Development of a User-Friendly Database for Combined Assessment of Doppler Coronary Flow Reserve and Wall Motion Abnormalities

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Abstract

The evaluation of coronary flow velocity reserve (CFVR), together with the assessment of regional wall motion by 2D-echocardiography, represents a new noninvasive tool potentially indicated in detecting mid-distal coronary stenosis or microcirculation pathologies. To facilitate data management in a cardiology department, both for clinical and research purposes, we developed a database able to integrate echo-Doppler exam, ECG evaluation and patient clinical history. The Database was built on SQL regulations in Access environment. Moreover, up to 4 images or movies for each patient can be included in the database. Useful criteria based on the patient population characteristics, examined artery, CFVR value, pathology, wall motion abnormality and ECG results, have been implemented to facilitate data retrieval for research and clinical purposes. Results of the research are made available in Excel format for further statistical analysis.

1. Introduction

Transthoracic Doppler echocardiographic imaging of coronary flow provides a revolutionary approach in the noninvasive diagnosis of coronary artery disease since alterations of flow, rather than the consequences of flow reduction on heart function and metabolism, can be directly evaluated [1,2]. By this technique, coronary flow velocity reserve (CFR) can be measured in the distal portion of the left anterior descending (LAD) coronary artery during adenosine or dipyridamole infusion, as the ratio of maximal (pharmacologically stimulated) to baseline (resting) diastolic coronary blood flow velocity peak [3].

In this way, the evaluation of CFR, together with the assessment of regional wall motion by 2D echocardiography, represents a new noninvasive tool potentially indicated in detecting mid-distal coronary stenosis or global microcirculation pathologies.

However, none of the databases actually available for data management in a cardiology department has been specifically designed to deal with this new kind of information. This constitutes a potential limitation when CFR data could not be visualized combined with other conventional clinical information, as well as when data retrieval of specific patient populations is needed for retrospective research studies.

Accordingly, our aim was to develop a database able to integrate in a single platform the information relevant to patient clinical history, ECG evaluation, 2D echocardiographic examination and Doppler coronary flow reserve test, and to allow easy-to-use and fast data management and retrieval, both for clinical and research purposes.

2. Methods

This application was built following the software's life cycle rules [4]. As a first step, the final users (cardiologists and biomedical engineering researchers) were asked to define all the possible functions they would have liked to find included in the final product, together with the information relevant to the patient's clinical record to store in the database.

This was followed by a Planning phase, in which we planned the database structure and data organization, together will the user-interface with the database.

The database was developed using the E-R (Entity-Relationship) model, and then built following SQL regulation [5-6] in Access (Microsoft) environment.

In Figure 1, a simplified version of the planning of the database is reported. The model is made of entities (object's classes that have similar proprieties), relationships and attributes: entities are represented with rectangles and relationships with rhombuses. For example, in the PATIENT entity, all the attributes useful for the patient identification (social security number, last name, name ,gender, birth date, phone) were included.

Relationships are used to connect every entity to the others. Every relationship has a cardinal number that express how many instances are involved. For example the relationship SUSTAIN between PATIENT and

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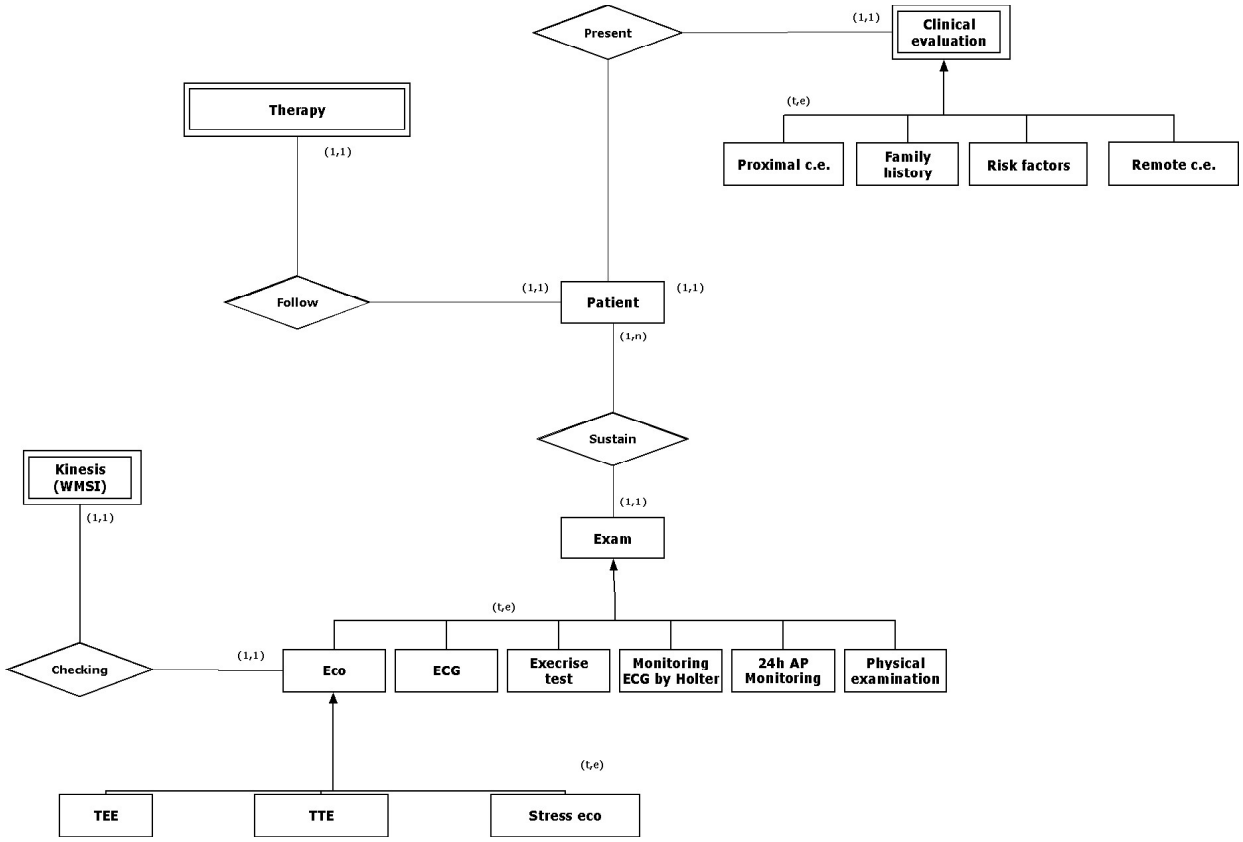

Figure 1. Simplified version of the planned database. Entities are represented with rectangles and relationships with rhombuses (see text for more details).

EXAM has cardinality (1,1) towards EXAM, which means that every exam can have only one patient, and (1,n) towards PATIENT, which means that every patient can undergo to a great number (n) of exams. In this way, the proper cardinality number for all relationships was defined in the E-R model.

To satisfy cardiologists' requirements, a separate entity for every exam (physical examination, ECG, exercise test ECG, ECG Holter 24h, 24 h arterial pressure monitoring, transthoracic (TTE) and transesophageal (TEE) ecocardiography, stress-echo) and two entities to describe patient's clinical evaluation and therapies were implemented. Every entity contains a series of attributes, corresponding to all the information collected by the cardiologist during the relevant examination.

2.1. Data Entry

The user-interface has been planned to allow easy and user-friendly data entry, with separate masks relevant to different entities in the database.

For each different clinical examination, a graphical mask has been created to make intuitive the data entry process: together with free-insertion fields, other fields, which content has to be chosen among predetermined selections, have been implemented.

For CFR evaluation (see Figure 2, top left), separately for each coronary artery (LAD, RCA, LCX), the database allows the insertion of both conventional measurements (Coronary Flow Ratio, Diastolic Systolic/ Velocity Ratio) and new parameters such as systolic and diastolic flow integrals, mean velocity and durations, slope of the diastolic phase, diastolic absolute maximum and minimum of the first derivative, computed automatically by an external routine implemented in Matlab environment [7]. Moreover, the value of some parameters is automatically computed from the inserted values (i.e., CFR is obtained as the ratio between peak stress and control diastolic velocity).

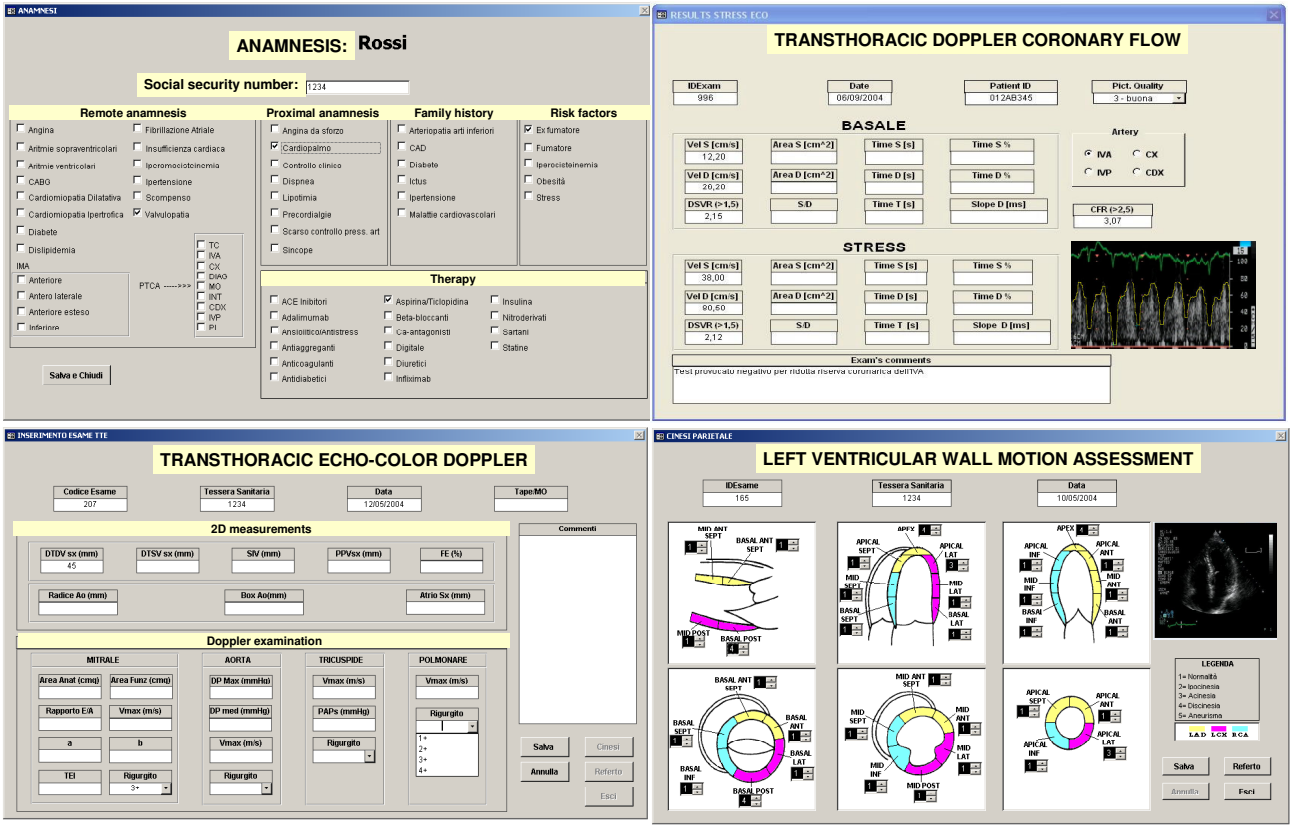

Figure 2. Specific masks for data-entry: general anamnesis (top-left), coronary flow reserve examination (top, right), thransthoracic 2D echo-color Doppler (bottom, left), left ventricular regional wall motion assessment (bottom, left)

If an echocardiographic evaluation has to be reported, a specific mask for the assessment of regional wall motion, has been implemented (see Figure 2, bottom left). It contains six conventional 2D echocardiographic views (apical 4- and 2-chamber, parasternal long-axis and parasternal short-axis at apical, papillary and base levels), where the operator has to set for each of the seventeen segments a value between 1 (normal) and 5 (aneurismatic), according to the Recommendations of the American Society of Echocardiography [8], to report the results of the left ventricular assessment of regional wall motion. As every segment is visualized in two different views, the operator have to insert the value only in one of them: the other is automatically copied in the corresponding box.

In the database, not only the insertion of numeric data has been implemented: up to four images or videos, relevant to the echocardiographic examination, can be uploaded to facilitate interpretation of clinical parameters.

Moreover, for every exam a comment window is available for free text insertion, to describe additional information, not previously assigned to other fields.

All the data inserted into a specific mask can be used to automatically generate the relevant report, by simply pressing a button, in which all the results and useful information for his clinical history are reported.

2.2. Data retrieval

Useful search criteria, based on the patient ID, patient population characteristics and on the results of specific examinations, have been implemented to facilitate data retrieval both for research and clinical purpose.

In particular, specific criteria for CFR values, selected coronary artery and image quality have been included (Figure 3).

In this way, it is possible to retrieve the record of a specific patient, as well as of all the available patients meeting the selected particular requirements.

The results of the research are made available in a separate Access window. A “Export to Excel” option is also available to facilitate further data processing and statistical analysis.

3. Discussion and conclusions

The availability of a single database integrating the information relevant to patient clinical history, ECG evaluation, 2D echocardiographic examination and

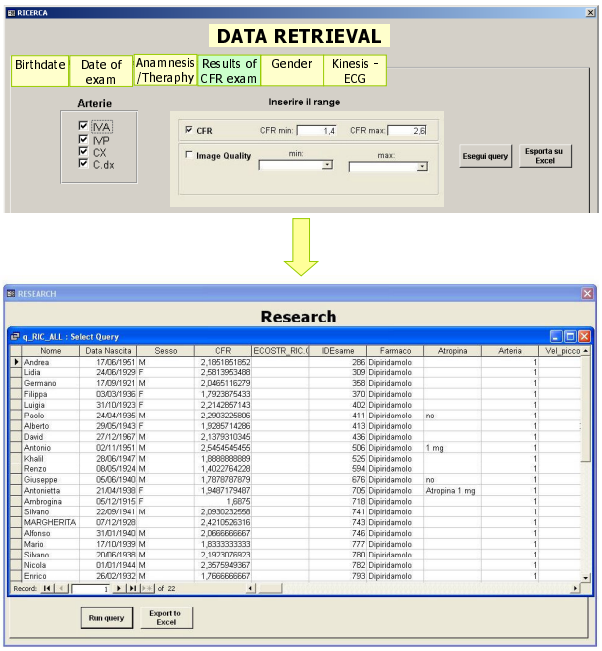

Figure 3. Data retrieval mask (top) and an example of the results of the research for the selected criteria (bottom).

Doppler coronary flow reserve test represents the basis for easy and complete access to all patient's clinical data.

Specific user-friendly masks for data insertion and retrieval have been designed with cardiologists support.

For CFR, even if not all the parameters included in the database are actually used for clinical purposes, the increasing interest in this kind of examination led us to presuppose their future importance in the diagnostic phase, and thus their inclusion.

The capability to store inside each patient's record both data and digital images allows immediate retrieving and visualization of the clinical examination.

The developed database is actually utilized in clinical practice by the Cardiology Unit of the Istituto Ortopedico Galeazzi in Milan, Italy.

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