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Data integration to assist gastric emptying data analysis

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Abstract. The diagnosis of dyspepsia is very difficult because the symptoms are clinically aspecific and the gastric emptying time tests are of complex interpretation. An integrated and automated analysis of clinical and instrumental data may improve the diagnostic process. We present a system to collect data on dyspeptic patient from different sources which has been set up to assist the clinician in the diagnosis of dyspepsia. The data base integrates a wide set of symptoms with data coming from laboratory tests. Moreover, we assess the feasibility of classifying gastric emptying profiles using both octanoid acid excretion data and electrogastrography.

1. Introduction

Dyspepsia is a common condition characterised mainly by pain or epigastric discomfort and frequently associated with delayed gastric emptying. The diagnosis is very difficult because the symptoms are clinically aspecific and the gastric emptying time tests are of complex interpretation. An integrated and automated analysis of clinical and instrumental data may improve diagnostic process. We present a database which has been set up to assist the clinician in the diagnosis of dyspepsia. The data base integrates a wide set of symptoms with data coming from laboratory tests. The data base has also been used to assess the feasibility of the classification of data on gastric emptying time, using artificial neural networks.

2. Methods

SVGAS is a system developed based on a relational database which can easily interface with other programs which produce raw laboratory data .The data structure has been designed using the mixed approach [1]. The main entities of the data base are: patient, examination and test, closely connected (fig. 1 shows the level 0 of the Entity-Relational diagram of the data base). Patient data can be recorded without duplication, independently of the number of examinations and tests which are stored. In the same way general test data are recorded only once, without any duplication for each specific test performed. Tables to record anamnestic information (smoke, alchool, etc.) and specific symptoms information (epigastric/retrosternal pain or discomfort, postprandial fullness, bloating, early satiety, postprandial nausea, belching after meals, postprandial vomiting, anorexia) are present in the database. These tables are directly linked to the corresponding patient records.

Test entity has been subdivided into three specific entities to retain the differences in methods. We consider above all two experimental methods: ^{13}C-octanoic acid breath test [2], and electrogastrogram [3]; but for some cases we recorded also data from scintigraphy [4].

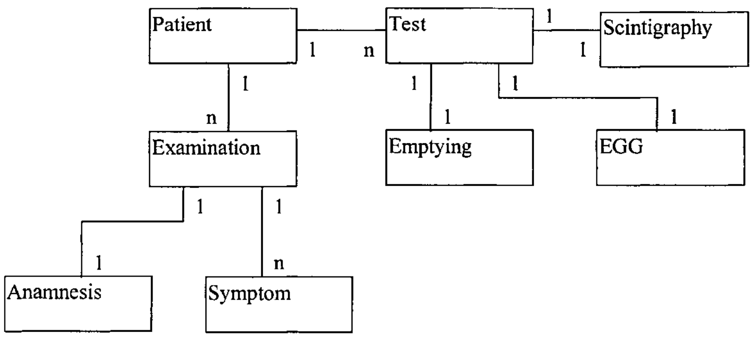

Fig.1 E-R level 0

^{13}C-octanoic acid breath test is a reliable tool for measuring gastric emptying. It is based on the administration of a substrate with a functional group containing ^{13}C which is the stable isotope of carbon. The functional group is enzymatically cleaved during the passage in the gastrointestinal tract, further metabolized by liver to $^{13}CO_2$ which mixes with the blood "bicarbonate pool" and finally expired in the breath. Therefore, $^{13}CO_2$ excretion reflects gastric emptying rate.

Electrogastrography (EGG) records gastric electric activity by means of electrodes attached to the abdominal surface, similar to electrocardiographic recording. The origin of the electric activity from the stomach has been confirmed in animal models and humans. Simultaneous myoelectric recordings with electrodes implanted in the gastric mucosa and placed on the abdomen have shown that EGG signal shows an underlying slow wave frequency [5]. Recently, EGG was used to examine the pathophysiology of upper gastroinestianl symptoms.

The three methods mainly differ, from a computer science point of view, for the inter sample interval, breath test and scintigraphy use inter sample time interval of 10 - 30 minutes; while electrogastrogram uses a inter sample time interval of 0.25 seconds. So the amount of data to be recorded for each test and the mathematical methods used for their analysis are significatively different.

The test tables contain quality control information for each test performed. The data tables are linked to both the test table (to allow the follow up of the patient) and external data analysis programs.The database is integrated with a series of automatic procedures to perform controlled data insertion and assisted data consultation. Specifically, some procedures to automate data insertion from laboratory instruments are present.

Patient insertion is a manual operation performed by the clinician, just after patient examination, in order to store reliable clinical data. The test data insertion is performed in a semiautomatic way: technicians only have to select the test type and the specific work list, locate the directory of the communication files and supervise the validation control and data interpretation procedures. Fig. 2 shows the data flow diagram of this operation.

The data is protected by a set of access password to identify the authorised user with a compulsory login procedure.

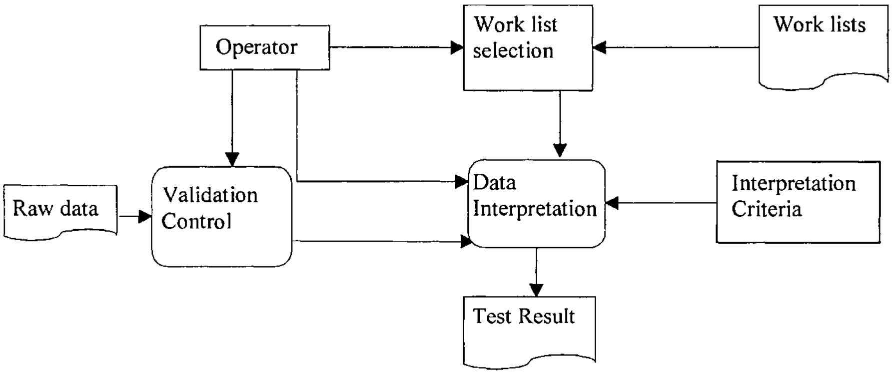

Fig. 2 DFD diagram of result insertion

3. Results

The data base is now being validated at the Gastroenterology Unit of the Department of Internal Medicine of the University of Genova, and is mainly used by internists in training without any specific experience in computer science, who have been given only a short presentation of the system and of its main opportunities. In the first three validation months, they have inserted, without any particular difficulty, data on 66 subjects. We have performed a preliminary study on these data to assess the feasibility of using artificial neural networks to classify, in an objective way, data obtained from acid octanoic excretion.
According to Ghoos's classical parameter [2] the 66 subjects were divided into 5 categories: 21 normal subjects, 8 accelerated subjects (A), 11 subjects with low level slowness (L); 8 subjects with medium level slowness (M); 18 subjects with severe slowness (S).
21 healthy volunteers and 45 dyspeptic patients (25 F, 20 M, mean age 41 years) were studied. Measurement of gastric emptying time was performed by ^{13}C-octanoic ac. breath test. Breath samples were collected before and every 15 minutes for 4 hours after a standard test meal with 100 mg ^{13}C-octanoic ac. (Cortex Italia, Milan, Italy) incorporated into egg yolk and analysed by isotope ratio mass spectrometer (AP 2003, UK). On the basis of T1/2 parameter of gastric emptying according to Ghoss et al. [2], all subjects were subdivided in the following subgoups: normal (N - 70±20), accelerated (A - < -2SD), slightly delayed (L - >2 SD), mild delayed (M - >4 SD), severe delayed (S - >6 SD).
The parameters indicated by Ghoos et al. [2] and the sequence of data coming from the octanoic acid excretion test have been appropriately normalised for each subject and given as input to an unsupervised neural network. The network used for this study is based on the Kohonen algorithm [6] with an output organised in a 9x9 matrix, implemented within a Matlab 4.3 environment, running on a Pentium PC. Fig. 3 shows the results obtained with this preliminary study. As it can be noted in fig. 3, all cells assigned to the categories are grouped in well distinguishable and ordered sectors of the output map. All subjects, except one, have been classified in the correct category. The only subject classified in the wrong category is one of the medium group, which has been classified together with subjects of the low level group.
We are also performing another feasibility study on the applicability of supervised neural networks in order to clear electrogastrographical signal from electrical noise and other external artefacts. We used input signals recorded on 10 healthy subjects about 30,000 samples long, in which 40% of samples were classified as noise by expert gastroenterologists. Of these signals 5 were used in the learning set and 5 in the test set. We

used a input window of 100 samples for a network structure of 100 input neurons, 50 hidden neurons and 2 output neurons. The agreement between the network and expert interpretation was 96% in signals of the learning set and 90% in the test set signals.

A1-A2-A3	A4-A5	N1-N3	N4-N6-N11	N21	L6	L3-L5	L9-L10-M1	
A6	A7-A8	N9	N12-N14	N20	L4-L7		M4	M7
N2	N5	N15	N18			M6		
N8-N10	N16	N17		M3		M8	S5	[illegible]
N13	N19	L1	L8	M5			S7-S9	
	L11	M2			[illegible]	S12	S14	S15
L2						S13		
			[illegible]	S10-S11				
		S2-S4		S16		S17		S18

Fig. 3 Output Kohonen map: A, accelerated subjects ; N, normal subjects ; L, slightly delayed subjects ♡; M mild delayed subjects ; S severe delayed subjects ♡.

4. Discussion and conclusions

The validation phase, carried out at the Gastroenterology unit of the Department of Internal Medicine, has been successfully completed, specially referring to use by gastroenterologists, who appreciated above all its user-friendly features. The preliminary results of the feasibility trials suggest that neural networks can improve the analysis of breath test data and allow a better discrimination among different groups of patients. However, further work is necessary before making methods based on neural networks become suitable for the clinical practice.

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