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SOME OBSERVATIONS CONCERNING THE PHYSIOLOGY OF THE DISTAL ESOPHAGUS WITH COMMENTS ON HIATAL HERNIA

JOSEPH A. RINALDO, JR.

The distal esophagus moves during swallowing. A knowledge of this movement is essential to an understanding of the physiology of the distal esophagus in normal patients and those with diseases of the distal esophagus.

In this paper we will summarize some of our recent combined manometric and cineradiographic studies and comment on some possible applications to hiatal hernia.

METHOD

Twenty-one control patients, 51 patients with hiatal hernia and 18 with narrow lower esophageal ring were studied. The criteria for diagnosis were those followed by Stein and Finkelstein, since the radiographs demonstrated in their paper provide a visual baseline that serves as a good point of departure in any discussion.

Esophageal pressures were measured through a 7-lumen polyvinyl tube which was swallowed by the patient. The lumens were filled with water and connected to 4 Sanborn Physiological Pressure Transducers (Model 267B) and a 6-channel Sanborn Polyviso Direct Writing Recording System (Model 356-5460). The internal diameter of the tube was 1.4 mm. and the distal openings were 1 mm. by 3 mm. Each opening was marked by a piece of lead solder 1 cm. long with its proximal margin at the distal edge of the opening in the polyvinyl tube. The first opening for pressure recordings was at the tip of the tube and 2 cm. from the next group of 4 openings, each of which was 1 cm. apart. The sixth opening was 5 cm. proximal to this group and the seventh opening was 5 cm. proximal to the sixth opening. A pneumograph (Sanborn Model 108 connected to General Purpose Preamplifier 350-1600) was used to record the respiratory cycle, and an electromyograph (Sanborn Plug-In 350-3 connected to High Gain Preamplifier 350-1500) to signal the onset of swallowing. This tube was manufactured according to our specifications by the United States Catheter Corporation.

Sixteen mm. film strips with the 6-channel pressure recorder and the cineradiographic data on the film were obtained in the following manner (Fig. 1). A 15 cm.

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Modification of a Picker kinescope which allows simultaneous photographing of the pressure recorder tracing and the radiographic image.

A strip of pressure tracing was transposed next to the television tube in the kinescope by modifying the standard Picker kinescope. This modification consisted of a hood attached to the kinescope. The kinescope and attached hood could be pushed next to the recording surface of the Sanborn Recorder. The hood contained a mirror, a converging lens and a piece of opaque glass for reconstituting the image, and a final mirror for projecting the image of the face of the pressure recorder into the plane of the television tube. The 16 mm. camera then photographed the pressure and radiographic image (Fig. 2). This means that every frame of the cineradiographic data could be related to a specific point on the pressure tracing.

The paper speed of the Sanborn Recorder was 10 mm/sec. during cine runs. This speed was necessary for accurate comparison of cine frames and pressure records. The Sanborn Recorder was modified by placing a grid in front of the chart. This grid was fitted with steel rods which corresponded to the 5 and 10 mm. marks on the recording paper. The baseline grid line was set at the level of end expiratory gastric pressure so that all pressures on the cine tracing could be related to this pressure.

All studies were done with the patient supine. At the beginning of the study the fundus was filled with 80 ml. of thin barium, and each swallow consisted of 10 ml. of thin barium.
One 16 mm. frame from each of 2 film strips which show the high pressure area with the esophagus empty. “Sw” is the line which shows the swallow signal; “R” indicates the pneumographic record of respiration with inspiration down; “F” is the fundus filled with barium. The pressure record is on the left of each frame. The pressures at the left hand margin of the pressure record correspond to the radiographic image, since the paper is traveling from right to left. The long, straight, white lines to the left of the large numbers are the baseline pressures. Each short white line above and below the long white line is equivalent to 10 mm. Hg. The white arrows indicate the place where pressures are being recorded. The short white rods in the radiographic image are 1-cm. pieces of lead solder.

**RESULTS AND DISCUSSION**

The esophagogastric mucosal junction of patients with a narrow (<1.2 cm.) lower esophageal ring (Schatzki or B ring) lies distal to the inferior esophageal sphincter when the distal esophagus is distended with a bolus. There is a gradation of rings from 0.3 cm. to 4.0 cm. in diameter. The ring is at the mucosal junction in most patients with narrow rings. The work of Zaino et al. with 10 necropsy specimens from patients who had premortem radiographic studies supports the contention that wide as well as narrow rings lie at the mucosal junction. Thus, we believe that the majority of rings having the characteristic appearance of the Schatzki (or B) ring — a width of less than 2 mm. and the sharp indented appearance — are at the esophagogastric mucosal junction. Since in our experience wide rings lie in the same relation to the sphincter as narrow rings, it has been possible to establish a conceptual model that allows integration of the manometric and cineradiographic data. It is then but a small step to control patients and hernia patients without rings. Fig. 3 diagrams our conceptual model for controls (A, A') and hernias (B, B').

During the resting state the inferior esophageal sphincter of normal people lies across the crura with a portion protruding above in the thoracic cavity and a portion lying below in the peritoneal cavity (Fig. 3A). With a swallow the inferior esophageal sphincter moves orad a variable distance and opens (Fig. 3A'). This is clearly demonstrable in hernia patients but more difficult to demonstrate in controls (Fig. 3; compare B and B'). However, the resting sphincter of many hernia patients lies more orad than that of controls. This has previously been shown by Atkinson et al. It agrees with the findings of Code et al. and Texter et al. that the area...
The position of the inferior esophageal sphincter and esophagogastric mucosal junction in a control (A,A') and hernia patient (B,B'). "S" marks the black sphincter; "J" marks the junction of the scalloped gastric mucosa and smooth esophageal mucosa. The gastric muscle is marked by short, closely spaced lines and the esophageal muscle is white. "D" marks the diaphragmatic impression. At rest, the sphincter is more orad in the hernia (B) than in the control (A). During swallowing, both hernia (B') and control (A') move about the same distance.

of high pressure between the stomach and esophagus is longer in hernia patients than in controls. This means that orad movement of an equal distance during swallowing will reveal the open sphincter at a greater distance from the diaphragmatic impression in hernias than in controls (Fig. 3; compare A,B and A',B').

As was pointed out above, the mucosal junction lies at the distal margin of the sphincter when the distal esophagus is distended. The relation of the mucosal junction to the sphincter when the distal esophagus is at rest is still an enigma. Our examination of combined manometric and cineradiographic records would lead us to believe that even at rest the esophagogastric mucosal junction lies at the distal margin of the sphincter (Fig. 3A and 3B). Again these observations are most definite for patients with rings, and from there have been extrapolated to controls.
DISTAL ESOPHAGUS

Figure 4

Radiographs of a small hernia “a”, larger hernia “b” and control “c”. “S” marks sphincter; “J” marks mucosal junction; and “D” the diaphragmatic impression. In “c” “?J” indicates that we do not have direct proof that the mucosal junction lies at that point without having a radiopaque marker. This interpretation is based on hiatal hernia and narrow lower esophageal ring patients.

However, support for this position of the mucosal junction in controls comes from Helm et al. who have indicated that the mucosal junction of controls lies at or just below the highest pressure in the high pressure zone. One could infer, therefore, that the mucosal junction was at or below the resting sphincter in controls. In hernia patients these same authors found the point of maximal change in potential difference (and presumably the mucosal junction) occurring at the upper end of the high pressure area. Code et al. pointed out in a previous paper that the true gastroesophageal sphincter resided there. The mucosal junction of these patients was identified by the greatest change that occurred when a potential measuring probe was withdrawn from the stomach to the esophagus.

Meckeler, on the other hand, stated that “the site of maximal potential change was variable occurring either within or following the zone of increased intraluminal pressure.” He then related the point of maximal potential change to biopsies obtained by a device allowing biopsy right at the site of maximum potential difference and 2.5 cm. distal to it. A summary of his results in 22 patients indicated that in 12 the mucosal junction was distal to the point of greatest change in potential difference; in 6 the junction was proximal to the point of greatest potential difference; in 4 there was a less definite statement but apparently the junction was either proximal or distal to the point of greatest potential difference. In summary, this abstract suggested that the point of greatest potential difference was variable in its relation to the mucosal junction and leaves us still uncertain about the location of these two structures when the sphincter is at rest.
What are the consequences of this interpretation of the dynamics of the distal esophagus? From an anatomic point of view the only difference between our controls and our patients with small hernias would be the presence of a visible esophagogastric mucosal junction; that is, a lower esophageal ring. In both groups of patients the sphincter and mucosal junction would have a similar relation at rest and during swallowing. Furthermore, the movement of the distal esophagus during swallowing would be qualitatively similar for controls and hernias. This is in keeping with the consistency of other natural phenomena.

This concept can be practically applied as shown in Fig. 4. In that figure, "a" shows a small hernia with the sphincter partially closed and a wide lower esophageal ring identified as the mucosal junction; "b" shows a large hernia with the sphincter again identified and a notch that we feel represents the mucosal junction; "c" shows a control with the sphincter as it was most often manifested in this study. Note that the label of the mucosal junction is preceded by a question mark in "c". This expresses our present uncertainty about the position of the mucosal junction in controls.

SUMMARY

The inferior esophageal sphincter and the esophagogastric mucosal junction are important landmarks. The mucosal junction is at the distal end of the sphincter when the distal esophagus is distended. The mucosal junction is probably at the distal end of the sphincter when the esophagus is at rest also, but this needs further study. The sphincter and the mucosal junction move orad during swallowing as the sphincter relaxes and the esophagus distends. Both the sphincter and the mucosal junction are useful in making a diagnosis of hiatal hernia.

REFERENCES


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