

# On-Line Integration and Analysis of Cardiological Data to Support Medical Decision Making

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## Abstract

A web application was built to support cardiologist's medical decision-making. Main components are: 1. a 3D-dynamic virtual heart, integrating the single patient's cardiac and coronary abnormalities. 2. Estimation of patient's outcome on the basis of historical data analysis on the sub-population/s with the closest similarity to the patient's risk profile. 3. Same derived from published clinical controlled trials. 4 External web links to international guidelines, risk charts and epidemiological surveys. Each patient is characterized by over one-hundred parameters belonging to anamnesis, test results, final diagnosis, therapy and follow-up. Historical data were retrieved from the Institute's cardiology database--containing more than 11.000 patients hospitalized in the last 30 years and systematically followed up for 10 years-- and were graphically rendered. Cardiologists have expressed appreciation toward the project as it gives easy access to a wide range of data, precious for medical decision-making and important for research protocols and clinical and administrative patient management.

## 1. Introduction / aims

Medical decision-making results from the analysis and integration of data collected from the single patient and confronted with previous experience, results of evidence-based studies and guideline recommendations. The end product is a therapeutic strategy tailored according to the estimate of risk for future events based on knowledge of cohorts of patients with characteristics similar to those of the patient being evaluated.

Aim of this project was to develop an on-line system able to support the pacing of the medical decision making process through a web application.

## 2. Web application

The application was designed in a way to visualize, analyze and compare single patient's data with information on risk and outcome of a selected sub-

population. The basic idea was to develop a single environment providing multiple specialized views.

The medical decision pathway, from the pathogenetic interpretation of patient's data up to the risk stratification and the final strategic design, may be supported following an analogous path through the application's views (figure 1). The "patient view" provides tools for the integration and the visualization of the information of the single case. Risk stratification and consequent therapeutic planning is centrally based on assimilating the single patient to the belonging population or sub-population with a known risk-related outcome. Thus, in the "population view" and in the "risk-related outcome view" the single patient is confronted with the local historical experience on "analogous" patients—provided an adequate data bank is available— and/or with the outcome of populations included in published reports. In addition, the application provides the user with the risk tables and the guidelines of possible interest toward the final decision.

## 2.1. Architecture

The system was based on a client-server architecture. A rich web-client was developed using Flash Macromedia technology, which offers and combines sophisticated graphical solutions and an almost acceptable programmable environment. On the server side, Java services retrieve, pre-analyze and provide data from the cardiological database. The communication between client and server was based on XML.

The Institute's cardiology database contains more than 11.000 consecutive cardiac patients hospitalized in the last 30 years, each patient followed up for 10 years. More than one hundred parameters relative to anamnesis, test results, final diagnosis, therapy and follow-up events, characterize each patient.

Queries on populations could be burdensome because of the large number of records and tables involved. In order to reduce the cost of such operation, the system offers an offline procedure for creating and defining sub-populations. No constraint is adopted to limit the number and the complexity of the off-line definitions. By this

procedure, data of patients who belong to a certain sub-population are stored in a dedicated DB table. Thus the complexity of a multiparametric definition no longer weighs on the efficiency of population queries, while the cost is attributed to offline updating of populations. We opted not to abolish the on-line dynamic definition of new sub-populations, although we did strongly limit it.

## 2.2. Single patient (view)

The pathogenetic analysis of the single patient's data is the first step in medical decision-making. This process leads to a complete or incomplete, clear or conflictual "picture" of the patient.

The "single patient view" provides detailed patient data, a graphical 3D dynamic heart representation containing integrated information, and an area dedicated to the comparison between patient and historical population features.

The graphical synthesis was obtained by the "Lego Heart Model" [1]. Based on the integration of all the patient's data available, this representation allows the visualization of the left ventricle surrounded by the coronary arteries and completed by the left valves. Regional abnormalities such as necrosis, ischemia and reduced motility, left ventricle dimension and thickness, coronary lesions and revascularization interventions, pace-maker, valves alterations and ECG alterations are condensed in a single 3D dynamic picture. The integration of information also produces automatic weighted diagnosis of regional abnormalities and is able to unmask the presence of conflicting or lacking information.

On the basis of the patient's parameter profile assigned by the physician, the application opens a list of the pre-defined sub-populations to which the patient might belong. With this action the application discloses an interface, described in the following section, in which the patient's profile is graphically confronted with that of the sub-population under scrutiny; this in order to approximate the highest similarity between patient and selected sub-population.

## 2.3. Population (view)

A module called "Pop-Surf" was developed to provide an on-line and user-friendly interface supporting the analysis and the visualization of population characteristics.

An almost complete list of the parameters encountered in the database is shown. They are grouped in anamnestic, risk factors, prognostic indexes, diagnosis, therapy, instrumental tests, follow up events and pre-definite populations.

In order to tailor reference-sub-population on the

patient's profile, the user may test one of the pre-defined sub-populations or create sub-populations ex-novo according to a new combination of parameters. The parameter/s selection produces the request for a service who queries the data bases and return the data back to build the frequencies chart. During the selection a pie chart shows the fraction of the total population included (being the overall population the entire cohort of patients stored in the cardiological data base). The user may discard sub-populations with too few patients, and visualize charts relative to the frequency distribution of a single or coupled parameter/s. In addition, the user may limit the analysis to a particular time period and/or choose to consider the complementary population (all who do not belong to the selected population).

The client side of the application permit to elaborate the received data in order to offer different graphical representation of the single chart and/or to produce a new chart including all data series belonging to the last two. Chart data may be represented as absolute, relative and/or cumulative frequencies and may be visualized using different chart's formats as bars, lines, points, pie, etc. In order to provide a simple graphical synthesis of each series the "box and whiskers plot" representation was implemented.

DB's sources data, patient records with a limited number of fields, were also provided, for authorized users only, in the Microsoft Excel format.

## 2.4. Risk / outcome (view)

Aim of the "risk/outcome" view was to create a separate environment for risk evaluation in historical sub-populations. The patient's risk is estimated according to the outcome of a reference sub-population of "similar patients in a similar environment". This can be either one of the predefined sub-populations or a new one if "similarity" is judged inadequate. The risk-related outcome view is derived from the 10 year follow-up and the relative end-points which are cumulative and cardiac death, myocardial infarction, coronary revascularization.

## 2.5. External view

Medical decision making should take into account and be confronted with the information continuously provided by the scientific community.

By this forth view, the application offers a list of links to web addresses focused on the results of controlled clinical trials, established guidelines, risk charts and epidemiological surveys [2,5]. The challenge of this very simple module is the updating of the information relative to well defined topics.

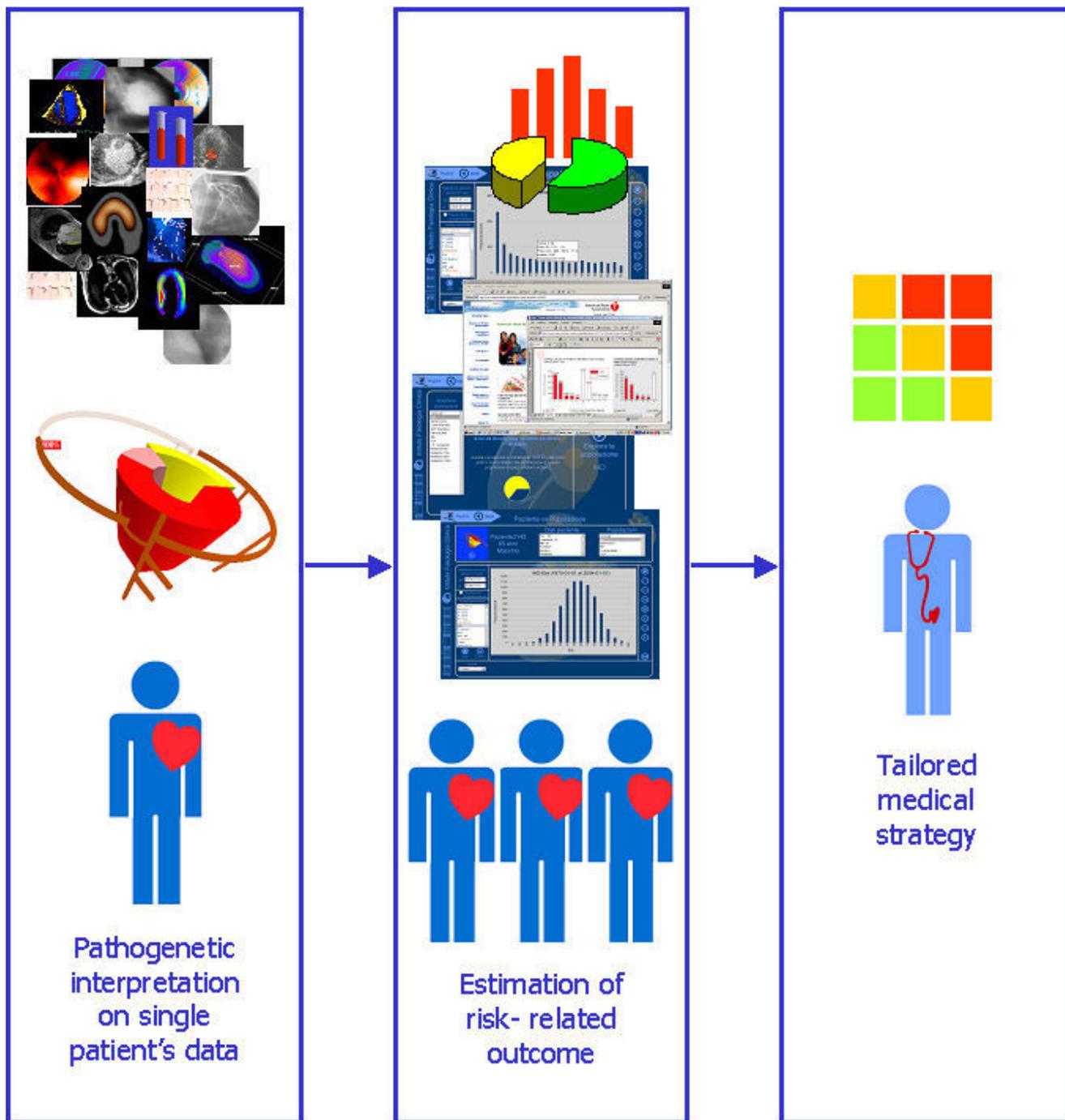


Figure 1. General view of the web application. Starting from the genetic diagnosis of the patient's heart abnormalities it moves to the risk stratification, based on historical experience and published evidence, up to the final personalized treatment strategy.

### 3. Discussion and conclusion

In order to support medical decision making, the application presented here provides a single easy access to both local and external data offering, through a friendly and smart interface, multiple views on single patient's profile, tailored population outcome, risk stratification and guidelines. The application allows to retrieve and explore a wide range of data on which the medical decision can be based although it does not impose any particular medical action.

The system is designed in a way to facilitate the introduction of new parameters, new populations and new views. The definition and the creation of new populations produce, as interesting side effect, an historical memory of the selected sub-population that could be monitored during following years at no additional cost. Definition of populations in a non-conventional way, such as according to outcome rather than to transversal characteristics might also be interesting.

Application upgrading foresees the implementation of additional views in order to enrich its analytical strength.

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