Redefining gastroesophageal reflux (GER)

Detection using multichannel intraluminal impedance in healthy volunteers

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Abstract

Background: The detection of gastroesophageal reflux (GER) has to date been limited to acid exposure observed on 24-h pH monitoring. It is clear, however, that nonacid reflux can be a significant clinical problem. Recently, as impedance technology with the capacity to detect all types of reflux (acid, nonacid, liquid, mixed, and air) has been developed.

Methods: Seventeen asymptomatic healthy volunteers underwent combined 24-h pH and impedance testing. In all patients, pH was measured at 5 cm above the lower esophageal sphincter (LES), and simultaneous impedance changes were recorded at 3, 5, 7, 9, 15, and 17 cm above the LES. Refluxes were classified as acid (drop in pH < 4 for > 5 sec), nonacid, short acid, or nonacid delta based on chemical properties; they were further classified as liquid, mixed, or gas based on the physical refluxate detected by impedance changes. The height of the reflux entering the esophagus was classified as distal (< 5 cm), intermediate (5–9 cm), or proximal (9–17 cm).

Results: A total of 868 reflux events were characterized. Fifty-nine percent of them were not conventional acid reflux and could only be detected by impedance changes. Less than 2% of the events that were detected by a fall in pH to < 4 were not detected by impedance changes. Pure liquid reflux was seen in 35.4%, a mixed pattern in 36.5%, and a gas reflux in 26.7%. Liquid was confined to the distal esophagus in 30%; it reached the mid-esophagus in 58% and the proximal esophagus in 11%. Liquid reflux reaches the mid and proximal esophagus 69% of the time and gas nearly always does (92%). The additional information provided by impedance technology is likely to have a major impact on the understanding and clinical management of patients with gastroesophageal reflux disease (GERD).

Key words: Gastroesophageal reflux (GER) — Nonacid reflux — Acid reflux — Impedence testing — Intraluminal impedance — Multichannel intraluminal impedanceometry (MII) — Esophagus

The clinical management of patients with gastroesophageal reflux disease (GERD) rests heavily on the detection and quantification of gastric contents in the esophagus. Although current diagnostic methods, including the radiographic demonstration of refluxed material during barium upper gastrointestinal examinations and 24-h ambulatory pH monitoring, have significant limitations, ambulatory pH monitoring has become the primary tool used to confirm the presence of reflux disease. There are several clinical limitations to pH monitoring: Nonacid reflux events are unrecognized, the height of reflux above the gastroesophageal (GE) junction is poorly delineated, and the technique cannot distinguish the physical nature of the refluxed material—namely, whether it is liquid, gas, or a mixture of the two. In addition, it is clear that reflux symptoms such as regurgitation and cough may be present in the absence of demonstrable reflux of acid material [2, 5]. Thus, there is a real need for new and improved diagnostic techniques.

Reflux detection via the use of intraluminal impedance sensors has the potential to overcome many of the limitations of pH monitoring, as well as providing new insights into the pathophysiology of reflux disease. Impedance technology is based on the generation of a small electric current between two electrodes; this current is used to detect the type and movement of material passing across the area. Multichannel intraluminal impedanceometry (MII) has recently been developed as a
means of esophageal functions testing and can reliably measure both bolus transport and the spectrum of reflux events across the length of the esophagus [3, 4]. Because of their differential conductivity, gas, liquid, or a mixture of the two can be distinguished independent of the pH of the material and the extent of migration of each individual component into the proximal esophagus [8, 11]. Preliminary studies have explored its utility in the detection of nonacid reflux in infants with GERD and respiratory dysfunction [8, 11], and short-term studies of adults have been done before and after medical therapy for erosive esophagitis [10].

The aim of this study was to elucidate the spectrum of gastroesophageal reflux (GER) events in normal healthy volunteers using combined pH and MII technology.

Patients and methods

Study population

Eighteen healthy volunteers with no symptoms of GERD or foregut disease were invited to participate in the study. All of the subjects completed the study. The data from one subject was excluded from analysis due to equipment malfunction. Segmental dysfunction of the MII-pH probe occurred in two patients but did not affect the results of the study. The median age of the subjects was 33 years (Interquartile range [IGR], 26–37). Ambulatory impedance studies were performed after an overnight fast and standard preliminary esophageal manometry to exclude coexisting motility disorders. Localization of the lower esophageal sphincter (LES) was done in the standard manner to enable probe placement for combined pH and MII study.

Catheter design

The combined impedance and pH (MII-pH) probe used for the study is shown in Fig. 1 (Sandhill Scientific, Denver, CO, USA). It consisted of a 2.1-mm polyurethane catheter constructed to incorporate six impedance segments and one pH-measuring electrode. The middle of each of the impedance segments was configured so they could be placed at 3, 5, 7, 9, 15, and 17 cm above the upper border of the LES; similarly, the pH electrode was positioned at 5 cm above the LES.

Data from the combined MII-pH probe was transmitted at a frequency of 60 cycles per sec and recorded on a portable data recorder (Z-Logger; Sandhill Scientific). The apparatus incorporated a removable compact flashcard from which data were transferred to a personal computer. Data analysis was performed via Bioview MII software (Sandhill Scientific).

Study protocol

The combined MII-pH probe was passed transnasally and positioned to sit with the impedance segments centered at 3, 5, 7, 9, 15, and 19 cm above the upper border of the LES and the pH electrode at 5 cm above the reference point. The probe was connected to the Z-logger and the recording process started. The subjects were sent home with specific instructions to record time to consume the meal, changes in body position, and GER symptoms. They were told to consume a refluxogenic meal, consisting of a hamburger, fries, and milkshake from a fast-food establishment. They were also provided with a list of foods to avoid because they could interfere with interpretation of the pH data. They were encouraged to spend a minimum of 6 h in a supine position. The subjects returned 24 h after the commencement of the study. The probe was withdrawn, data recording was stopped, and the study was concluded.

Identification of reflux events: rules and characterization

Impedance was measured in ohms (Ω)

Identification of a reflux event. The arrival of any bolus/refluxate in a segment was determined by a fall in impedance to 50% from the resting impedance; its exit was said to have occurred when a 50% rise from the nadir impedance was attained. When these criteria were met in the distal two channels and the onset of events was seen to progress in the aboral direction, a reflux event was said to have occurred. (A caudal progression signifies a swallow.)

Physical characteristics of the refluxate

Liquid only. A fall in impedance to <50% from resting impedance signified the presence of liquid in a reflux event (Fig. 2).

Gas only. An abrupt rise in impedance from resting impedance to an absolute value to >7,000 Ω was a marker for gas. When this abrupt rise occurred as a stand-alone phenomenon, hence falling back to resting impedance, it signified a gas-only reflux event if the onset was shown to have a retrograde or simultaneous progression (Fig. 3).

Mixed. When a fall in impedance to <50% of resting impedance (liquid) was preceded or followed by an abrupt rise to over 7,000 Ω (gas), it was determined to be a mixed refluxate (Fig. 4).

Chemical characteristics of the refluxate

Acid reflux. A fall in pH to <4 from a pre-event pH >4 associated with a reflux event as determined by impedance changes reflected an acid reflux lasting for >5 sec. This definition conforms to the standard acid reflux episode detected by conventional pH monitoring systems (Fig. 4).

Nonacid reflux. A reflux event with no noticeable fall in pH or with a fall of >1 pH unit and a nadir pH >4 was defined as nonacid reflux when it was associated with an impedance-detected reflux (Figs. 2 and 3).

Nonacid delta. A fall of >1 pH unit from resting levels to a nadir pH that was higher than an absolute pH value of >4 was defined as nonacid delta reflux with an impedance-detected reflux.

Short acid reflux. Acid reflux episodes lasting <5 sec before which chemical clearance is obtained to a pH >4 was defined as short acid reflux.