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Project of an Expert System Supporting Risk Stratification and Therapeutic Decision Making in Acute Coronary Syndromes

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The aim of the project was to create a computer program - expert system, which will support a doctor when a management for patients with acute coronary syndrome needs to be chosen. The expert system consists of four modules: knowledge base, previous cases database, inference engine and explanation module. Knowledge base was created with support of clinical experts, based on current management standards, guidelines and results of clinical trials according to evidence-based medicine rules. Data from new patient are added to the case database. Inference engine integrates two types of reasoning rule-based and case-based reasoning. Computer expert system gives unambiguous and objective answer. Recommendation given by an expert system can be reliable. At present the system is tested in clinical practice. Strategies recommended by the system are compared to the management applied in patients treated in Cardiology Clinic.

Introduction

Acute coronary syndromes (ACS) include acute coronary syndromes with ST-segment elevation and without persistent ST-segment elevation [3]. Both of them can lead to unstable angina or non-Q myocardial infarction or Q-wave myocardial infarction as a discharge diagnosis. Patients with acute coronary syndromes are subjected to a range of therapeutic alternatives. There are two main directions: early invasive strategy versus conservative therapy. The decision which therapy should be used for individual patients depends on clinical presentation, risk stratification and the estimated treatment benefits. Computer-based technologies such as expert systems (ES) can be helpful in diagnosis and therapeutic decision making in patients with presumed acute coronary syndrome [2]. Recommended strategy in ACS is shown in Figure 1.

ES are intelligent computer programs that use knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution. ES emulates the decision-making ability of a human expert. ES together with neural networks belong to artificial intelligence field.

Typical ES consists of three main components: knowledge base which contains the knowledge on the subject, inference engine which draws conclusions from the knowledge and explanation module [6]. Schema of components of ES is shown in Figure 2.

The aim of this paper is to present our very first experience with ES - a computer program, which will support a doctor when a therapy for patients with ACS needs to be chosen.

Methods

At first we analysed the need of presence and possibilities to take advantage of such computer program. Then we specified functions of the system and users' expectations.

Knowledge base was created with support of clinical experts, based on current management standards, guidelines and results of clinical trials according to evidence-based medicine rules. For the risk stratification in ACS without persistent ST-elevation we adopted TIMI Risk Score for Unstable Angina/Non-ST Elevation Myocardial Infarction which uses seven predictor variables: age 65 years old or older, at least three risk factors for coronary artery disease, prior coronary stenosis of 50% or more, ST-segment deviation on electrocardiogram at presentation, at least two anginal events in prior 24 hours, use of aspirin in prior seven days, and elevated cardiac markers [4]. For the risk stratification in ACS with persistent ST-elevation we adopted TIMI Risk Score for ST-Elevation Myocardial Infarction which uses eight predictor variables: age, history of hypertension or diabetes or angina, blood pressure, heart rate, Killip class, weight, anterior ST elevation or Left Bundle Branch Block in ECG, time to treatment [1].

Data from new patient are added to the case database due to key data elements and definitions for measuring the

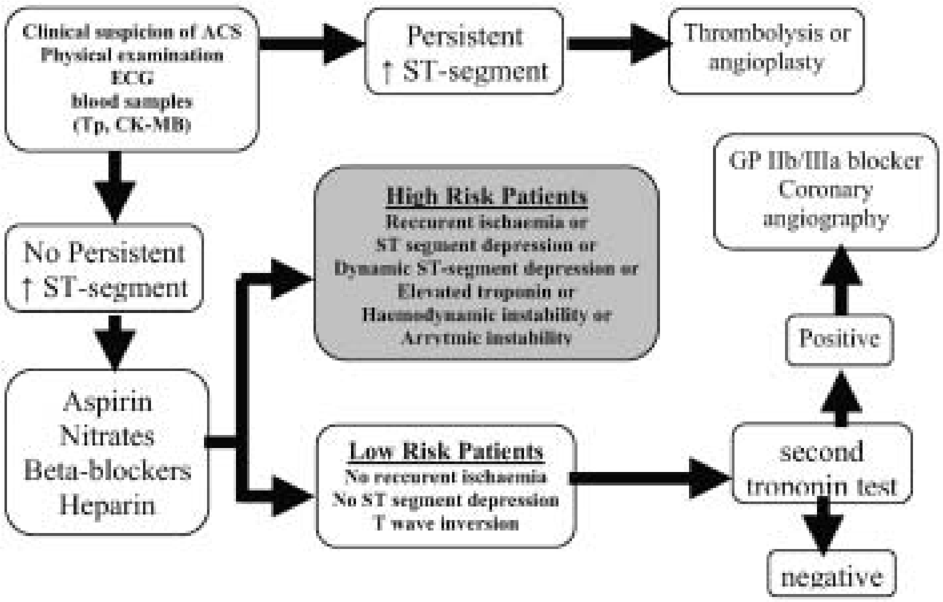

Fig. 1. Recommended strategy in Acute Coronary Syndrome (adapted from Braunwald et al, Europen Heart Journal 2000, 21, 1406-1432).

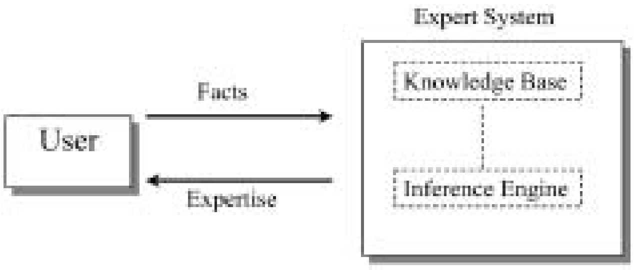

Fig. 2. Components of an Expert System.

clinical management and outcomes of patients with acute coronary syndromes [7]. Schema of dialogue between doctor and expert system is shown in Figure 3.

Inference engine integrates two types of reasoning: rule-based and case-based reasoning [6]. Rule-based programming is one of the most commonly used techniques for developing expert systems. In this programming paradigm, rules are used to represent heuristics, or "rules of thumb", which specify a set of actions to be performed for a given situation. A rule is composed of an *"if"* portion and a *"then"* portion. The *"if"* portion of a rule is a series of patterns which specify the facts (or data) which cause the rule to be applicable. The process of matching facts to patterns is called pattern matching. The expert system tool provides a mechanism, called the inference engine, which automatically matches facts against patterns and determines which rules are applicable. The "*if*" portion of a rule can actually be thought of as the condition. The "*then*" portion of a rule is the set of actions to be executed when the rule is applicable. The actions of applicable rules are executed when the inference engine is instructed to begin execution. The inference engine selects a rule and then the actions of the selected rule are executed (which may affect the list of applicable rules by adding or removing facts). The inference engine then selects another rule and executes its actions. This process continues until no applicable rules remain. Example of "*if-rule*" is presented below:

IF
conditions 1 (e.g. *high risk patient*)
are **TRUE**
THEN
action 1
(e.g. *invasive strategy recommended*)
ELSE
action 2 (e.g. *further stratification*)

As the programming environment we used CLIPS which is a productive development and delivery expert system tool, which provides a complete environment for the construction of rule and object based expert systems. CLIPS is being used by numerous users throughout the public and private community including: all NASA sites and branches of the military, numerous federal bureau, government contractors, universities, and many companies [5].

Results

Decision making procedure begins when the expert system receives information of a new patient, who appeared at the Admission Department. The following clinical factors are analysed: chest pain character, presence of risk factors, findings in physical examination, changes in electrocardiogram and the results of quick test for specific markers for cardiac damage such as: troponin, myoglobin and creatine kinase isoenzyme MB (CK-MB). Then the system suggests one of the following managements: early reperfusion, transport to cardiac intensive care unit, observation at chest pain unit.

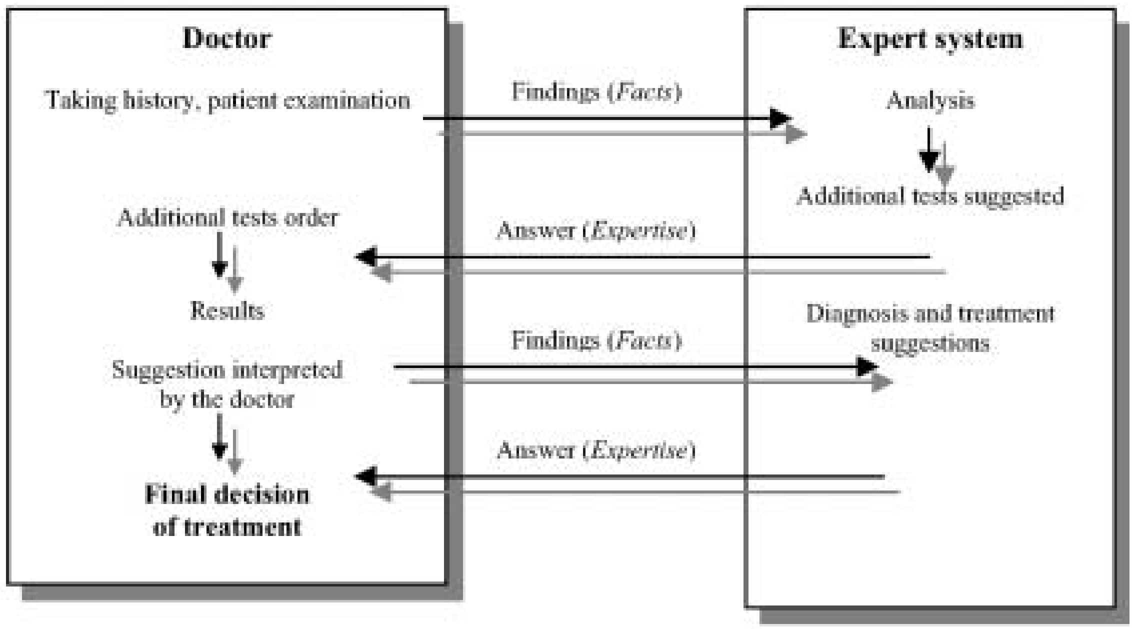

Fig. 3. Schema of dialogue between doctor and expert system.

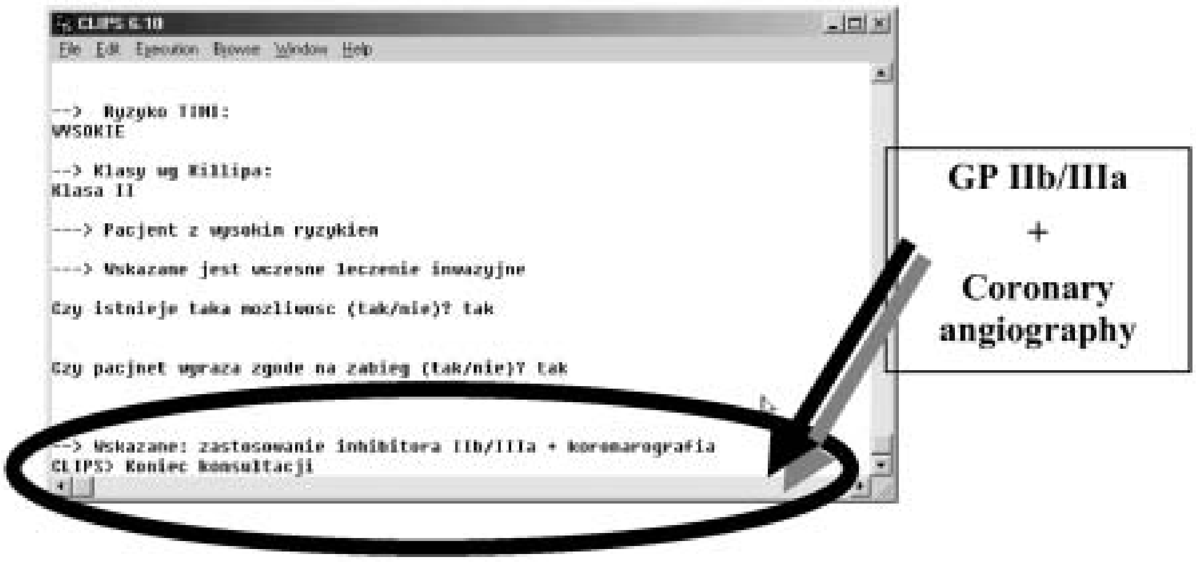

Fig. 4. Example of screenshot from consultation performed by our ES-final step. Data put from the real patient: 67 year old man; 3 anginal events in last 7 hours; risk factors: prior history of CAD, smoker, diabetic (oral treatment); ECG: ST depression in V4-V6, negative T waves V3-V5; positive troponin I test.

For the patient taken to cardiac intensive care unit risk stratification is performed. In patient with intermediate and high risk system recommends early invasive strategy: coronary angiography followed by angioplasty or coronary artery bypass grafting. In patient with low risk conservative treatment is proposed.

For the patients observed at chest pain unit check-up of electrocardiogram and markers in another three hours is ordered.

At each stage system analyses indication and contraindication for trombolysis and drug treatment and if it is advisable recommends usage of antiplated drugs (aspirin, thienopiridins, glycoprotein IIb/IIIa antagonists), heparin, morphine, beta-adrenolytics and nitrates. Example of screenshot from consultation performed by our ES is shown on Figure 4.

As the initial assessment of reliability of suggestions given by ES we used data from 147 patients with

ACS. In 127 (86%) patients ES suggested the same strategy as doctor did. No significant difference in outcomes both group of patients in 1-month follow-up was observed.

Discussion

Experience with use of expert systems in medical decision support shows that recommendation given by an expert system can be reliable. Computer expert system gives unambiguous and objective answer, doesn't get into a routine and once created can be used as many times, as needed. Knowledge base includes knowledge obtained from many experts. Contraindications for drugs were quite clear and could be put in knowledge-base of ES.

Usage of ES in cardiology, rapidly changing domain knowledge, can provide expertise to novice clinicians, and also ES can be used to train them. ES works faster than human expert, does not get tired, avoids delays when expertise is needed, is available at all time and records decision-making processes, actions, and outcomes.

Our program gives advises and suggestions to the user. Physician always makes the final decision of therapy.

Conclusion

At present the system is tested in clinical practice. Strategies recommended by the system are compared to management applied in patients treated in Cardiology Clinic.

Future plans include widening of knowledge base to make ES able to propose management in complications accompanying ACS, make access to ES via Internet, assess clinical reliability for answers given by system, connect to telecardiology system database and use case-based reasoning.

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