Computer-Aided Analysis of Human Esophageal Peristalsis

I. Technical Description and Comparison with Manual Analysis

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Manual and computer analysis of esophageal peristaltic activity induced by swallows of 5ml water were compared in 6 healthy subjects under basal conditions and following i.v. injection of 4 pharmacological agents: edrophonium (E, 0.08mg/kg), atropine (A, 0.6mg), pentagastrin (PG, 0.6mcg/kg), and glucagon (GL, 1mcg). Esophageal manometry was performed using a low compliance perfusion system and recorded on paper for standard manual analysis. The signal was concurrently taped on an analog recorder for subsequent digitization and analysis on a PDP-11 computer using a locally developed program. With both methods we determined the wave amplitude, duration, average upward slope (dP/dT), and velocity of wave progression. In addition, the computer allowed calculation of area under each wave and maximum upward slope (Max dP/dT). We found no significant difference between results of the parameters measured using both methods. Wave amplitude was significantly increased by E and significantly decreased by A. Average upward slope was decreased and velocity was significantly increased only by A. Computer-calculated wave area and Max dP/dT were significantly changed by both E and A. PG and GL had no effect on any of the measured parameters of the peristaltic wave. Esophageal peristalsis can be analyzed using a computer-aided method, providing a rapid and objective measurement of classical parameters and access to more in-depth analysis.
vide a more in-depth analysis of esophageal pressure waves.

The purpose of the present study was twofold: (1) to develop a program for computer analysis of esophageal motility recordings; and (2) to evaluate its feasibility and potential advantages by comparing results obtained by manual and computer analysis and by studying the effects of pharmacologic agents on esophageal peristalsis in man. Hopefully, computer-assisted analysis of esophageal peristaltic pressures would eliminate some of the limitations of the standard manual analysis technique.

MATERIALS AND METHODS

Subjects. All studies were performed in six healthy volunteers, four male and two female, ranging in age from 28 to 45 years. After informed consent was obtained, the subjects were studied following an overnight fast on two separate occasions as described below.

Esophageal Manometry. An eight-lumen polyvinyl esophageal manometry catheter was used; each lumen having an inner diameter of 0.8 mm. Five lumens, with orifices spaced at 5-cm intervals longitudinally and radially spaced at 90° angles, were used for these studies. The other three orifices, located at the same axial level as the most distal orifice, were not used. The catheter was introduced through the nose and passed until all orifices were recording gastric pressure. It was then withdrawn slowly across the lower esophageal sphincter (LES) and finally taped in place with the distal orifice 2 cm above the sphincter. The five orifices thus recorded pressures at 2, 7, 12, 17, and 22 cm above the LES. Due to variation in esophageal length, the proximal orifice often recorded upper esophageal sphincter (UES) pressures, so measurements of peristaltic indices were only evaluated at the four distal orifices. Pressures in the UES, LES, or pharynx were not regularly measured in the design of these studies. The lumens of the catheters were constantly perfused by a low-compliance pneumohydraulic capillary infusion pump (Arndorfer Specialties, Inc.) at a rate of 0.5 ml/min using distilled water driven by a nitrogen pressure head of 16 psi. The pump and catheter system was developed locally at the Armed Forces Radiobiology Research Institute (Bethesda, Maryland) and written up by both manual and computer analysis. Pressure levels of the esophagus. Amplitude of the peristaltic waves and test the possibility of greater sensitivity of computer analysis.

Computer Analysis. During each study, the manometric signal recorded on paper was taped concurrently on an Ampex PR-2230 analog recorder (Ampex Corp., Redwood City, California). During a subsequent session, the taped analog signal of one or several studies was conditioned with a 5-Hz low-pass filter before being digitized at a sampling rate of 100 Hz and presented to the computer. The computer used was a DEC (Digital Equipment Corporation) model PDP 11/70 using a 12-bit ADV-I 1 analog-to-digital (A/D) converter. The input voltage was transformed into a voltage trace spanning a 10-V range from +5 to −5 V. This transform allowed us to use the full 12-bit discrimination of the A/D converter. The precision of the digitized data reflects this resolution, giving a relative measurement error of approximately 0.02% of the input voltage per measurement. The program for this analysis was developed locally at the Armed Force Radiobiology Research Institute (Bethesda, Maryland) and written using the FORTRAN program language.

Data Analysis. Routine manual reading of each group of swallows was performed measuring amplitude, duration, and velocity of the peristaltic wave at each of the four levels of the esophagus. Amplitude of the peristaltic contraction in response to swallowing in millimeters of mercury was measured as the change in pressure from the mean baseline resting esophageal pressure to the peak of the contraction wave. Duration of the contraction in seconds was recorded as the width of the pressure wave from the beginning of the rapid upstroke of the wave to the point where the downslope reached baseline. The beginning of the upstroke was defined visually as the extrapolated intersection of the tangent to the initial rapid upstroke and of the baseline. It was chosen because the

Edrophonium (80 μg/kg) was injected intravenously over approximately 10 sec and a series of 10 swallows performed immediately upon completion of the injection. Twenty minutes later, an injection of atropine (0.24 mg) was given intravenously, and an additional series of 10 swallows was performed starting 5 min later.

On day 2, following the baseline series of swallows, sequential injection of two gastrointestinal hormones was performed. A bolus of pentagastrin (0.6 μg/kg) was injected intravenously and a series of 10 swallows begun immediately following the injection. Twenty minutes later, a bolus of glucagon (1 mg) was injected intravenously and a series of 10 swallows performed beginning after 5 min.

The selection of pharmacologic agents was based on the following concepts. Edrophonium and atropine were used as cholinergic and anticholinergic agents which have been previously shown to have definite effects on esophageal peristaltic waves (5, 6). It was hoped that this would provide the opportunity to compare the responses obtained by both manual and computer analysis. Pentagastrin and glucagon represent two hormonal agents which have been shown to raise and lower, respectively, the lower esophageal sphincter pressure (7, 8) but which have not been shown to affect esophageal peristalsis (8, 9). It was hoped that these studies might provide the opportunity to identify more subtle changes in peristaltic pressure waves and test the possibility of greater sensitivity of computer analysis.

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