METHODS AND TECHNIQUES

The Effect of Manometric Assembly Diameter on Intraluminal Esophageal Pressure Recording

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Recent studies indicate that lower esophageal sphincter pressure is influenced by manometric assembly diameter. This study determines the effect of assembly diameter on both esophageal sphincter pressure and peristaltic pressure in the esophageal body. We performed esophageal manometric studies in 6 normal subjects using graded assembly diameters. High-fidelity recording was achieved by using a noncompliant catheter-infusion system. The results indicate that increases in assembly diameter cause significant increases in peristaltic pressure amplitudes and in resting sphincter pressure in both the smooth and striated muscle portions of the esophagus. This phenomenon is best explained by the length-tension characteristics of esophageal muscle, increased stretch causing greater contraction force.

Studies in both animals (1–3) and man (4) suggest that recorded lower esophageal sphincter pressure is a function of manometric assembly outer diameter. This investigation determines the effect of manometric assembly diameter on upper esophageal sphincter pressure and peristaltic pressure amplitude in the esophageal body.

MATERIALS AND METHODS

We performed esophageal manometric studies in 6 normal human volunteers, age 18–22 years. The manometric tube assembly used for all studies featured three recording levels, each differing in outer assembly diameter. The three respective recording levels, spaced 5 cm apart and designated A, B, and C in distal to proximal sequence, measured 3.3, 4.8, and 6.7 mm in diameter. Assembly circumference at the three respective recording levels was 11, 17, and 22 mm. To construct the manometric assembly, polyvinyl catheters of 0.8 mm internal diameter and 1.8 mm outer diameter were fused longitudinally using tetrahydrofuran. The assembly was fashioned so that 3 catheters running the entire length of the assembly were present at level A, 6 catheters were present at level B, and 12 catheters were present at level C. Three radial side-hole recording orifices, oriented equidistantly at 120° angles, were cut at each of the three assembly recording levels.

During manometry, each recording catheter was infused with water (0.5 ml/min) using a hydraulic infusion system (5) with negligible compliance (6). Resting sphincter pressures were recorded by a rapid, continuous withdrawal pull-through technique described previously (7, 8), and peristalsis was induced by wet swallows (5-ml boluses) (9).

After nasal intubation, resting lower esophageal sphincter (LES) and upper esophageal sphincter (UES) pressure were recorded by performing three rapid pull-throughs for each manometric assembly diameter (levels A, B, and C). Also recorded at each assembly diameter were peristaltic pressure complexes in the distal esophagus, 3 cm above the LES, and in the proximal esophagus, 3 cm below the UES. In each subject, 8 WS (wet swallows) were recorded for each of the three respective assembly diameters in both the distal and proximal esophagus.

From the pressure tracings, resting LES pressure and peristaltic amplitude were scored and calculated as described previously (8, 9). UES pressure was scored taking the absolute value of maximal pressure referenced to atmospheric pressure as zero. In each circumstance, values from the three radial catheter orifices of a given assembly

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Table 1. Relationship Between Manometric Assembly Diameter and Intraluminal Esophageal Pressure

Site	Catheter levels*			Statistical comparison		
	A	B	C	A and B	B and C	A and C
Esophageal sphincters						
LES (smooth) muscle	24 ± 8	31 ± 10	39 ± 11	> 0.01†	0.05†	> 0.005†
UES (striated) muscle	79 ± 16	111 ± 37	138 ± 47	0.05†	> 0.1	0.005†
Esophageal body						
Distal (smooth) muscle	85 ± 38	94 ± 47	113 ± 41	> 0.1	> 0.005†	> 0.001†
Proximal (striated) muscle	68 ± 22	88 ± 27	92 ± 35	> 0.005†	< 0.02	> 0.05†

*Values given as $\bar{X} \pm 1$ SD mm Hg.
†$P \leq 0.05$, paired t test.

level were averaged. Pressure differences recorded using different assembly diameters were analyzed for statistical significance by the paired Student's t test.

RESULTS

The results (Table 1) reveal significant differences for esophageal sphincter pressure and peristaltic pressure amplitude, respectively, when recorded using assembly sites differing in outer diameter. For the LES, UES, and both esophageal body locations, recorded pressure increased with increases in manometric assembly diameter.

DISCUSSION

The results of this study indicate that recorded resting pressure in the UES as well as in the LES is determined, at least in part, by outer diameter of the manometric recording assembly. A similar variation was observed for peristaltic pressure amplitude in both the proximal and distal body. Esophageal squeeze, therefore, in both the striated and smooth muscle portions of the esophagus, occurs as a function of recording assembly diameter.

What explanation might account for these findings? Some consideration might be given to the possibility that pressure increases associated with increased assembly diameter represent recording artifact or a change in recording fidelity at different assembly diameters. Prior studies, however, have shown that the recording system used in this study is capable of high-fidelity esophageal pressure recording. The observed pressure increases, therefore, are almost certainly real. A more plausible explanation for the observed phenomena relates to the length–tension characteristics of esophageal muscle. Because recording assemblies produce luminal distention, the assembly necessarily causes radial stretch of circular esophageal muscle, the degree of stretch being directly related to assembly diameter and circumference. In the case of resting sphincters, circular sphincter muscle may be resistant to stretch (10). Radial stretch probably causes increased circumferential tension, leading to increased intraluminal pressure. On the upslope of the circular muscle length–tension curve, even small increases in tension are associated with large increases in pressure (3). Within the esophageal body, increases in catheter diameter have no effect on baseline pressure, but do cause significant increases in peristaltic amplitude. This phenomenon appears analogous to the findings of *in vitro* studies, whereby increases in resting muscle length cause increased isometric contraction force (11, 12).

The results of this and other studies (1–4) indicate the need for standardizing manometric assembly diameter in order to permit meaningful comparison of esophageal pressure values recorded in different laboratories. Due to investigator individuality and preference, such standardization may not occur in the near future. In the interim we suggest that the specific details of manometry, including assembly diameter, accompany all esophageal pressure values, particularly in investigative studies. Unless the specifics of manometry are known, esophageal pressure values are ambiguous, similar to gas pressures at unspecified gas temperature and volume.

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