Outpatient Computer-Based 32-Hour Esophageal pH Studies Teletransmitted to a Central Esophageal Laboratory

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- Using a computer-based 32-hour esophageal pH system with a small patient-worn digital recording computer, outpatient studies are performed in the physiologic environment of the patient's workplace and home. Samples are taken at 15-s intervals, and the pH data stored in this computer are then fed into the main computer in the Central Esophageal Laboratory for analysis, scoring, printing out, and storage. Satellite esophageal laboratories located in regional hospitals, clinics, and physicians' offices conduct pH studies by telecommunication, using antimony electrodes, a recording computer, and a modem to transmit data to the main computer for high-quality computer analysis. One main computer and associated personnel serve multiple satellite stations. This maintains patient-physician relationships and is highly cost-effective. (Arch Intern Med 1985;145:1617-1619)

Twenty-four-hour esophageal pH monitoring, introduced in 1974 by Johnson and DeMeester to quantify gastro-esophageal reflux, has become the most widely accepted and informative of the many currently available tests. In 1981 we described a telemetric method for outpatient pH monitoring. Small glass esophageal electrodes were attached to a small patient-worn combined pH meter and radiotransmitter to sample and transmit esophageal data every 15 s to a radio receiver for printout. Transmission distance was limited to 210 m (700 ft). In previous techniques the patient had to be tethered to a bedside receiver, but with our method the patient was ambulant, could be an outpatient, and was able to pursue normal activities in the physiologic environment of his home.

Disadvantages of the system included the erratic performance of the glass electrodes, transportation of the radio system to and from the patient's home, the limited range of the radiotelemetry, and the four to five hours spent scoring the test by hand-generated waveforms. These disadvantages have now been eliminated by employing antimony electrodes, with a totally computerized system. We also have adapted the Holter electrocardiograph concept to the teletransmission of esophageal pH data, transmitting pH from satellite laboratories to a central esophageal laboratory for analysis, printout, and storage. Technical features of our current system and the clinical application to both inpatients and outpatients are the subject of this report.

MATERIALS AND METHODS

Antimony electrodes are used because they are small (1.5 mm in diameter), soft, pliable, inexpensive, durable, and of lower impedance than glass electrodes. Telemetry has been replaced by a patient-worn, digital pH recording computer weighing 0.45 kg (1 lb). This battery-powered computer, carried in a pouch or placed at the bedside at night, stores pH samples with a resolution of 0.05 pH units. To indicate pH storage and proper operation of the unit, a small light-emitting diode blinks at 15-s intervals. A switch allows the patient to indicate position, upright or supine. Prior to and following each use, the system is calibrated at three pH values using solutions of known pH. On completion of the test at a satellite laboratory, the memory is attached to a modem for telephone transmission to the data-processing computer at the Central Esophageal Laboratory. Thirty-two hours of data are transmitted in 15 minutes. Objective and subjective events both standard and nonstandard for esophageal reflux are rapidly entered in the final printout through the use of a coded list.

If a minute-to-minute visible pH record is needed, as in patients in the intensive care unit who have potential ulceration, bleeding, or perforation secondary to hypersecretion and reflux, the data-processing computer is coupled with our telemetry system.

Analysis and scoring are done according to the six weighted factors of Johnson and DeMeester: (1) the number of reflux events, (2) the total time the esophageal pH is below 4, (3) the number of episodes lasting five minutes or longer, (4) the duration of the longest episode, and (5) upright or (6) supine time the pH is below 4, with the scoring weighted in favor of supine reflux.

Statistics including means, SDs, and frequency histograms are generated for total, upright, and supine records. The summary report includes the score and trend graphs, with embedded patient comments and histograms drawn on either linear or logarithmic scales.

REPORT OF CASES

Case 1.—An overweight, 52-year-old man was admitted complaining of dysphagia, regurgitation, frequent heartburn, and rare

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Fig 1.—The pH record from patient 1 while asleep. Heartburn at 11:30 PM was preceded and followed by prolonged episodes of reflux. Score was 200.51 (upper normal, 17.92).

Fig 2.—The pH record from patient 2, one month after Nissen fundoplication, while asleep. Patient was awakened at 5:30 AM by coughing and prolonged acid reflux. Score was 143.37 (upper normal, 17.92).

episodes of hematemesis. Roentgenograms disclosed a small hiatal hernia without reflux. Manometric studies demonstrated marked hypomotility of the lower two thirds of the esophagus with a lower esophageal sphincter pressure of 18 mm Hg. On endoscopy there was moderate erythema of the lower esophagus. The 24-hour esophageal pH showed (1) long, frequent reflux episodes while the patient was supine, with numerous short episodes while he was erect, (2) a drop in pH following two of his three meals, (3) close correlation between heartburn and drops in the pH values (Fig 1), and (4) a very high composite score—200.51—using the scoring system of Johnson and DeMeester	extsuperscript{a} (upper limit of normal, 17.92).

This male patient presented with typical findings of reflux esophagitis including obesity, an atomic lower esophagus, roentgenographic evidence of a hiatal hernia, and endoscopic findings of esophagitis.	extsuperscript{7} His composite reflux score of 200.51, the highest we have ever seen, related to long periods of reflux with concurrent heartburn while he was recumbent. His reflux pattern was a combined upright-supine, with the supine position predominant. With classic evidence of reflux esophagitis despite the absence of reflux on esophagogram, the pH study was performed only to convince the patient of the severity of his problem.

Case 2.—A 7-month-old boy with myelodysplasia, multiple congenital defects, reduced mentality, and long periods of apnea on crying was admitted to Children’s Hospital—Medical Center, Akron, Ohio, with a recurrent pulmonary infection. A Nissen fundoplication had been performed one month earlier to treat reflux and aspiration coupled with recurring pulmonary sepsis. There was roentgenographic evidence of reflux, and it was assumed that the fundoplication had broken down. Because of the complexity of a repeated fundoplication in a sick child, the reflux was confirmed by a pH study. The study performed at the Children’s Hospital—
Medical Center was teletransmitted to the Central Esophageal Laboratory. The score was 143.37, a mixed supine-erect reflux, predominantly supine (Fig 2).

Of the objective tests for esophageal reflux in children, esophageal pH monitoring during sleep identified and quantified the significant acid reflux in this severely disadvantaged child. The hallmarks of reflux were present, ie, mental retardation, recurrent pulmonary sepsis, and failure to thrive. Boix-Ochoa performed 24-hour pH studies in 130 children and concluded, like Hill et al, that the test was the most informative of the many tests available.10

COMMENT

Our computer-based esophageal pH system incorporating antimony electrodes, a patient-worn recording computer, and a data-processing computer uses the Holter concept for teletransmission of long-term pH data from satellite esophageal laboratories to a central esophageal laboratory. A satellite esophageal laboratory may be located in a regional hospital, clinic, or physician's office and thus preserves physician-patient relationships. The pH data are rapidly analyzed, scored, printed out, reported to the referring source, and stored for future comparison and reference. This allows long-term esophageal pH studies to be performed in the patient's own environment—his home and his workplace—and provides high-quality computer-generated analysis. It also eliminates the need in the satellite esophageal laboratory for both personnel and an expensive computer and thus is highly cost-effective. Cost-effectiveness is further increased by performing outpatient studies, facilitated by the small size of the patient-worn memory.

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References