AN AUTOMATED SYSTEM FOR ASSESSING GASTRIC MOTOR FUNCTION IN PATIENTS WITH DUODENAL ULCER

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Methods of examination of the motor function of the gastrointestinal tract (GIT) are of significant diagnostic importance in patients with alimentary system diseases. However, these methods have not yet gained wide recognition because of short supply of high-sensitivity diagnostic devices and difficult interpretation of the results of examination. The last condition can be observed only with accumulation of a sufficient amount of data, skill, and experience.

Methods of examination of motor function of GIT are developed most extensively in surgery, because objective evaluation of this parameter provides valuable information for selecting adequate tactics of surgery and monitoring its efficiency.

The method of manometry (simultaneous measurement of pressure in various lumen segments of stomach and duodenum) has been practiced at the Hospital Surgery Clinics No. 2, Russian State Medical University since 1968. A classification of ulcerous piloroduodenal stenoses (PDS) was proposed on the basis of significant clinical experience, results of endoscopic examinations, and motor functions of the GIT [1]. According to this classification, there are four stages of PDS development: formation, compensation, subcompensation, and decompensation. Although the manometric method is used in diagnostic examinations of patients, there are serious problems in the interpretation of its results because manual processing of GIT images in patients with PDS is rather ambiguous. Therefore, automation of manometric measurements is an urgent problem.

Currently available automatic systems of computer-assisted record and analysis of intracavitary pressure provide only off-line data processing with manual rejection of artifacts [2]. In recent years there have been individual reports on the on-line systems of data processing with automatic rejection of artifacts by preset identification characters [3]. However, no automatic systems for comprehensive evaluation of motor functions of the GIT and computer-assisted diagnosis are presently available.

The first model of automated diagnostic system for evaluating the motor functions of the GIT and PDS by the method of intracavitary multichannel manometry was developed at the Department of Medical and Biological Cybernetics and Hospital Surgery Clinics No. 2, Russian State Medical University.

1. General Description

The automated Motorika system includes the following components: pressure sensors EMT-35 of the EDEMA model 81 myograph, a pressure signal converter, a computer (standard set of IBM PC/AT and a Shchit analog-to-digital converter (ADC)).

The software of the automated Motorika system was written in the Turbo C language.

The user menu of the automated Motorika system contains the following options: questionnaire, calibration of pressure signal in three channels, pressure curves, data processing, diagnostic conclusion, database, exit.

2. Questionnaire

Before examination, the following information should be entered: patient name, age, number of medical card, and clinical diagnosis. Then, the pressure sensors are calibrated, pressure signals are recorded and processed.

3. Calibration of Pressure Signal

Calibration mode is necessary to test the correspondence between electrically and manometrically measured values.
Fig. 1. Calibration screen. Explanation in text.

Fig. 2. Location of gastric probe with sensors during three-channel manometry of stomach (1), antral segment of stomach (2), and bulbar segment of duodenum (3).

The calibration of pressure signals is implemented by sequential connection of the manometer to each of the sensors. Two standard values of pressure (0 and 60 mm Hg) are routinely set and verified (Fig. 1).

4. Pressure Curves

Intracavitary multichannel manometry of the stomach and duodenum is performed with a radiopaque probe with three manometric catheters with inner diameter of 1.2 mm. The catheter tips are located at 12 cm, 26 cm from the distal end of the probe, and at the distal end itself. Under X-ray control, the probe is installed so that its distal end matches the duodenal bulb. Patients are examined on an empty stomach. A "hungry" motor function is monitored for 1.5 h. Then, after so-called physiological breakfast (200 g of semolina) a food motor function is recorded for 30-40 min (Fig. 2).

The signal with pressure sensors is applied to a 10-bit integral ADC (K113PV1A) and then to an IBM PC/AT computer.

5. Data Processing

At the first stage of compilation of an algorithm of signal processing, the threshold criteria and optimum number of smoothing points were selected for different signals of intracavitary pressure from different segments of the GIT.

The data processing algorithm includes the following stages:
- signal smoothing designed to remove artifacts of patient body position changes;
- search for contractions (start, end, and amplitude of each contraction);
- calculation of diagnostically significant parameters.

Before processing, the correspondence between the input channels and segments of the GIT is tested. Then the user places a cursor at the points on the curves corresponding to 10-min intervals before and after the breakfast (Fig. 3).

Then a digital signal is stored in a file and smoothed by replacing the initial values of the data array by an averaged value as calculated from two neighboring elements of the array and the element itself.

The smoothed array and threshold values are processed by the program of the search for contractions. This gives three arrays of coordinates of the start, end, and amplitude of the contraction.

The program of the search for contractions consists of the following subroutines: search for start and end of contraction, test for contraction, test for food-induced contraction (food-induced contractions have low amplitude and period of 1/3 min), and test for tonic-peristaltic contraction.

Then, the parameters necessary for diagnostic conclusion are calculated.