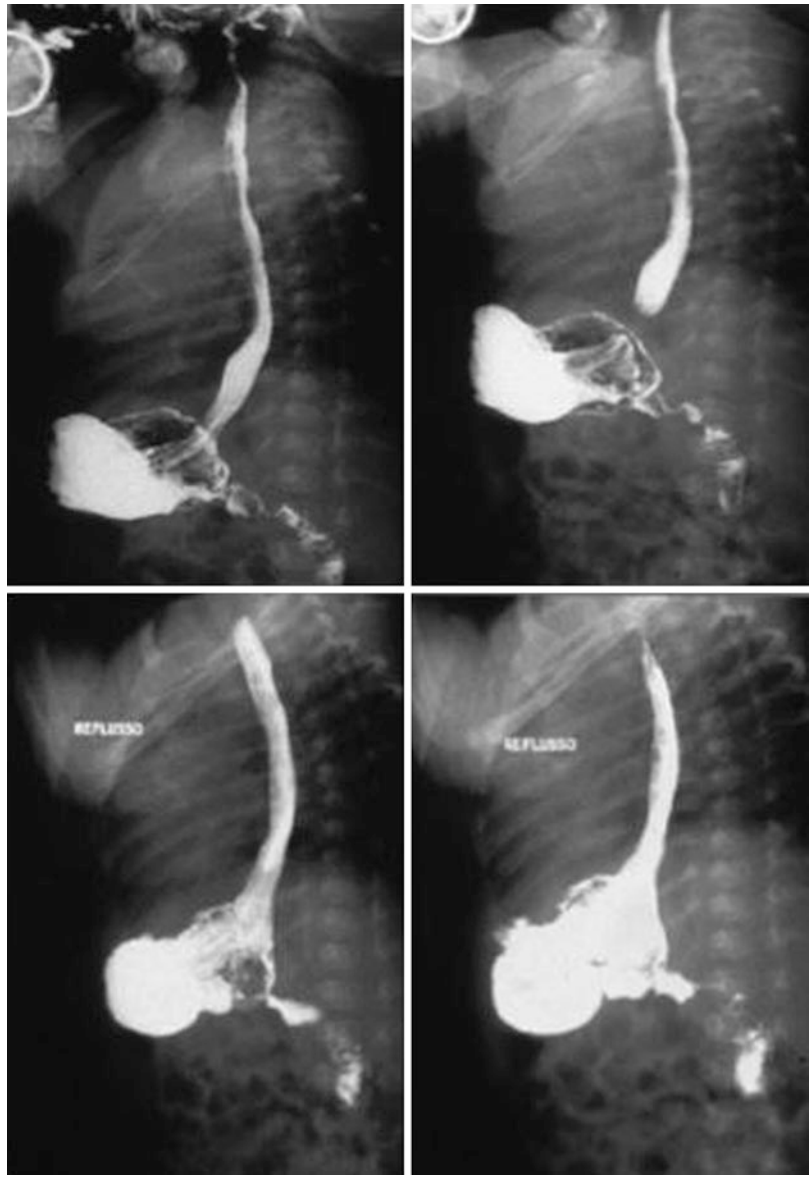

Fig. 80.2 Gastro-esophageal reflux (Photographs made available by Department of Radiology, University of Naples Federico II, courtesy of Hana Dolenzalova, M.D.)

et al. [46] studied 117 patients with clinical findings suggestive of reflux by using GI series and pH-metry. Seventy (59 %) had a positive pH-metry while 47 (41 %) had a negative one. They found, according to previous data, that using provocative maneuvers, including abdominal compression, the Valsalva maneuver, positional changes, leg lifting, coughing, and water siphon test, induced an enhancement of sensitivity (44–92 %), with decrease in specificity (0–75 %) [6, 17, 46]. In addition, it has been observed that the upper GI series is not indicated for infants less than 1 year of age because it has a specificity of 50 % and a sensitivity of 29 % when compared with 24-h pH-metry [1].

Several reasons could explain the limits of an upper GI series in detecting GER. One being that many infants have non-pathological, or physiological, reflux, producing false-positive results. Moreover the short duration of the upper GI series is the cause of false-negative results. Importantly the relatively high level of radiation

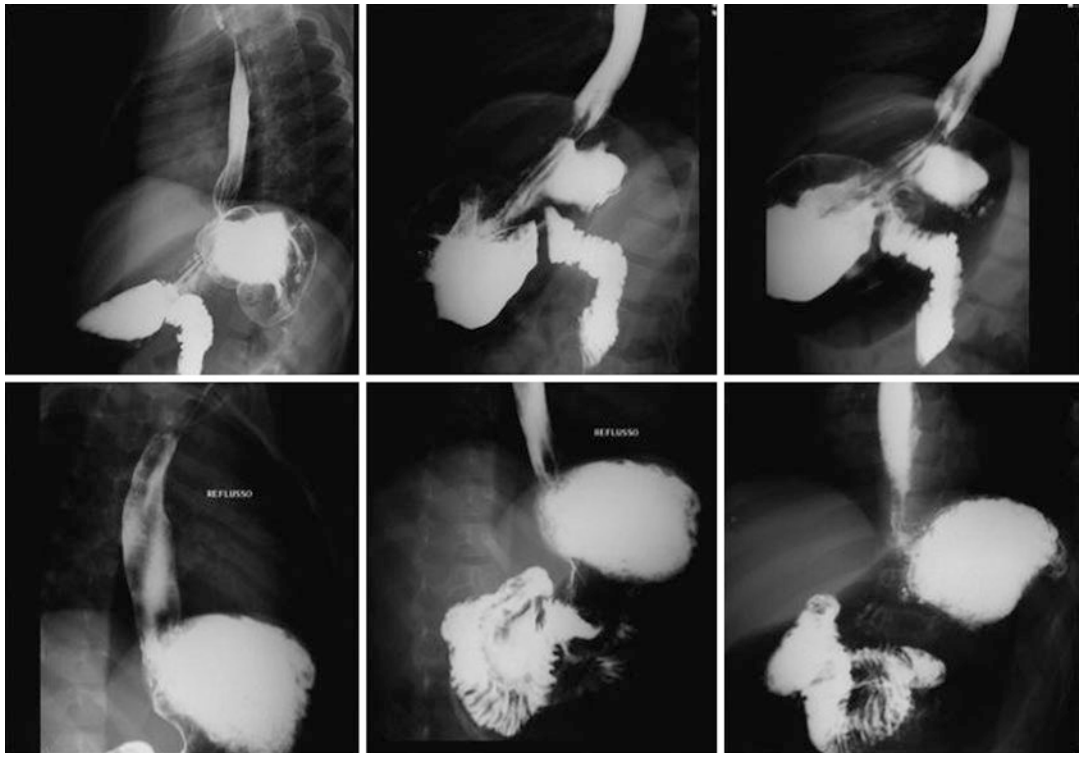

Fig. 80.3 Gastroesophageal reflux (Photographs made available by Department of Radiology, University of Naples Federico II, courtesy of Hana Dolenzalova, M.D.)

received by the child during a barium contrast examination is another important limitation for the use of this technique which should be considered in the diagnostic approach of a child with GERD suspicion [53]. For all the abovementioned reasons, GI series is not of value for the routine diagnosis of GERD, but its possible indications in GER are confined to the evaluation of upper GI anatomical abnormalities such as esophageal strictures, hiatal herniae, achalasia, tracheoesophageal fistulae, intestinal malrotations, or pyloric stenoses, which may be considered in the differential diagnosis of infants and children with symptoms suggestive of GERD.

The upper GI series is reported by some to have a sensitivity of 90 % in the detection of reflux esophagitis. The early manifestations of reflux esophagitis are said to be represented by a fine nodular or granular appearance with poorly defined radiolucencies that fade peripherally for the edema and inflammation of mucosa [10, 31] (Fig. 80.4). In patients with severe reflux, barium contrast radiography may, it is said, show the evidence of small ulcers, erosions, or strictures of the esophagus, but this remains highly dubious and generally thought to be without substance or reliability [43]. The classic signs of Barrett's esophagus instead are found only in 5–10 % of all patients, and this modality remains extremely suspect in this essentially histological diagnosis [13, 21, 22]. Achalasia is characterized by the incomplete relaxation of the lower oesophageal sphincter (LES) and the absence of esophageal peristalsis which causes a functional obstruction of the distal esophagus. Using barium contrast radiography, the esophagus appears dilated with a tapered beak-like narrowing near the gastroesophageal junction [28, 29, 36, 44] (Fig. 80.5).

Hiatal herniae consist of the herniation of parts of the abdominal contents through the oesophageal hiatus of the diaphragm. The relationship between esophagitis and hiatal hernia

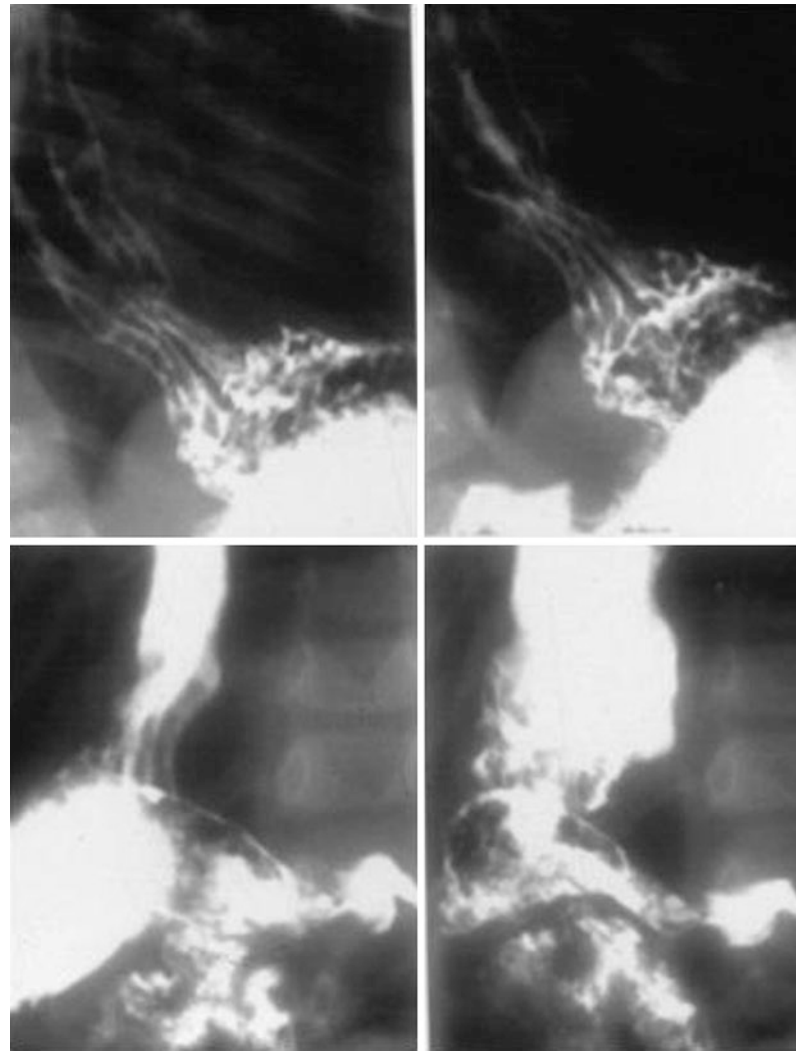

Fig. 80.4 Early esophagitis. It is possible to note the edema of the mucosa with an increasing of the esophageal folds (Photographs made available by Department of Radiology, University of Naples Federico II, courtesy of Hana Dolenzalova, M.D.)

has been established for many years both in children and in adults. It is known that in the presence of a hiatal hernia, all of the antireflux barriers at the LES (including crural support, intra-abdominal segment, and angle of His) are compromised [7, 9, 33, 50], and transient LES relaxations also occur with greater frequency [33], increasing the possible onset of GERD. On the contrary the presence of erosive esophagitis by itself may promote esophageal shortening and consequent hiatal herniation, although this remains conjectural [33]. Both the presence and size of the hiatal hernia are important factors determining the GERD severity [8, 25]. As of now an upper GI series remains the most sensitive technique in the diagnosis of a hiatal hernia and its size.

Intestinal malrotation can occur as an acute abdomen or as a recurrent episode of abdominal pain and/or vomit. An intermittent volvulus or a duodenum compression due to Ladd's band or to adhesions of the ileum or colon can explain this symptomatology. GI radiography, especially barium contrast radiography, is useful for the diagnosis of this malformation. It remains the most sensitive and specific technique for the diagnosis of malrotation, and the presence of bile-stained vomiting is categorically not needed for the suspicion of this diagnosis – in other words any child with intermittent abdominal pain/vomiting should

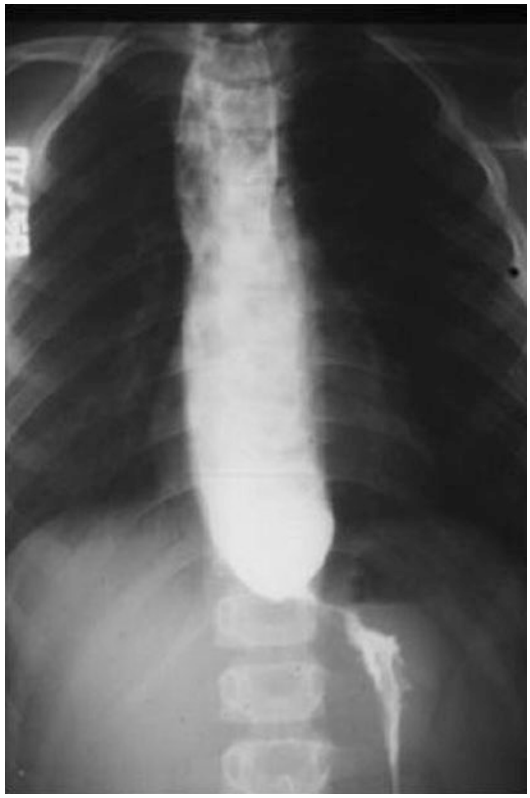

Fig. 80.5 An image of esophageal achalasia (Photographs made available by Department of Radiology, University of Naples Federico II, courtesy of Hana Dolenzalova, M.D.)

have this diagnosis borne in mind by their doctor. Anything less than a high index of suspicion for this potentially devastating condition with volvulus and small bowel necrosis leading to short bowel syndrome and a life dependent on parenteral nutrition is inadvisable.

Esophageal strictures can be congenital or acquired. They can be caused by or associated with GERD, esophagitis, dysfunctional LES, disordered motility, hiatal hernia, surgical anastomosis, infections, and caustic ingestion (Fig. 80.6). GI series is the gold standard to diagnosis of the majority of esophageal strictures.

Classically, infants with hypertrophic pyloric stenosis have non-bilious vomiting or regurgitation which sometimes can be interpreted as consequences of GERD. In these cases an upper GI series may show an elongated pyloric canal, a prominence of the pyloric muscle in the gastric antrum (the so-called *shoulder sign*), and parallel barium streaks in the narrowed canal which determine the so-called *double track sign*. Nowadays ultrasound is considered the gold standard for pyloric stenosis diagnosis.

Scintigraphy

First Kazem in 1972 tried to develop a new technique, scintigraphy, for the evaluation of GI function [27], and since that time it has been applied to a variety of pathophysiologic conditions. Esophageal scintigraphy, which was introduced in 1976 [16] as a diagnostic tool to try to evaluate GER, seemed to be a potentially accurate and noninvasive technique to diagnose and quantify reflux. However, the lack of a standardized technique for the performance and the interpretation of this test and the absence of age-specific values are the main reasons to explain why the importance of scintigraphy in the diagnosis of GER has decreased. Nevertheless, several studies have been conducted to estimate the role of scintigraphy for the evaluation of upper GI function, especially the ability to detect gastroesophageal reflux, both in pediatric and adult populations. Scintigraphic evaluation of children with suspected GERD is performed with several approaches using caloric liquid or solid meals labeled with ^{99m} technetium (Tc), appropriate to the patient's age. A gamma camera equipped with an adequate collimator placed in front of the recumbent patient is needed to obtain a dynamic study of the esophagogastric region and lungs. Standard protocols and guidelines on GERD scintigraphy require a 60-min dynamic acquisition during which reflux episodes with their duration, extension, and aspiration are recorded. Since transient reflux can rapidly dissolve, a rapid imaging (10–20 s/images) is needed. At the end of dynamic acquisition, 5-min static images of the anterior and posterior lung fields are acquired. Reyhan et al., comparing the posterior dynamic imaging with the anterior imaging in the evaluation of children with GERD, showed that posterior imaging was superior to anterior imaging, being more comfortable and with less motion

Fig. 80.6 A stricture of the distal esophagus due to an advance esophagitis (Photographs made available by Department of Radiology, University of Naples Federico II, courtesy of Hana Dolenzalova, M.D.)

artifacts, especially for infants and anxious children [41]. Finally gastroesophageal reflux can be described using different indices, which usually consider the volume of each episode, the frequency of the episodes, and the rate of reflux clearance from the esophagus.

Scintigraphy in Diagnosis of Upper Gastrointestinal Diseases

Although gastroesophageal scintigraphy is a practical and noninvasive technique with low levels of radiation exposure for children compared to barium, its significance in diagnosing GER, it is limited by the failure of scintigraphy to achieve a sensitivity similar to that of other tests, particularly esophageal pH monitoring. Sensitivity and specificity of a 1-h scintigraphy for the diagnosis of GERD are 15–59 % and 83–100 %, respectively, when compared with 24-h pH-metry [2, 3, 14, 42, 47]. Seibert et al. [42] first reported a sensitivity and a specificity of 79 % and 93 %, respectively, when comparing gastroesophageal scintigraphy to 24-h pH-metry, analyzing 49 infants and children with suspected GER. Tolia et al. [47] comparing esophageal pH-metry with gastroesophageal scintigraphy observed that the incidence of GER was 69.5 % by pH-metry and 66.0 % by gastroesophageal scintigraphy in symptomatic infants of less than 1 year of age. Vandenplas et al. also performed simultaneous pH monitoring and scintigraphy in children and found that among 123 separate reflux episodes detected, only six were recorded by both techniques [3]. Gastroesophageal scintigraphy evaluates only postprandial reflux and it is not able to correlate refluxes with gastric pH. This offers certain advantages over pH monitoring because gastric acidity may be neutralized by food, especially milk, in the immediate postprandial period, making pH studies unreliable [49]. Scintigraphy may be particularly useful in patients with GERD suspicion, but with negative result at pH monitoring. Gastroesophageal reflux can be acid, nonacid,

or weakly acid. GERD-associated respiratory problems seem to be related to nonacid refluxes which can be missed by intraesophageal pH monitoring. Studies using multichannel intraluminal impedance/pH-metry have shown that sensitivity of pH monitoring for the detection of retrograde bolus reflux is only 8%, and up to 90% of refluxes may be missed since they are neutral or slightly alkaline [34, 54]. It is known that in infants, only 16% of all reflux episodes associated with breathing abnormalities and oxygen desaturation were detected by pH monitoring [57], and only 22% of apnea-associated reflux episodes were acid and thus detected by pH monitoring [56]. According to the previous study, Thomas et al. [55] studied 126 children aged 6 months to 6 years and found that 70% of them had no gastrointestinal symptoms suggestive of GERD despite scintigraphic evidence of reflux. Karaman et al. using radionuclide scintigraphy showed a 21.1% incidence of GERD in 74 children with recurrent wheezing [45]. These data confirmed a possible use of gastroesophageal scintigraphy for the diagnosis of GERD in patients with atypical GERD symptoms in which gastric pH could be within the physiologic range. A recent study [26] assessed the validity of GERD scintigraphy in children older than 7 years demonstrating that of 75 patients who presented with chronic cough, 65 (86%) had GERD on scintigraphy. Nevertheless gastroesophageal scintigraphy has a relatively low sensitivity to analyze microaspiration [5, 15, 19] so that a negative test does not exclude the possibility of infrequently occurring aspiration [19]. Evidence of pulmonary aspiration may be detected during a 1-h scintigraphic study or on images obtained up to 24 h after administration of the radionuclide [16]. One study of children with refractory respiratory symptoms found that half had scintigraphic evidence of pulmonary aspiration [19]. However, aspiration of both gastric contents and saliva also occurs in healthy adults during deep sleep [17, 40]. Scintigraphy can provide information about gastric emptying. It is known that delayed gastric emptying may predispose to GERD in adults [32] and in children [20, 24]. Gastric emptying studies have shown prolonged half-emptying times in children with GERD. Gastric emptying scintigraphy has become a complementary part of routine gastroesophageal reflux scintigraphy, and even if tests of gastric emptying are not a part of the routine examination of patients with suspected GERD, they may be important when symptoms suggest gastric retention or when gastrostomy placement is needed [12, 23, 38, 52]. Respect to barium studies, scintigraphy is unable to delineate anatomic features, such as hiatus hernia, frequently associated to GERD, but its radiation exposure is considerably less than with barium studies. In addition, it has the advantage of allowing long periods of observation to detect refluxes. In a study on 35 children with a suspicion of GERD, comparing barium studies and scintigraphy with endoscopic findings, authors found that scintigraphy was more accurate to estimate reflux episodes than barium studies [18]. However, there was no significant relationship between scintigraphic study and endoscopic findings. In conclusion these data confirm the notion that even if scintigraphy can explore some important aspects of GERD, it is not recommended in the routine diagnosis and management of this disease in infants and children [39, 48].

Conclusions

According to the last evidence-based NASPGHAN and ESPGHAN guidelines on the diagnosis of GERD, we recommend:

1. The upper GI series is not useful for the diagnosis of GERD, but is useful for the diagnosis of anatomic abnormalities (Quality of Evidence B).
2. Scintigraphy could have a role in the diagnosis of aspiration in patients with chronic refractory respiratory symptoms, but the technique is not recommended in patients with other potentially gastroesophageal reflux-related symptoms (Quality of Evidence B).

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