Esophageal Scintigraphy in Systemic Sclerosis: A Simplified Imaging and Reporting Method

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Patients suffering from systemic sclerosis can suffer from significant esophageal dysmotility. Standard tests such as esophageal manometry are invasive and can be distressing to the patient. Esophageal scintigraphy would be ideal, but most protocols are too time consuming for a busy clinical department. The aim of this study was to produce an optimal imaging and reporting protocol that would allow esophageal scintigraphy to become a standard clinical tool.

Methods: We imaged 301 patients using a single swallow of a radiolabeled puree meal with the patient erect and in the supine position. A condensed image was produced, which was reported semiquantitatively using a five-point grading scale (0–4), where 0 was normal and 4 represented severe dysmotility.

Results: All patients, even those with severe dysphagia, were able to tolerate the test. A sample of 25 studies was reported twice by two observers, who were blind to this study. There was no significant intra- or interobserver variation.

Conclusion: We recommend this method in routine assessment of patients with systemic sclerosis.

Key Words: systemic sclerosis; dysmotility; esophageal scintigraphy; semiquantitation

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Systemic sclerosis (SSc), or scleroderma, causes progressive dysfunction of the gastrointestinal tract (*1*). Objective measures of gastrointestinal function are important to decide when changes of disease-modifying medication are appropriate (*2*). Because the disease affects many organ systems, a series of rapid, noninvasive functional tests can play a key role in patient care.

Esophageal scintigraphy involves minimal patient discomfort at low radiation doses (*3*). It allows visualization of an important part of the gastrointestinal tract that is likely to be affected early and frequently in the course of the disease (*1*). Scintigraphy provides sufficient information to determine both the site and severity of disturbances of peristalsis and can provide evidence of reflux less invasively than esophageal manometry (*4*). Widespread use of the technique has been limited by both the multitude of different techniques described (*5–7*) and by descriptive and nonquantified reporting of the resulting images. However, it is important to measure the function of the esophagus both when the patient is erect, in the natural swallowing position, and when supine. The supine images may allow early subclinical disease to be recognized.

Disagreement exists between the use of liquid or solids as the medium to be measured; some observers use both. Multiple swallows may improve the accuracy of the test (*8*) but the increased time required to perform an extended study precludes its use as a standard clinical measurement.

The first purpose of this study was to determine whether it is possible to use a single-swallow semiliquid-semisolid (puree) meal with patients who are imaged both erect and supine in a clinical setting. The second purpose was to develop a semiquantitative grading system to allow accurate and reproducible reporting of the results.

MATERIALS AND METHODS

Patients

Esophageal single-swallow scintigraphy was performed on a series of 301 fasting patients with established SSc over 30 mo.

Meal Preparation

The radioactive tracer was administered using the single-swallow method of Åkesson et al. (*9*); 50 MBq of ^{99m}Tc-tin colloid were measured, added to and thoroughly mixed with 50 ml of pineapple puree, giving an activity concentration of approximately 1 MBq/ml.

Imaging

Images were taken with a large field-of-view gamma camera, fitted with a low-energy general-purpose collimator. The camera was interfaced with a dedicated nuclear medicine computer. First, patients were imaged erect, seated with their backs to the camera at a 35° left posterior oblique position. Cobalt-57

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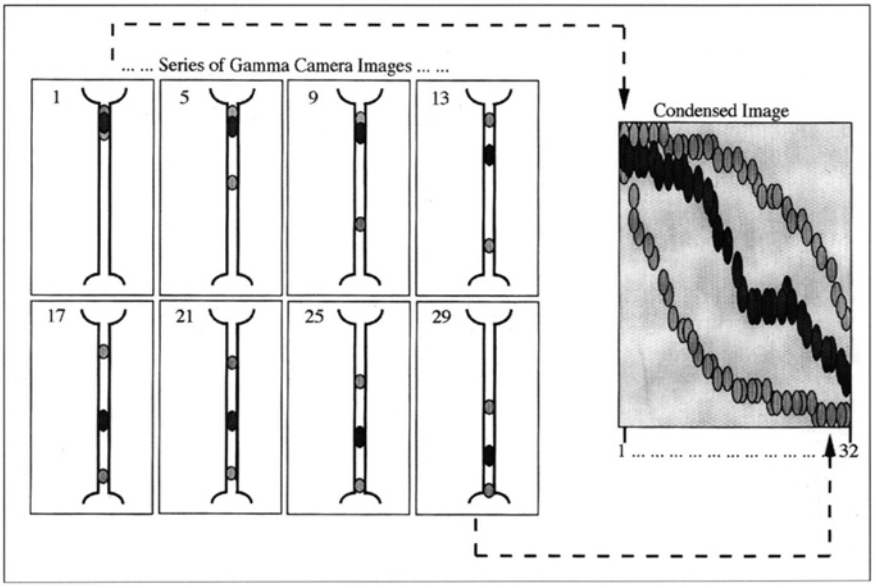

FIGURE 1. A series of gamma camera images are summed into a condensed image. The upper set of ovoids represents severe dysmotility, the middle set of ovoids (darker in shade) represent mild dysmotility and the lower set of oviods normal esophageal motility

markers on the external jugular vein and the xiphoid sternum ensured the esophagus was in the field of view.

The patient was given a nonradioactive test dose of 10 ml of the pineapple puree on a teaspoon. They were asked to swallow once on command. After the swallow, sips of water were taken to aid the clearance of puree from the esophagus. This was repeated using 10 ml of the radiolabeled puree. During the swallow, the computer acquired a dynamic dataset in a 64 × 64 word matrix at a rate of four frames per second for 30 sec followed by 15-sec frames for an additonal 5 min. During this time, only a single swallow was allowed. The patient was given water again and when the esophagus was clear of activity on the persistence scope, the procedure was repeated with the patient supine. The camera again was in a 35° left posterior oblique position.

Data Processing

Data was processed with a program dedicated to esophageal motility (OESOPH, Nuclear Diagnostics, London, England). Using a summed image, and after adjusting the thresholds to provide optimum images, the operator drew ROIs for the mouth, esophagus and stomach. A condensed image was then produced to show the passage of the bolus through the esophagus compared with time (Fig. 1). These condensed images were displayed as linear and logarithmic black and white images. The logarithmic display was used to identify small areas of retained radioactivity.

Semiquantitative Grading System

This system is based on the combination of swallowing difficulties detected when both supine and erect. (Table 1, Fig. 2). A mild abnormality is defined as occurring when less than 25% of the activity in the mouth remains in the esophagus 5 min later. Moderate abnormality is when 25%–75% is retained and severe when >75% is retained. In the unlikely event of there being more abnormality of swallowing when erect, compared with the supine position, the mean of the two resulting grades was taken. All scans were reported by one trained observer.

Inter- and Intraobserver Variability

Erect and supine images from 25 patients, including all four grades, were selected for reporting by two observers. Each study was reported twice within a 2-wk interval. Neither of the observers had seen the studies or patients when they were acquired. One observer (Observer A) had 6 mo experience reporting esophageal studies using the grading system outlined above. The second observer (Observer B) had no experience in reading these studies but was given a teaching file with illustrations of scans from each grade before the first reading. The intra- and interobserver variability was then tested using the Mantel-Haenszel test for linear association with a significance level of $p < 0.05$.

RESULTS

The single-swallow method proved easy for both the patient and the technologist. All patients were able to tolerate the meal and found the radioactive pineapple puree palatable. Positioning and imaging the patient took a maximum of 20 min allowing three patients per hour to be imaged. Patients with clinically severe dysphagia were imaged easily and, using sips of water, the activity in the esophagus was easily cleared before the patient was repositioned for supine imaging.

The condensed image gave a clear picture of the passage of the bolus down into the stomach and the logarithmic display

TABLE 1
Semi-Quantitative Grading of Esophageal Dysmotility

Grade	Supine	Erect
0	No dysmotility	No dysmotility
1	Mild dysmotility	No dysmotility
2	Moderate dysmotility	Mild dysmotility
3	Severe dysmotility	Moderate dysmotility
4	Severe dysmotility	Severe dysmotility

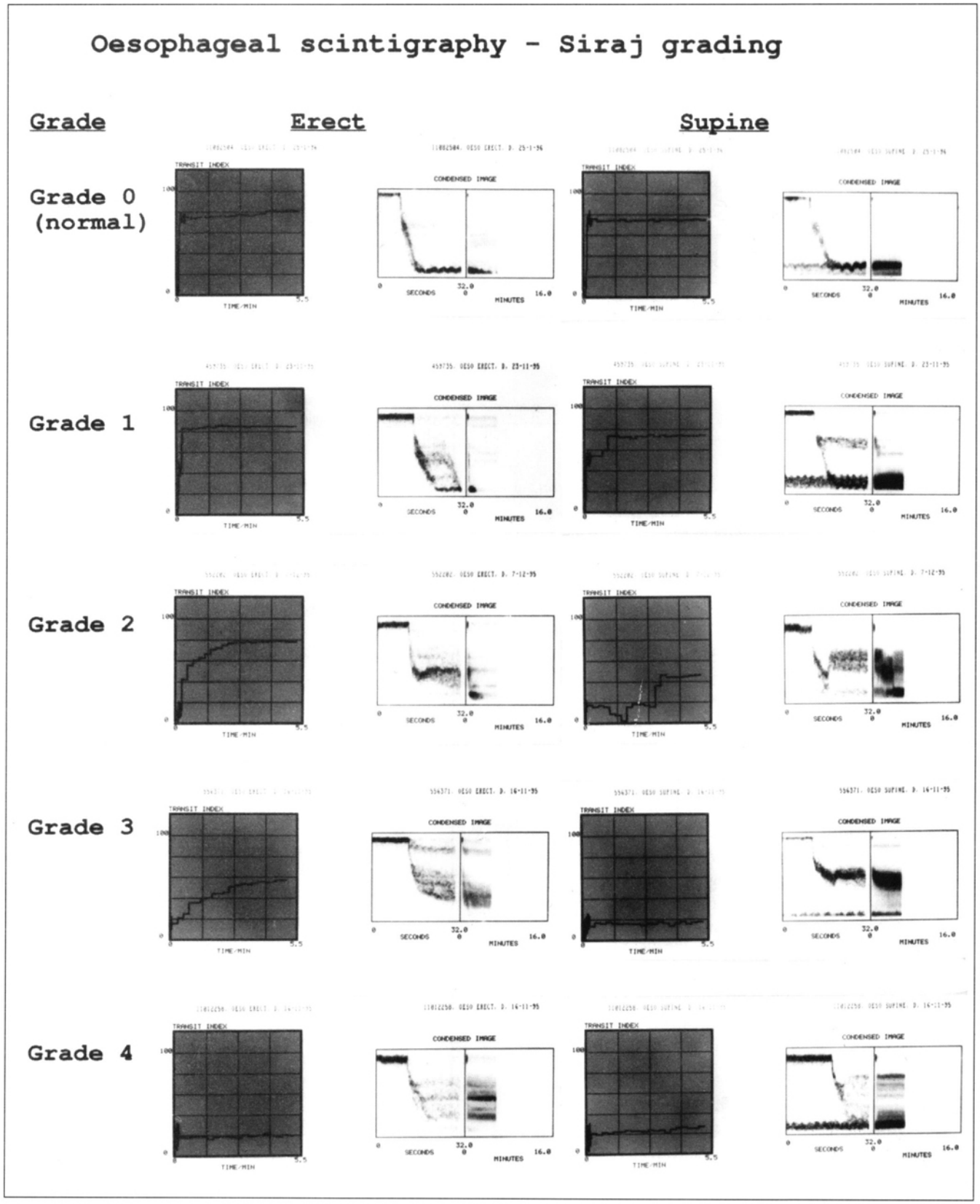

FIGURE 2. Time-activity curves and condensed images of patients with normal (Grade 0) and abnormal (Grades 1–4) esophageal motility.

allowed subtle and less obvious degrees of dysfunction to be seen. For example, in one patient it appeared that all activity had left the mouth using the linear display, but the logarithmic display clearly showed retained activity in the mouth (Fig. 3). Care must be taken to ensure that the patient has not swallowed or attempted to swallow during the acquisition of the

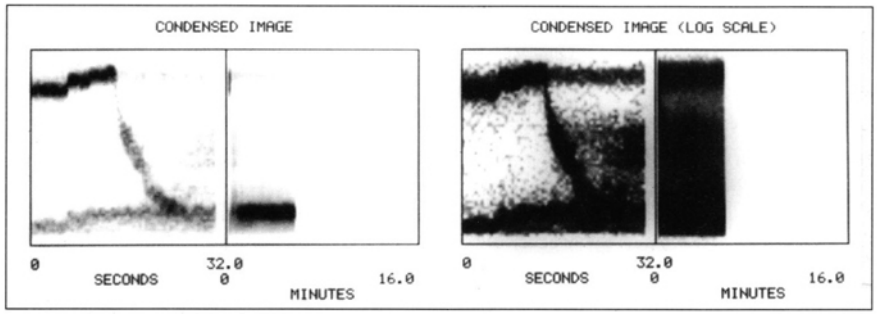

FIGURE 3. Condensed image of a patient with apparently normal motility seen on the linear scale image (left), however, in the log gray scale some activity remains in the pharynx and is not swallowed. There is also some pooling of activity in the mid esophagus.

study. Reflux from the stomach into the esophagus was clearly visualized on the condensed image and it was possible to see reflux from the lower esophagus into the middle or upper esophagus (Fig. 4).

The grading proved to be robust with an intraobserver agreement of one grade or less for Observer A of 84% and for Observer B of 92%. The two observers agreed with each other within one grade or less 88% of the time and by two grades or less 95% of the time. There was no significant disagreement between each reader's first and second reading and between each other.

DISCUSSION

Systemic sclerosis is a progressive and unpleasant disease. Dysphagia is one of its most distressing manifestations. The semiquantitative erect and supine esophageal scintigraphy method described in this study is a simple but effective method to determine the severity of dysphagia accurately and without patient distress. Our results show that, with minimal training, it is possible to produce consistent results. There are clear advantages in the time required for the study. Ten patients may be imaged in the standard morning or afternoon imaging session.

While it is accepted that esophageal manometry remains the gold standard method for the diagnosis of esophageal dysmotility, it requires some patient cooperation and may be distressing to patients with significant dysphagia. It is also more time consuming than single-swallow esophageal scintigraphy, but can give excellent direct evidence of any disorder of peristalsis. It is clearly unsuitable as a screening test for possible esophageal dysmotility.

The choice of a pureed meal is a compromise. Liquids often pass into the stomach without initiating a peristaltic wave (*10*). A solid meal takes too long to pass into the stomach in patients with a mild degree of esophageal dysfunction such that it may not have passed into the stomach by the end of the test (*11*). The use of a commercially-prepared semisolid puree meal meant that both viscosity and consistency did not alter between tests. It was also acceptable to all of our patients to use the pineapple flavor, which avoided religious and medical dietary restrictions. Furthermore, there is an excellent correlation of the results of this method of assessing esophageal motility and other objective markers of disease in SSc (*12*).

Transit times were not used as they reflect the transit only of the bulk of the radioactivity at the front of the bolus. Our semiquantitative method using the condensed image can allow visualization of partial hold up within the esophagus. This can be significant as the sensation of food sticking in the esophagus may not be related to the whole swallow but to some portion that remains within the esophagus after the swallow has finished. Only the type of image that allows data to be plotted against time, such as the condensed image used in this protocol, enables this partial hold up to be seen.

The grading system proved to be robust with no significant intra- and interobserver variation even in inexperienced readers. This is better than figures obtained in other nuclear medicine tests (*13*) and means that the method can be transferred easily to other centers.

The imaging protocol used a left posterior oblique position. This has been found previously to provide a uniform attenuation and give less variable organ depth, which is not possible

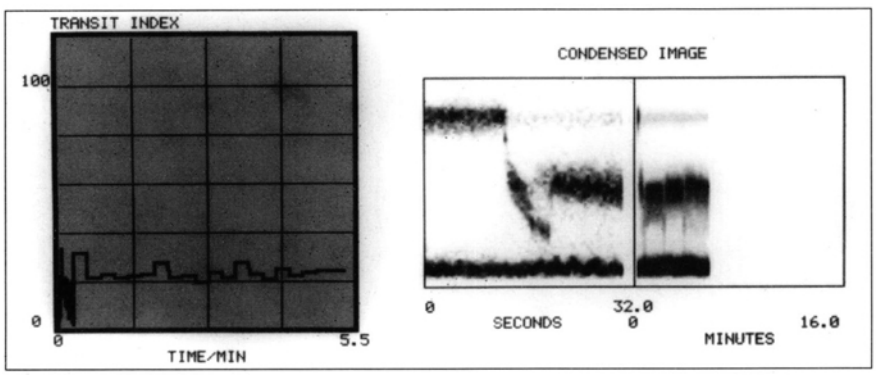

FIGURE 4. Patient imaged in supine position showing severe dysmotility. After the activity passes into the lower esophagus it refluxes back into the mid esophagus. Three further episodes are recorded in the remaining 5 min of the study.

from a standard anterior projection (*14*). This projection was easily obtained by the staff and comfortable for the patients.

CONCLUSION

Esophageal scintigraphy, performed using a two single-swallow acquisition, erect and supine, provides an easily performed and inexpensive screening test for esophageal dysmotility in patients with systemic sclerosis. The use of the condensed image allows consistent reporting by even the most inexperienced reader. This method should become standard practice in all patients with esophageal disease.

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