Role of the Overall Length of the Distal Esophageal Sphincter in the Antireflux Mechanism

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The antireflux mechanism in man consists of the esophageal body – a pump, the distal esophageal sphincter – a valve, and the stomach – a reservoir. Abnormalities in any of these components of the antireflux mechanism can be responsible for increased esophageal acid exposure, the basic abnormality of gastroesophageal reflux disease.

Clinical and in vitro studies of the distal esophageal sphincter have shown that the length of the sphincter distal to the respiratory inversion point, that is, the length exposed to the positive pressure environment of the abdomen, is an important factor in maintaining competency of the cardia against challenges of intraabdominal pressure. Additional studies have shown that the relationship between the sphincter pressure and its abdominal length indicate that the shorter the length of the sphincter exposed to intraabdominal pressure, the greater the amplitude of pressure necessary to maintain competency. For any given pressure, a minimum sphincter length is required to protect against challenges of intraabdominal pressure; if absent, reflux occurs secondary to straining or changing of body position [1].

Further clinical studies have shown that reflux occurs in some patients despite a normal pressure and a normal abdominal length of the distal esophageal sphincter. It was noteworthy that many of these patients had a very short overall sphincter length [2]. Under these conditions, reflux could occur despite a normal distal esophageal sphincter pressure because the length of sphincter over which the pressure was exerted is insufficient to provide enough resistance to retard the flow of gastric contents into the esophagus. Herein, we report four studies, three experimental and one clinical, designed to test this hypothesis.

Experimental Study 1

The relationship of the distal esophageal sphincter pressure and overall length to the resistance of flow through the cardia was examined using an original electrolytic transducer and an in vitro model of the cardia [1]. The transducer is designed to measure the change in resistance to the flow of electrons through an electrolytic column caused by a variation in the degree of length of compression of the column [3]. Canine specimens were used for the experiments. The transducer was positioned across the sphincter portion of the model and sphincter pressure was incrementally varied. Results of the study, shown in Fig. 1, demonstrate that the re-
Fig. 1. In vitro model designed to simulate the forces acting on the distal esophageal sphincter. A gastric reservoir (A) is connected to a chamber (B) where the specimen is located. A second reservoir (C) is attached to this chamber. The gastric end of the specimen is connected to an adjustable ring (D) representing the circumference of the cardia, and the esophageal end of the specimen is attached to a metal tube (E). The length of esophagus exposed to the pressure within chamber B is adjusted by sliding a watertight stent (F) through the specimen. Competency is determined by a comparison of fluid levels in reservoir A and manometer 1.

Resistance to the flow of the electrons varied with changes in the cross-sectional area along the length of the electrolytic column caused by the sphincter pressure and the length over which the pressure was exerted. Thus, the resistance to flow through the cardia was related to the integrated effects of distal esophageal sphincter pressure and length.

**Experimental Study 2**

The relationship of overall distal esophageal sphincter length and the ratio of sphincter/intragastric pressure to competency of the cardia was examined using the in vitro model with a 1-cm diameter of the cardia (31.4 F). The gastric pressure was maintained at 20 cm water. Sphincter pressure was gradually increased from 20 to 100 cm water, thereby increasing the ratio of sphincter/intragastric pressure from 1:1 to 5:1. The overall length of sphincter necessary to achieve complete competency was determined with each increment of sphincter pressure. The results are shown in Fig. 2. The resistance of the cardia to the flow of fluid, as with electrical resistance, was related to the integrated effect of sphincter pressure and length. The ratio of sphincter/intragastric pressure necessary to maintain competency was inversely related to the length of the sphincter. Moreover, whenever intragastric pressure was greater than sphincter pressure, competency could not be obtained regardless of the length of the sphincter present. When the sphincter length was 3 cm or less, a ratio of sphincter/intragastric pressure of 2:1 or more was necessary to maintain competency. This suggests that when an overall sphincter length of 3 cm or less is measured in the fasting patient at rest, a dis-