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A Preliminary Study of Expert System to Support a Patient's Decision in the Diagnosis of Selected Blood Circulatory and Respiratory Systems' Diseases

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Expert, data based and information systems developed for medical applications are usually meant for physicians who need them in making diagnoses, training and study processes. Several similar systems meant also for patients have been developed abroad. In Poland there are no expert systems that could be supportive for making a decision by the patient and adapted to the Polish conditions. Therefore, development of such a system has been pressed ahead, of which preliminary results are presented in the report. Certain features and characteristics of existing systems and needs of the Polish patient as well as advantages for the physician have been taken into account in the report. The preliminary development of the system has been limited to selected diseases of blood circulatory and respiratory systems, with consideration of apparent symptoms concerning these systems.

K e y w o r d s: expert systems, blood circulatory systems' diseases, respiratory systems' diseases, support patient's decision

1. Introduction

Most of the expert systems that have been developed for medical applications in the last 40 years are useful in teaching, training or research. In medical practice, when usually many people are waiting at the door of the surgery, the physician simply doesn't have enough time to apply the expert system. Moreover, usually after a short period most of the systems become of no use because the physician knows the final results generated by the system. Physicians become familiar with such systems, which enables them to easily predict the final results. This effect is well known also in other fields which apply expert systems, for instance technology, agriculture and

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so on. Nevertheless, most expert systems for medical applications are developed for physicians because of a conviction that the main aim of such systems should be to assist the physicians in the diagnostic process. There is also an additional problem to solve: if the diagnosis is based only on the expert system, in a short time the physician can lose the ability to give the right diagnosis. Therefore, the most useful area of the diagnostic expert system application appears in the period of the physicians' education.

In interactions between the patient and the physician, the patient has the weaker position because of the lack of appropriate education. But the patient must make a very important decision connected with his health. Figure 1 presents the route from the preliminary diagnosis to the final decision of the patient, who should be able to make a responsible decision on acceptance of the doctor's diagnosis and the recommended therapy. The patient's decision is influenced by many factors, including knowledge of the medical problem related to the state of his/her health, means to study appropriate medical cases in popular or scientific literature like books or papers, means to find information on the Internet, the opinion of family and friends and so on. The patient should accept the diagnosis and the form of treatment proposed by the physician. If not, he/she goes to another physician for further consultation and sometimes comes back to the same physician. For the reasons given above, an expert system to support the patient's decision is being developed. The system is called ELMECO — Electronic Medical Consultant — see Fig. 1.

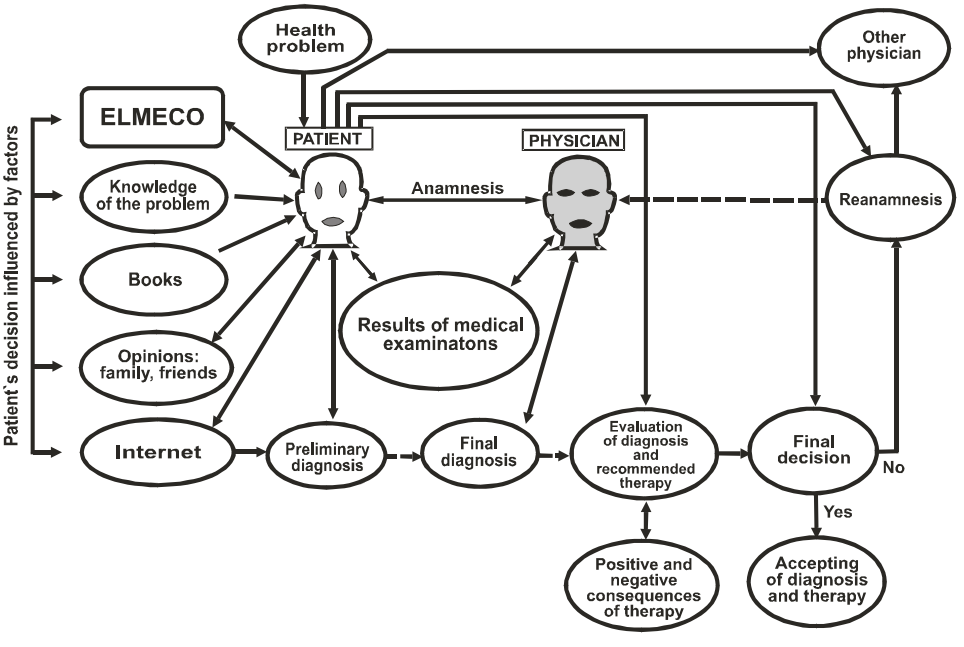

Fig. 1. The route from the preliminary diagnosis to the final decision of the patient. ELMECO — Electronic Medical Consultant — an expert system to support patient's decisions

In recent times some expert systems to support patient's and physician's decisions have been developed [1]. Access to these systems is possible via the Internet. These systems were dedicated to everybody [2], with special attention to travellers when they needed quick access to their medical data in order to be given a new diagnosis during their journeys. One such system [3] was based on [2] and it was developed for patients from countries in Africa or Asia, where medical centres were situated usually very far from settlements and access to the system via the Internet could help the patient in the process of receiving suitable medical aid. Special attention was given to the diagnosis of tropical diseases. Recently, the contents under some of the addresses has been changed [3] or the diagnostic possibilities have ended [4]. Therefore, the diagnosis of the patient via the Internet can sometimes be doubtful, however some systems are functioning. Access to the [5] is free of charge, whereas the others are commercial [2, 6, 7].

The commercial reason mentioned above can play an important role in many countries, including Poland, because the potential patient must pay monthly for access to the expert system and to the Internet. These additional payments do not allow avoiding payment for a typical health insurance, because personal contact between the patient and the physician is necessary in order to receive the correct diagnosis.

Existing expert medical systems for the patient are not adapted to the medical help system in Poland. That is why the ELMECO system is being developed [1, 9]. This system is developed according to the following rule:
"The final decision on the diagnosis and method of treatment belongs to the physician, but the final decision on the application of the treatment, consent for surgery or to the continuation of the management by the same physician belongs to the patient".

As a consequence of this rule, the patient before anamnesis carried out by the physician receives some amount of basic information on his/her medical problem from the system and can easier understand what the physician is talking about, he/she can put questions and finally can easier accept the diagnosis and the method of treatment proposed by the physician. The diagnosis obtained from the system can be supported by information from databases on the Internet like [8] or others and in this way the patient can be a partner for the physician and consumes less time than other patients that are not ready for anamnesis.

2. Method

2.1. A General Algorithm of a Patient's Activity in the Case of His/Her Health Problem

Basic information on general assumptions and particular solutions of the system are given in [1, 9] and they are based on information on the structure of expert systems and applicable rules given in [10, 11]. The system's simplified solutions given at the early stages of its development are presented below. This simplified system is called a model

of the system and is limited only to the diagnosis of selected diseases of the blood circulatory and respiratory systems — BC&RS. This model will be developed in the future and will include other diseases of the BC&RS and other organs of the human body.

Access to the model is based on the basic symptoms of the patient's disease and their location on/in the body of the patient. The model generates a series of questions connected with the basic symptom and its location. The patient answers them only *Yes* or *No* or in some cases he/she does not give an answer, because of a lack of information, for example no knowledge of the results of laboratory investigations. The lack of an answer is treated by the model as a positive answer in order not to forget about the possibility of an influence of additional symptoms on the differentiation of diseases. The main purpose of the system is the generation of information on possible diseases as a result of the analysis of symptoms given by the patient and laboratory investigations.

Table 1 presents the relations between the patient, the physician and the model of the ELMECO system. In the table are presented only possibilities of the model because of limitations made at the beginning of the system development [9]. The patient can choose the kind of access to the model and next he/she can follow the continuation of the algorithm.

Table 1. General algorithm of a patient's activity in the case of a health problem. Compare with Fig. 1. Underlined information indicates its further development in the algorithm. The rest of the explanations are given in the text

Relations between the patient, system and physician

1. ***Access to the system****: the diagnosis, control of the diagnosis, information, the Electronic Health Card (EHC), changes in the Medical Knowledge Base (access only for the administrator).*
2. ***EHC****: **EHC-ID** (the identification data of the patient), **EHC-DT** (history of the diseases and the treatment), **EHC-SD** (symptoms of the diseases), **EHC-RI** (results of the routine laboratory investigations → numbers), **EHC-SI** (results of the qualitative investigations → description, quantification).*
3. ***EHC-SD*** *(symptoms of the diseases): pain, rash, weakness…*
4. ***Location of the pain:*** *head, neck, chest, back etc.…*
5. ***Kind of the chest pain:*** *retrosternal pain, rib pain, clavicular pain etc...*
6. ***Generation of full information*** *on possible diseases connected with the retrosternal pain (17 diseases).*
7. ***Completion of the data in EHC-SD*** *or reading of the data from EHC-SD.*
8. ***The system's preliminary diagnosis****.*
9. ***Anamnesis****.*
10. ***The physician's preliminary diagnosis****.*
11. ***Routine laboratory analysis*** *(numbers): parameters of the blood, urine…*
12. ***Qualitative investigations****: ECG, effort ECG, RTG…→ quantification.*
13. ***Introduction of the results*** *of the investigations to EHC-SD.*
14. ***The system's secondary diagnosis****.*
15. ***Secondary anamnesis —*** *by the same or another physician.*
16. ***The physician's secondary diagnosis****.*
17. ***Repetitions*** *of pp. 11 — 16 until the final diagnosis is made.*

In the model of the system only some diseases of the BC&RS connected with symptoms of a retrosternal pain have been chosen for distinction and only two parts of the patient's electronic health card have been developed. The further explanations are given below.

2.2. Diseases Diagnosed by the Model

Some selected diseases connected with BC&RS have been chosen for distinction by the model at the early stages of the ELMECO system development. These diseases have a common indicator — a pain located in the chest that by the patient can be qualified as a retrosternal pain symptom (RPS) that should be connected with myocardial ischemia. But such a symptom can be caused by many other diseases and sometimes it is difficult to give a right diagnosis if it is based only on anamnesis without quantitative and qualitative investigations. A list of diseases that seem like RPS follows (based on [12–13] and the Internet):

1. Respiratory system's diseases: *inflammation, pleurisy, neoplastic tumors of the lungs, sarcoidosis*.
2. Diseases of organs in the chest and neck: *myocardial ischemia (angina pectoris, myocardial infarction, acute coronary insufficiency), pulmonary embolism, arteriovenous aneurysm, perioesophagitis, oesophagocele, hyperthyroidism*.
3. Diseases of the rib cage: *spondylarthrosis, rib fracture.*
4. Diseases of the abdominal cavity's organs: *cholecystolithiasis, pancreatitis, gastric ulcers*.
5. Diseases of the nervous system: *intercostals neuralgic pains.*
6. Psychogenic disorders: *depression*.

Underlined diseases mentioned above are recognized by the model. The rest of the diseases will be introduced to the model in the future. Sarcoidosis can be located in any organ of the human body. When it appears in the lungs, it can sometimes cause symptoms similar to the retrosternal pain. That is why it belongs here only to the respiratory system's diseases.

2.3. Electronic Health Card

The Electronic Health Card (EHC) is the card that belongs to the patient and it is just the opposite of the practice in Poland, where the health card belongs to the medical centre and to the physician. The EHC is composed of five parts:

1. EHC-ID — that stores the identification data of the patient,
2. EHC-DT — that stores the history of the diseases and the treatment,
3. EHC-SD — that stores the symptoms of the diseases,
4. EHC-RI — that stores the results of the routine laboratory investigations expressed in numbers,

5. EHC-SI — that stores the results of the specialized qualitative investigations presented as descriptions which are next transformed into logical values that allow to qualify the symptoms connected with these investigations as influencing or non-influencing the analyzed disease.

The underlined symbols of the parts indicate the ones used by the model. The rest of them will be developed in the future.

2.4. Diagnosis Generated by the System

Diagnosis of potential diseases with RPS is based on the analysis of answers to questions generated by the system. The nature of these questions depends on the basic symptom of the disease and on its place on/in the body of the patient. Each question and disease is encoded which allows for each operation with the codes. The codes are composed of the patient's answers, and they allow for the creation of two columns of the table *TABPAT,* where the first column corresponds to the code of questions and the second corresponds to the given answers, and where a positive answer corresponds to a logical value equal 1, whereas a negative one corresponds to a logical value equal 0. The lack of any answer is treated by the program as a positive answer in the way given below

$$TABPAT \quad \rightarrow \quad TABCOM \tag{1}$$

where *TABPAT* is a table created by the patient — it may not be completed (with blank places when the patient cannot answer any questions), and *TABCOM* is a table completed by the program — there are no blank places. So, we have

$$TABPAT = \begin{pmatrix} AaaAaa01 & 1 \\ AaaAaa02 & 0 \\ AaaAaa03 & \\ " & " \\ " & " \\ AaaAaaNO & 1 \end{pmatrix} \tag{2}$$

$$TABCOM = \begin{pmatrix} AaaAaa01 & 1 \\ AaaAaa02 & 0 \\ AaaAaa03 & 1 \\ " & " \\ " & " \\ AaaAaaNO & 1 \end{pmatrix} \tag{3}$$

where *AaaAaa* is the code of a question that corresponds to a given symptom of the disease and *NO* indicates the successive numbers of the questions. The transformation of *TABPAT* into *TABCOM* is based on the assumption that if the patient cannot answer the question, for example because of a lack of results of the laboratory investigations, the model should generate information about the possible influence of the answer on the identification of the disease, and this corresponds with the positive answer to the question.

TABCOM is divided into two parts, where the first corresponds to important questions and the second to optional ones. The inference method is based on calculations of special indicators that characterise *TABCOM* and indicate the numbers of positive and negative answers given by the patient. Minimal values of these indicators are characteristic for each disease separately and they allow to diagnose the right disease and eliminate diseases that do not generate RPS. If the patient, in accord with the basic symptom, for example RPS, does not give any answers to questions generated by the system, he/she receives information about all possible diseases that can cause real or apparent RPS symptoms, i.e. 6 diseases in the case of the model BC&RS or 17 diseases in the future, after further development of the model. Each positive or negative answer to a question can eliminate a given disease from the set diseases causing RPS.

3. Results

The model of the BC&RS plays the role of a subsystem for the ELMECO system and it has been developed instead of the full system in order to concentrate efforts on the basic functions of the system. The general and detailed projects of the model, selected diseases of the BC&RS and appropriate questions that allow giving the diagnosis have been elaborated. The functioning of the model is based on the main symptom of the patient's disease that causes the generation of the list of questions connected with additional symptoms of the disease. The answers to the questions are placed in the Electronic Health Card in the part concerning the symptoms of the disease — *EHC-SD*. The other part of the card called identification data — *EHC-ID* has been also elaborated. The inference in the model is based on analysis of the data given in *EHC-SD*, in the way given above. The newest report [14] also developed an idea of an electronic card for the patient as a support system in diagnosis and statistics.

The problem of the language used in the model is not crucial at the early stages of the system development. The model is developing in Delphi-6 and it is sufficient to check the whole basic functions of the model. The language of the final version of the system will be chosen in the next stage of the system's development. A similar approach was presented in [15], where the model of the system for diagnosis and treatment in urology was built and it was based on Pascal.

4. Conclusion

As follows from the analysis and projects of ELMECO given in [9] and presented shortly above, there is a need to develop an expert system that should help the patient in making the decision in the case of his/her health problem. The patient often doesn't understand what the physician is talking about but he/she must make an important decision connected with his/her health and the consequences of accepting or not accepting the physician's diagnosis and recommended therapy. Because tasks put before ELMECO are very vast, the system's possibilities have been limited only to the diagnosis of selected diseases of the BC&RS at the early stages of the development of the system. This simplified version has been called the model of the system. This model will be developed by increasing the amount of diseases recognised by the model and by increasing output products generated by the model until the full version of ELMECO will be built.

As follows from contacts with the physicians, the presented idea of the system causes some controversy. Part of the physicians are satisfied with the development of such a system, whereas others are against. This paper should help in the better understanding of the problem. During typical anamnesis, the patient is stressed and can easily forget about important additional symptoms of the disease, but he/she expects the correct diagnosis. The model's or system's development is based on the relations between the patient and the physician in accord with the rule given in the Introduction. These relations during the anamnesis create some kind of a positive feedback. The more adequate information the doctor receives, the better chance the patient has of receiving the appropriate diagnosis and the method of therapy. ELMECO will be applied by the patient before the anamnesis and that is why it can be of help to the patient and also to the physician.

A huge number of different diagnostic systems published recently and dedicated to the patient indicate that in the patient-physician relation the former needs real help and that such systems can be supportive in the patient's treatment (see for example [16-20]). This trend of development does not stop the development of new diagnostic systems for physicians (see for example [21, 22] and many others), while both directions of expert systems development support the diagnostic process.

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