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Original Article

Observations of Acid Reflux and Motor Function in Distal Esophagus Using Simultaneous Measurements of Intra-esophageal pH and Pressure in 8 Directions With Novel Sensor Catheter - A Feasibility Study

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Background/Aims

Esophagogastric junctional lesions, such as mucosal breaks with Los Angeles grade A or B reflux esophagitis, lacerations in Mallory Weiss syndrome, and short segment Barrett's esophagus, are mainly found in the right anterior wall of the distal esophagus. Asymmetrical lower esophageal sphincter pressure and resting radial asymmetrical acid reflux may be causes of this asymmetrical distribution of reflux esophagitis and short segment Barrett's esophagus. We developed a novel pH and pressure catheter to investigate the asymmetrical distributions of pH and intra-esophageal pressure in the distal esophagus.

Methods

One healthy male volunteer was enrolled in this study. Acid reflux and motor function in distal esophagus was investigated using simultaneous measurements of intra-esophageal pH and pressure in 8 directions with novel sensor catheter.

Results

Thirty-six acid and weak acid reflux events were observed, of which 22 were circumferential refluxes with pH drops in all channels and 14 were partial refluxes with pH drops in some channels. Increase in transient circumferential intraesophageal pressure was observed just after 72.7% of the circumferential reflux and 42.9% of the partial reflux events.

Conclusions

Using a novel sensor catheter, 2 different types of acid reflux events were identified in the present study.
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Key Words

Catheters; Gastroesophageal reflux; Pressure

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Introduction

Esophagogastric junctional lesions, such as mucosal breaks with Los Angeles grade A or B reflux esophagitis, lacerations in Mallory Weiss syndrome, and short segment Barrett's esophagus, are mainly found in the right anterior wall of the distal esophagus.[1-4] Previous studies have shown that the esophageal wall of the distal esophagus is thicker and resting pressure in the lower esophageal sphincter (LES) higher in the left posterior side than the right anterior side.[1] High-resolution manometry is useful to assess esophageal motor function,[5] while this cannot measure circumferential distribution of intra-esophageal pressure. In our previous study, the presence of radial asymmetric acid exposure in the distal esophagus of patients with GERD was clarified.[6] However, simultaneous examinations of circumferential distribution of gastroesophageal acid reflux and intra-esophageal pressure in the distal esophagus have not been reported. Therefore, we developed a novel pH and pressure catheter to investigate the distributions of pH and intra-esophageal pressure in the distal esophagus.

Materials and Methods

We developed a novel multi-channel pH and pressure sensor catheter with the assistance of Starmedical Inc., Tokyo, Japan. This device has 8 pH and 8 pressure sensors radially arrayed at the same level of the catheter, while it is equipped with 2 radiopaque marks on the one surface of the sensor, which are used to identify the rotation of the catheter under fluoroscopic imaging and show the position of each radially arrayed sensor (Fig. 1). The pH and pressure sensors located on the same direction of the radiopaque marks are channel 1 followed by channels 2, 3, 4, 5, 6, 7 and 8 in a clockwise rotation with 45 angular degrees apart.

The proximal portion of the catheter placed in the nasal cavity and pharynx was thinned to 3.1 mm in diameter, while the portion with the sensor array, a 30 cm distal portion of the catheter, was 4.6 mm in diameter. The sensor catheter was made with polyvinyl chloride tubings equipped with solid state pressure sensors and antimony electrodes on their surface.

One healthy volunteer was recruited for a feasibility study of the prototype of our 8-channel pH manometry catheter. Written informed consent was obtained before starting the study, which was carried out in accordance with the Declaration of Helsinki. This study was approved by the Ethics Committee of Shimane University.

Upper gastrointestinal endoscopic examination and 36 channel high resolution esophageal manometry were done on the volunteer before the study. No morphological or functional abnormality was found. Following a 6-hour fast, the catheter was inserted transnasally into the esophagus. The pressure sensors were calibrated at atmospheric pressure and 100 mmHg while pH

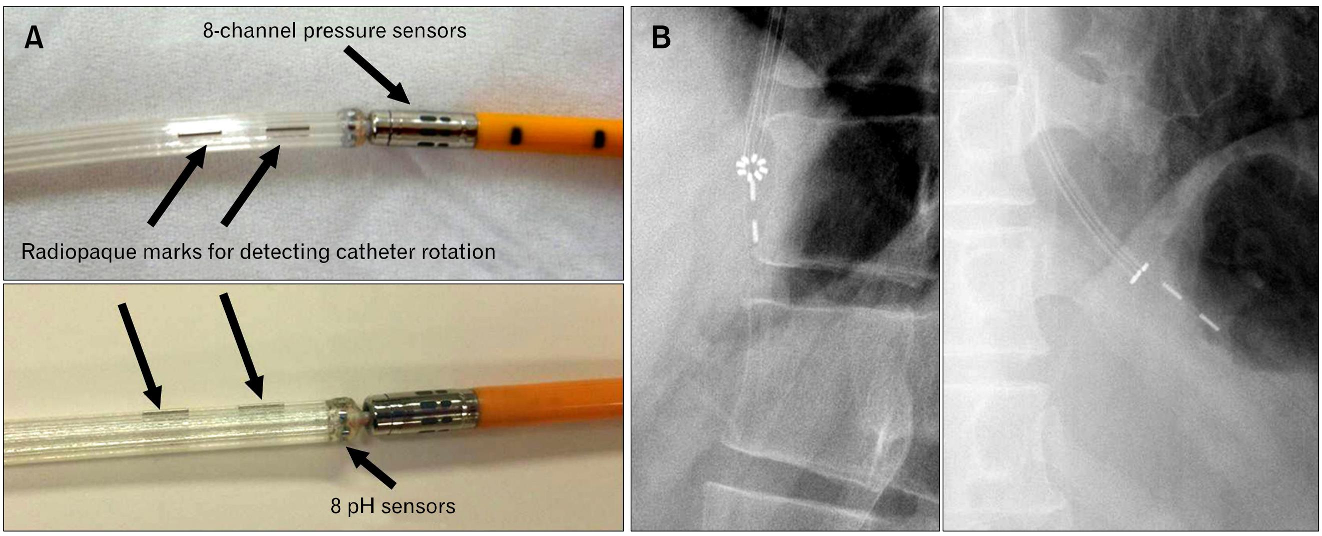

Figure 1. Our novel sensor catheter equipped with 8 pH and 8-channel pressure sensors radially arrayed at the same level. It is equipped with 2 radiopaque marks, which are used to identify the rotation of the catheter under fluoroscopic imaging and show the position of each radially arrayed sensor. (A) Frontal and lateral view. (B) Fluoroscopic image.

Table. Reflux Events Before and After a Meal, and Circumferential Distal Esophageal Pressure Increase

	Reflux episodes		Acid reflux (times)		Weak acid reflux		No. of increases in acid reflux-related distal esophageal pressure (rate [%])	Circumferential distal esophageal pressure increase		
	Before meal (/hr)	After meal (/2 hr)	Before meal (/hr)	After meal (/2 hr)	Before meal (/hr)	After meal (/2 hr)		Time to pressure increase (sec)	Contraction time (sec)	Max amplitude (mmHg)
Circumferential reflux	6	16	6	15	0	1	16/22 (72.7)	10.6	6.75	86.88
Partial reflux	5	9	0	0	5	9	6/14 (42.9)	14.0	5.57	73.15

sensors were calibrated at pH 4.0 and 7.0 before and after the monitoring period. The sensors were positioned 2 cm above the upper portion of the LES. This position has already been shown to be the appropriate position to prevent the dislocation of the sensors into the stomach and can detect the radial asymmetry of the acid reflux in our previous study.[6] The catheter was fixed to the cheek at 2 cm outside the nostril and attached to the skin of the neck with surgical tape after being hung on the ear, and then pH and intra-pressure monitoring was started. The pH and pressure sensor catheter used in this study was made based on the 8-channel pH sensor catheter which we developed and published previously.[6] In our previous study using 8-channel pH sensor catheter, horizontal rotation during monitoring period was examined. Horizontal rotation was not observed during monitoring period when the subject remained in a sitting position quietly. Therefore, we instructed the subject to quietly stay in the sitting position without rotating neck in the present study. In addition, to assure the uniformity of the position and rotation of the catheter, fluoroscopic imaging was performed before and after pH and pressure monitoring.

One hour after catheter insertion, the subject consumed a meal (614 kcal clear through; Kewpie Inc., Tokyo, Japan), after which post-prandial pH and intra-esophageal pressure were monitored for 2 hours. The number of acid reflux episodes and intra-esophageal pressure value obtained from each pH and pressure sensor were recorded. Eight-channel pH data were recorded simultaneously by connecting the catheter to 4 portable digital recorders (Pocket Monitor GMMS-200 pH; Starmedical Inc., Tokyo, Japan). Eight-channel pressure data were also recorded by connecting the catheter to a portable digital recorder (Pocket Monitor GMMS-1000; Starmedical Inc., Tokyo, Japan). The pH recording data obtained were analyzed using computer software (Eight Star; Starmedical Inc.), while pressure analysis was performed using software (Anorect; Starmedical Inc.) originally developed for anorectal manometry.[7]

An acid reflux episode was defined as an event where esophageal pH dropped below 4.0 for over 5 seconds, while weak acid reflux was defined as an esophageal pH drop of 1.0 to a level between 4.0 and 7.0. Circumferential reflux was defined as a pH drop in all of the circumferentially arrayed channels, while partial reflux was defined as a pH drop in some of the channels.

Results

We successfully obtained values reflecting the circumferential distribution of acid exposure and pressure at the same time using our novel sensor catheter without complications. Reflux events were monitored for an hour before meal and 2 hours after meal. Thirty-six acid and weak acid reflux events were observed (Table), of which 22 were circumferential refluxes with pH drops in all channels and 14 were partial refluxes with pH drops in some channels. In the volunteer investigated in this study, asymmetrical reflux was most frequently observed in the posterior wall of the distal esophagus. Eleven refluxes in the total 14 partial refluxes were observed in the posterior wall-sided sensors.

Representative circumferential and partial reflux episodes are shown in Figure 2. Increase in transient circumferential intra-esophageal pressure was observed just after 72.7% of the circumferential reflux and 42.9% of the partial reflux events. The typical case is shown in Figure 3. No circumferential asymmetry was observed during the transient rise of intra-esophageal pressure. All partial refluxes observed were weak acid reflux.

Discussion

Transient LES relaxation (TLESR) with volume reflux is considered to be a major mechanism of symptomatic gastroesophageal reflux in patients with gastroesophageal reflux disease (GERD).[8-10] During volume reflux, the entire surface of the dis-

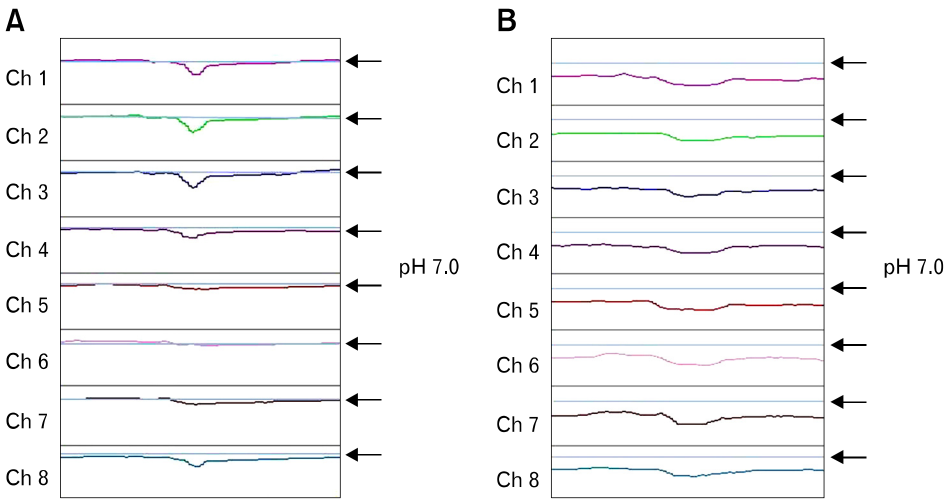

Figure 2. Two types of reflux patterns and transient increases in circumferential intra-esophageal pressure. (A) Partial reflux. (B) Circumferential reflux.

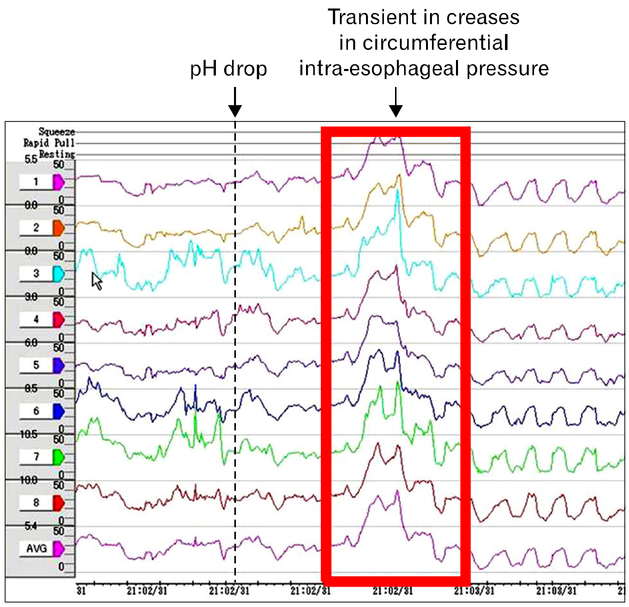

Figure 3. Transient increases in circumferential intra-esophageal pressure.

tal esophagus is thought to be exposed to gastric acid. Therefore, volume reflux cannot be responsible for asymmetrical localization of mucosal breaks. To understand the pathogenesis of asymmetrical localization of mucosal breaks in patients with low grade reflux esophagitis, circumferential acid exposure immediately above the squamocolumnar junction and esophageal contraction requires investigation. Thus, the present sensor catheter equipped with 8 pH and 8 pressure sensors radially arrayed at the same level was positioned 2 cm above the upper limit of the LES. In this study, we found 2 types of reflux events at this position; circumferential reflux and partial asymmetrical reflux.

Pressure monitoring showed different pressure patterns after the circumferential and asymmetrical reflux. A transient increase in circumferential intraesophageal pressure after reflux episodes, was observed more frequently after circumferential than partial reflux. The causal mechanism of this observation is not clear. The possible explanation of this phenomenon can be described as follows. Firstly, it could be due to longitudinal shortening of esophagus and the pressure sensors might have actually measured the upshifting high pressure zone of LES. Secondly, it could be caused by the common cavity that occurred during belching or TLESR. Thirdly, it could be swallow-related primary peristalsis. Finally, it could reflect secondary peristalsis. Secondary peristalsis is important for clearing refluxate from the esophagus.[11-14] Therefore, if these changes reflect secondary peristalsis, acid exposure caused by partial reflux may continue for longer periods in mucosa above esophagogastric junction.

Fletcher et al[15] reported 2 types of refluxes using clip-fixed multi-channel pH monitoring, one that reached 5 cm above the LES and another that remained in the distal esophagus above the squamocolumnar junction. In addition, previous studies have shown that acid exposure is significantly higher immediately above the squamocolumnar junction than that measured at the traditional level for pH monitoring, 5 cm above the LES.[16-18] The partial reflux mainly found on the right anterior side may explain why esophagogastric junctional lesions are frequently found in the right anterior wall of the distal esophagus.

This study has several limitations. Firstly, only 1 healthy volunteer was investigated in this study. Secondly, monitoring period was only for 3 hours but not for 24 hours. Thirdly, the presence of 2 types of gastroesophageal reflux should be tested in patients with GERD in addition to the normal individuals. Future studies will be necessary to clarify the asymmetrical acid reflux and motor function in distal esophagus in larger number of cases.

In conclusion, using a novel sensor catheter, 2 different types of acid reflux events were identified in the present study.

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