# Gastroesophageal and Pharyngeal Reflux Detection Using Impedance and 24-Hour pH Monitoring in Asymptomatic Subjects: Defining the Normal Environment

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Airway symptoms are often caused by aspiration of refluxed materials into the larynx. In this study we sought to define the frequency, character, and proximal extent of refluxed contents — including nonacid reflux—in normal subjects using intraluminal impedance to improve our understanding of the relationship between reflux and aspiration. Ten subjects, who had no symptoms of gastroesophageal reflux disease or airway disease, underwent impedance/pH monitoring with a catheter that allowed simultaneous esophageal and pharyngeal monitoring. Impedance detected 496 gastroesophageal reflux episodes in the 10 subjects during 240 hours of study. The majority, 399 (81% of the total) were acid reflux episodes (pH $<$ 4). Ninety-seven were nonacid (pH $>$ 4). Most reflux episodes (348 of 496) reached the mid esophagus (9 cm above lower esophageal sphincter). There were 51 reflux episodes that reached the pharynx (PR). Only 13 (25%) of PR were acidic (pH $<$ 4), while 38 were nonacid. Twenty-six PR episodes were liquid and 25 were mixed (liquid and gas). The median number of PR episodes measured with impedance was 5 (0–10). In asymptomatic subjects, most episodes of gastroesophageal reflux are acidic and reach the midesophagus. Reflux into the PR appears to be more common than previously believed, and most of these episodes are not acidic. Thus, traditional 24-hour pH monitoring may underestimate the presence of pharyngeal reflux. The combination of impedance with pH monitoring markedly enhances our ability to accurately detect potential microaspiration. (J GASTROINTEST SURG 2006;10:54–62) 

KEY WORDS: Gastroesophageal reflux, respiratory symptoms, extraesophageal symptoms, airway symptoms, pharyngeal reflux detection, esophageal impedance

Gastroesophageal reflux is a normal phenomenon that results from transistory loss of gastroesophageal competence due to a decrease of lower esophageal sphincter (LES) pressure, an increase in abdominal pressure, gastric distention, and a variety of other physiologic conditions. When the number, the duration, or the upper extension of these episodes exceeds a certain threshold and/or when the patient develops symptoms or mucosal damage, physiologic reflux becomes gastroesophageal reflux disease (GERD).

Most previous studies have analyzed the physiology and pathophysiology of reflux episodes using 24-hour pH monitoring. Indeed this technique remains the goal standard to differentiate physiologic from pathologic reflux. However, 24-hour pH monitoring has limitations, particularly in that it is not able to detect episodes of reflux unless the pH is

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below 4 and usually measurements are limited to relatively short segments of the esophagus.

A better understanding of the character, composition, and proximal extension of gastroesophageal reflux and of pharyngeal reflux in normal people may yield valuable information and set the basis for a more thorough explanation of ways in which reflux causes esophageal and extraesophageal pathology. We undertook this study to examine these and other aspects of normal reflux episodes. We wished to determine how often a *normal* reflux episode was acidic or nonacidic, how high it reached in the esophagus, whether its composition changed while in the esophagus, and whether some of these episodes reached the pharynx. To do this end, we used impedance and 24 hour pH measurements. Impedance provides information about (a) the physical characteristics of the refluxate (liquid, gas, or mixed); (b) the direction of the flow (oral or aboral); and (c) the acidity of the reflux event by placing pH sensors on the catheter. Since microaspiration is a major component of GERD-related airway disease, we hypothesized that combined pH/impedance pharyngeal monitoring would provide valuable information regarding the mechanism by which aspiration occurs.

## METHODS

### Patient Selection

Ten subjects (seven males and three females) were provided a self-administered, standardized symptom questionnaire. The questionnaire queried the frequency (0 = never, 1 = once/month, 2 = once/week, 3 = once/day, 4 several times/day) of the following 18 symptoms: heartburn, regurgitation, chest pain, solid dysphagia, liquid dysphagia, bloating, odynophagia, hoarseness, abdominal pain, nausea, postprandial pain, bloating, globus, aspiration, wheezing, cough, shortness of breath, and sore throat. Each subject answered "never" for all symptoms, and this was confirmed by a study investigator.

This study was approved by the University of Washington's Human Subjects review board (HSD-02-4684-D02).

### Manometry/Impedance

A solid-state combined manometry and impedance measurement catheter was used to exclude motor disorders and to accurately identify the location of the upper esophageal sphincter (UES) and LES. The design combines five manometry channels with four pairs of impedance sensors, each separated by 5 cm. A station pull-through measurement of the LES pressure determines the characteristics of the sphincter. The LES pressure was averaged over a series of three respiratory cycles. The peristaltic pump of the esophageal body was assessed over a minimum of 10 episodes of deglutition with 5-ml aliquots of normal saline. Ten additional swallows with 5 ml of viscous material (Sandhill Scientific Inc., Highlands Ranch, CO) were performed. Each swallow evaluated the speed, duration, amplitude, and propagation of the peristaltic wave, as well as the clearance of the swallowed bolus across each pair of impedance sensors and through the esophagus. The UES location, pressure, and relaxation were measured before completion of the procedure.

### Twenty-Four – Hour Esophageal and Pharyngeal pH and Impedance Monitoring

A specially designed bifurcated solid-state pH/impedance catheter was used (Sandhill Scientific Inc.) (Fig. 1.) The bifurcation allows one branch to be positioned with a pH sensor 5 cm above the LES while the other was placed with the proximal sensor 2.0 cm above the UES as determined by stationary esophageal manometry. In this position, one catheter has four pairs or impedance sensors that were placed in the esophagus 3,5,7, and 9 cm above LES and a pH sensor 5 cm above the LES. The other catheter branch has a pH sensor 2 cm above the UES and a pair of impedance sensors below (5 cm) and above (2 cm) the UES. The catheter was placed transnasally and connected to a recording device worn by the patient for 24 hours. The information was entered into a software program, which reported events (number and duration of reflux episodes) and calculated acid exposure times over the course of the study. Data were acquired with Sleuth Software (Sandhill Scientific Inc.) and analyzed with the Bioview GERD Analysis Software (Sandhill Scientific Inc.) All tracings were individually reviewed, rather than relying on the computer interpretation, to determine reflux episodes and the proximal extent as measured by pH and impedance. Meal periods were excluded from the analysis. All subjects tolerated the procedure well without incident or complications.

### Impedance Definitions

***Liquid episodes.*** We defined as "liquid" an episode of reflux that manifested as a drop in the impedance (measured in Ohms) of more than 50% from its baseline. To be considered as reflux, the episode should start in the distalmost sensor and propagate aborally in at least the two distalmost sensors. The height reached within the esophagus by the reflux episode was defined as the most proximal impedance