Esophageal Scintigraphy in Achalasia and Achalasia-like Disorders

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J Nucl Med 1992; 33:590–594

CASE PRESENTATION

An 81-yr-old white male presented with temporary aphagia with a sensation of fullness in his lower chest and an inability to swallow his saliva while he was eating a steak sandwich. Within 1 hr, he had regained the ability to swallow his saliva and had relief of the sensation of fullness in his lower chest. At this point, he sought medical attention to determine the cause of his symptoms.

Since the age of 25, he had noted dysphagia for solids localized to his midchest area, approximately four to five times per year. He would typically ingest liquids to "wash down the solids." He did not have any associated chest pain, nausea, or vomiting. In 1960, a barium swallow was performed which was reported to be normal. For 2 yr prior to this evaluation, he had noted an increased frequency of dysphagia such that it was occurring at least one to two times daily when eating solid foods.

A barium swallow revealed markedly abnormal esophageal motility with weakening of primary peristalsis below the level of the aortic arch, associated with multiple nonpropulsive contractions, producing a corkscrew appearance of the esophagus. This was interpreted to be suggestive of symptomatic diffuse esophageal spasm along with an epiphrenic diverticulum. Endoscopy confirmed the presence of a tortuous esophagus and an epiphrenic diverticulum. Esophageal manometry was notable for the presence of multiple simultaneous contractions that were repetitive and of prolonged duration in the esophageal body. The basal midrespiratory lower esophageal sphincter (LES) pressure was moderately elevated at 34 mmHg (normal midrespiratory LES pressure is from 15 mmHg to 30 mmHg) with a mean end-expiratory LES pressure of 25 mmHg that relaxed incompletely to swallowing. With Tensilon provocation, the patient developed high amplitude prolonged contractions with chest pain. Overall, this manometry was consistent with a major motor abnormality of the esophagus (somewhere along the continuum between symptomatic diffuse esophageal spasm and achalasia) with achalasia-like features. The patient subsequently had an esophageal emptying study performed following the ingestion of 300 μCi of ^{99}Tc-sulfur colloid mixed with water. This study exhibited markedly delayed esophageal transit; At 60 min, there was approximately 10% esophageal emptying (Fig. 1).

The patient underwent a transabdominal modified Heller myotomy with a Nissen fundoplication. The dissection was carried past the level of the epiphrenic diverticulum. The total length of the myotomy was 7–8 cm.

One week postoperatively a repeat barium swallow was performed which revealed persistent abnormal esophageal peristalsis with a Nissen fundoplication and an open esophagogastric junction and no gastroesophageal reflux. Similarly, a liquid radionuclide esophageal transit study was repeated 6 wk postoperatively and the patient had 98% emptying of the administered radionuclide by 2 min. At that time, the patient had noted resolution of his dysphagia. He was able to eat solid food (specifically, bread and steak) without any difficulty.

This case illustrates several important points in a symptomatic patient with an achalasia-like esophageal motility disorder. Prior to treatment the patient had a markedly abnormal esophageal transit and a high LES pressure as determined by manometry. After treatment by pneumotomy, the patient had an excellent clinical response, a markedly improved esophageal transit study and his LES pressure on esophageal manometry was within the normal range on follow-up. Several points with regard to this case and points of importance regarding esophageal scintigraphy will be stressed and reviewed below.

DISCUSSION

Radionuclide Esophageal Emptying

Since Ismail Kazem (*1*) initially described the use of radionuclide esophageal emptying in 1972 in 12 normal patients and compared them to 20 patients with organic

Received Sept. 11, 1991; revision accepted Oct. 16, 1991.
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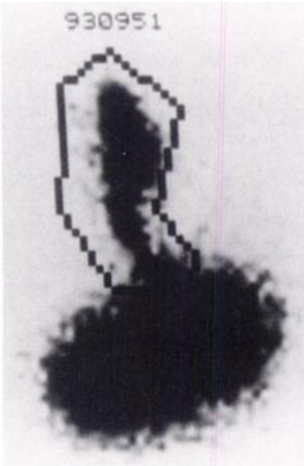

FIGURE 1. This radionuclide image exhibits markedly delayed esophageal emptying with some activity seen in the stomach. This pattern is considered typical for achalasia.

esophageal obstruction, this "physiologic" test has gained popularity and has been used for assessment of a multitude of esophageal disorders. Scintigraphic techniques have been similarly applied to quantitative and qualitative assessment of gastric emptying and gastroesophageal reflux. In 1979, Tolin et al. (*2*) described the first quantitative esophageal scintigraphic measurement. Since then, quantitative esophageal scintigraphy has become the standard method of assessing esophageal transit. Esophageal emptying is typically expressed as percentage of total clearance from the esophagus in a given unit of time.

General Method of Esophageal Scintigraphy

Typically, the method for performing esophageal nuclear scintigraphy involves oral ingestion of a standard quantity of a radiolabeled liquid or solid (typically with ^{99m}Tc-sulfur-colloid) after a short period of fasting while the patient is in the supine (preferred position) or sitting position. The patient is positioned adjacent to a scintigraphic camera and the images of the esophagus are subsequently analyzed by a computer to determine the percentage emptying over a specified time course. The esophagus can be divided into upper, middle, and lower esophageal areas to assess emptying and transit in a specified segment. The oropharyngeal area can be similarly assessed if such information is clinically important. Corrections are typically made to account for background counts but not for radionuclide decay.

Esophageal Scintigraphy in Normal Subjects

In normal control subjects without esophageal symptoms, esophageal radionuclide transit time is quite short. Table 1 summarizes the reports in the literature with regard to emptying or total clearance of the radionuclide.

The data in Table 1 show that normal esophageal transit study results can vary widely. Ideally, each laboratory should develop their own normal ranges using a specific technique. The rate of transit is dependent upon several extrinsic factors, including the density of the bolus swallowed (solid or liquid) and the patient's position (prone versus supine) (*10*).

It has been shown that changing the position from prone to supine or vice versa has an important effect on esophageal transit. When the subject is in the supine position, the effect of gravity is minimized and the propulsive forces of the esophagus are the primary parameters measured. It has been suggested that patients should be screened in the supine position when searching for abnormal esophageal transit in esophageal motility disorders, since this is more likely to detect an abnormal transit if an esophageal abnormality exists (*14*). Sandmark (*15*) illustrated that the density and viscocity of barium sulfate can change its behavior; specifically, these factors might influence esophageal transit. Most of the published series referenced in Table 1 have used liquid as their radiolabeled vehicle. Solids, however, are felt to be more representative of physiologic states in patients with esophageal disorders (specifically patients with achalasia), since patients do complain more frequently of dysphagia for solids than for liquids. Thus there have been suggestions for using solids in the evaluation of patients with known achalasia (*12*).

It is also possible to examine esophageal transit in a specific segment of the esophagus with scintigraphic techniques, (i.e., the upper, mid or lower third of the esopha-

TABLE 1
Emptying or Total Clearance of Radionuclide

No. of patients	Position	Solid/Liquid	Transit (sec)	Total clearance time	Reference
15	Supine	Liquid	42% at 3 sec	~9 sec	2
15	Supine	Liquid	83% at 15 sec	~60 sec	3
5	Sitting	Liquid	65% at 10 sec	60 sec	4
12	Supine	Liquid	—	5.9 ± 1.9 sec	5
16	Supine	Liquid	—	8.6 ± 3.4 sec	6
	Erect solid	—	—	13–16 sec	7
10	Sitting	Liquid	50% at 5 sec	~6–8 sec	8
14	Supine	Liquid	—	9.6 ± 2.1 sec	9
19	Supine	Liquid	—	9.5 ± 1.5 sec	10
11	Upright	Semisolid	—	6.98 ± 2 sec	11
8	Standing	Solid	95% at 60 sec	—	12
16	Supine	Liquid	—	7.3 ± 2.3 sec	13

gus). It is said that the use of multiple areas of interest often permits differentiation between an adynamic esophagus and incoordinate activity typical of diffuse esophageal spasm (*13*).

Gastrointestional factors (intrinsic esophageal factors) which influence the propulsion of the radiolabeled bolus from the esophagus to the stomach in normal and pathologic states include the patency of the esophagus, the presence of esophageal peristalsis and the pressure gradient between the esophagus and the stomach (i.e., the resistance to travel).

Detection of Esophageal Motility Disorders

The use of esophageal scintigraphy as a screening test for detection of esophageal motility disorders has been suggested by several authors (*2,6,9,10,11,13,16,17*). The sensitivity of esophageal scintigraphy for detection of esophageal motility abnormalities ranges from 75% (*17*) to 96% (*6*), with a positive predictive value of 73%–100% and a negative predictive value of up to 94% (*18*).

Patients with abnormal esophageal transit may have a multitude of disorders, including those listed in Table 2. The finding of delayed esophageal transit is not specific for any of these disorders. It should be mentioned, however, that there are patients without esophageal symptoms with normal esophageal manometries who have been found to have abnormal esophageal transit by radionuclide esophageal scanning. The reason for this remains unclear.

Achalasia

Idiopathic achalasia is a primary motor disorder of the esophagus, characterized by absent esophageal peristalsis, elevated intraesophageal pressure and an incompletely relaxing and often hypertensive lower esophageal sphincter. A dilated esophagus with a "bird-beak" appearance of the lower esophageal sphincter is the classic appearance of achalasia on barium studies. Delayed esophageal emptying has been demonstrated on esophageal scintigraphy and on barium studies of the esophagus.

The first treatment of a patient with achalasia is attributed to Sir Thomas Willis when he performed the first esophageal dilatation using a whale bone in 1682 (*19*). The therapy for achalasia is aimed at relief of the functional obstruction at the lower esophageal sphincter whether it be by forceful (pneumatic) dilatation of the LES or surgical (Heller's) cardiomyotomy. Calcium channel blockers have also been used for treatment of achalasia and have been shown to relieve dysphagia and lower manometric LES pressure (*20,21*).

When esophageal transit is assessed in achalasia patients and the results are compared to those obtained in normal controls without esophageal symptoms, it has been clearly demonstrated that these patients have markedly delayed esophageal transit (*12*). The actual values for esophageal transit in patients with achalasia as reported in the literature are shown in Table 3. Patients with achalasia tend to have the longest esophageal transit when compared to other patients with and without esophageal motility disorders.

Basal lower esophageal sphincter pressure does not correlate in a linear fashion with esophageal clearance in patients with achalasia (*12*). Esophageal transit generally improves when patients with achalasia are treated with esophagomyotomy or pneumatic dilation (*8,12*). Although esophageal transit improves, it does not return to a normal value. In other words, a return to a normal esophageal transit value is not expected for patients after treatment for achalasia to suggest successful treatment. If, however, after treatment (either by pneumatic dilatation or by esophagomyotomy) a patient does not show improvement in esophageal emptying, the problem may be due to ineffective treatment and thus may require retreatment (*12*). Alternatively, a patient may have symptomatic improvement without significant improvement in esophageal scintigraphic parameters. Robertson et al. (*8*) suggest that this may be due to a placebo effect.

It would appear that a primary role for esophageal scintigraphy would be in following the long-term response of patients with achalasia and comparing the scintigraphic findings to other clinical parameters, including symptoms. Unfortunately no such long-term study critically assessing this role has been reported. Our patient had a good short-term clinical response and markedly improved esophageal emptying.

Several authors have described specific patterns seen in

TABLE 2
Disorders with Abnormal Esophageal Transit

1. Achalasia
2. Hypertensive lower esophageal sphincter
3. Gastroesophageal reflux
4. Symptomatic diffuse esophageal spasm
5. Nonspecific esophageal motor disorder
6. "Nutcracker" esophagus
7. Esophageal obstruction
   Intrinsic: Stricture, carcinoma, etc.
   Extrinsic: Aortic compression, etc.
8. Scleroderma
9. Barrett's esophagus

TABLE 3
Esophageal Transit in Patients with Achalasia

Number of pts.	Position: Liquid/Solid	E. E. (min)	Reference
29	Sitting: solid	32%: (15)	12
2	Sitting: liquid	30%: (30)	4
15	Sitting: liquid	30%: (1.5)	8
9	Supine: liquid	(>3.3)	9
8	Supine: liquid	30%: (10)	2
14	Supine: solid	(1.6 ± 0.7)	10
4	Supine: liquid	(>1.0)	13
6	Supine: liquid	(>0.5)	6

E.E. = esophageal emptying.

esophageal scintigraphy performed on patients with achalasia and other esophageal motility disorders. O'Connor et al. (*11*) noted that patients with achalasia often had a specific radionuclide pattern: "the bolus progresses halfway down the esophagus and shows episodes of retrograde motion. The administration of water fails to wash the bolus into the stomach and results in more pronounced retrograde motion." Holloway et al. (*9*) noted that "in achalasia virtually none of the bolus entered the stomach and appeared to slosh around in the distal esophagus." Similarly, DeVincentis et al. (*10*) found that in patients with achalasia there is a conspicuous stasis of the bolus, particularly in the distal esophageal and LES regions. Finally, Netscher et al. (*6*) reported that patients with achalasia characteristically have a wide esophageal outline with extremely slow accumulation of radioactivity in the stomach, and then only after standing.

Achalasia-like Esophageal Motor Disorders

As discussed above, achalasia is a distinct manometrically defined entity and has a relatively typical scintigraphic feature. Often, however, patients exhibit the majority of features for a known motor disorder of the esophagus, but do not meet all the criteria of a known esophageal motor disorder. Those patients described as having a nonspecific motor disorder of the esophagus closely resemble but do not quite meet the criteria for diagnosis of known esophageal motility disorders such as achalasia, symptomatic diffuse esophageal spasm (manometrically defined by high amplitude, simultaneous contractions with intermittent normal peristalsis accompanied by chest pain and/or dysphagia), hypertensive lower esophageal sphincter (manometrically defined by elevated LES pressure, normal LES relaxation and normal peristaltic progression), etc. Those patients with nonspecific motor disorder of the esophagus closely resembling achalasia are said to have an achalasia-like motor disorder of the esophagus. These patients may be somewhere along a continuum between symptomatic diffuse esophageal spasm (DES) and achalasia (as was the patient presented in this case history). These patients are classified manometrically as having nonspecific motor disorders of the esophagus. DES is manometrically defined by high amplitude, repetitive, frequently nonperistaltic contractions (i.e., nonperistaltic contractions associated with >30% of wet swallows) in the distal two-thirds of the esophagus. Patients with symptomatic DES retain some peristaltic function, have normal LES relaxation and normal resting intraesophageal pressure and suffer from chest pain and/or dysphagia (*9*).

Patients with symptomatic DES typically have a delayed esophageal transit similar to patients with achalasia. Several characteristic patterns have been described in patients with DES. De Vincentis et al. (*10*) note that "spasms are evident when a characteristic pattern of several peaks is present in one or more activity/time curves, very close in time and not synchronized with swallowings; in the meantime, the activity accumulation curve over the stomach shows a continuous, although delayed increase." Netscher et al. (*6*) note similar findings and report that patients with DES have a pattern of "disorganized bolus progression through the esophagus with multiple peaks and occasional retrograde (movement) within the esophagus." In general, however, esophageal transit is more prolonged in patients with achalasia as compared to patients with symptomatic DES.

Possible Sources of Misinterpretation of Radionuclide Images

False-negative radionuclide esophageal transit tests have been reported in patients with manometrically demonstrated motility disorders. One study (*13*) noted that 3 of 13 patients with symptomatic DES had normal esophageal transit studies. This can perhaps be explained by the intermittent nature of this motility disorder.

False-positive radionuclide esophageal transit tests have also been reported. One possible source of error is due to incomplete swallowing of the bolus, as observed by Russell et al. (*22*). If part of the initial bolus is swallowed and the remainder is retained in the mouth until a later time when the patient takes a second swallow, it will appear as if the patient has had a delayed esophageal transit. This second peak of radioactivity might be interpreted as either prolonged esophageal clearance or reflux. Thus, it is important to include the patient's mouth in the field of view to determine when the radionuclide bolus leaves the patient's mouth. A second possible source of error may occur when a patient has a large hiatal hernia because the hiatal hernia can easily be mistaken for a dilated distal esophagus.

CONCLUSION

In general, esophageal manometry has been accepted as the diagnostic technique of choice for patients with suspected esophageal motility disorders. However, some authors have questioned the cost-effectiveness of esophageal manometry (*23*), noting that this test requires a certain level of expertise and a considerable amount of time for conclusive results.

As noted by Holloway et al. (*12*), radionuclide measurement of esophageal emptying is a reliable, easily performed, and physiologic test of esophageal function. It is well tolerated by patients and preferred over esophageal manometry. It is noninvasive and the radiation exposure (approximately equivalent to one chest x-ray) is considerably less than that in a barium swallow. Additionally, it is inexpensive and readily available (*19*).

As expected, esophageal scintigraphy is not used to discern anatomic features of the esophagus; rather this is considered the primary role of endoscopy and/or radiography. In patients undergoing esophageal scintigraphy, it is important to determine if esophageal obstruction has been shown by anatomic methods. This information is of utmost importance when interpreting esophageal scintigraphic studies and may help avoid inaccurate interpretation of test results.

Several studies have evaluated the short-term effect of various therapies on esophageal scintigraphy in patients with achalasia. Esophageal transit has typically been shown to improve after effective therapy and has been reported to remain unchanged when therapy was ineffective (*19*). Thus, it is fair to say that esophageal scintigraphy allows an objective assessment of immediate and short-term results of treatment and it correlates well with patient symptoms.

The value of esophageal scintigraphy, however, has not been critically assessed in the long-term clinical follow-up of patients with achalasia, an area deserving further attention.

This review summarizes the current utility of esophageal scintigraphy in patients with achalasia and achalasia-like esophageal motor disorders. As noted by McCallum (*19*), "the era of (routine) gastrointestinal radionuclide studies is at hand. This will be an exciting period when physiologic principles can be re-evaluated using physiologic meals and a methodology which is sensitive, (accurate), noninvasive, and safe."

The case discussed here clearly illustrates the utility of esophageal scintigraphy in patients who suffer from achalasia or achalasia-like motility disorders. This test provides the clinician with an objective assessment of the degree of dysfunction noted clinically and by other means. This quantitative technique and its resulting measurements can be used to follow the course of the disease as well as the effects of therapeutic interventions in this serious disorder. The case described above clearly demonstrates the critical role that esophageal scintigraphy can play in the management of these patients.

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