Expert System for the Diagnosis and Treatment of Preeclampsia

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Abstract: - In this paper we present an Expert System for the Diagnosis and Treatment of Preeclampsia (ESPRE), a ruled-based medical expert system that supports diagnostic and therapeutic decisions in the realm of this disease and that is being used for training physicians. ESPRE applies pragmatic criteria for classifying, diagnosing, and treating preeclampsia. This system can guide the user to collect patient information easily, and based on those items of information that leads to the possible diagnose and treatment of preeclampsia. ESPRE has been deployed at Hospital Universitario de Los Andes, a large tertiary-care teaching hospital in Mérida, Venezuela, since June 1998. We describe the expert system design, and a predeployment performance evaluation. The features of ESPRE are presented, and the possibilities and limitations of its use as well as that of expert systems in general are discussed. Systems such as ESPRE require careful evaluation and, if proven effective and accurate, present to practitioners a new tool for delivering high-quality and individually adapted health care.   IMACS/IEEE CSCC'99 Proceedings, Pages:5141-5144

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1   Introduction

An expert system is computer software that employs knowledge captured in a computer program to solve difficult problems that usually require human expertise. Well-designed expert systems (ES) imitate the reasoning process experts use to solve specific problems and can be used by nonexperts to improve their problem-solving capabilities and by experts as knowledgeable assistants. ES also can maintain scarce knowledge resources and produce consistent results. [1]

An human "expert" collects plenty information dealing with his working domain and this information may not be found in books or are not well known or understood. ES concentrates information given by an human expert in order to replace him when his knowledge is needed in many places at the same time or when he is not available. ES are application tools based on logic and containing a wide knowledge in a specific field; their aim is the simulation of an expert's behavior in reasoning and making decisions inherent a small cultural domain. They are capable of performing at or near to the level of an expert. [2-11]

Artificial intelligence includes Knowledge Based Systems [2-4], which recopilates information about a subject; and if that information is given by human experts it is call «Expert System» [5-6]. A medical knowledge base contains nosological descriptions of diseases.

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in general are discussed.

The paper is organised as follows: in section 2, an introduction of expert systems is presented including some remarks of their utilisation in medicine, in section 3 we show a brief scope and magnitude of the impact of preeclampsia, we describe ESPRE in section 4, and finally in section 5 we mention some concluding remarks.

2 EXPERT SYSTEMS (ES)

ES were first developed by computer scientists in the mid-1960s. This period of research on artificial intelligence was dominated by a belief that the coupling of powerful computers and reasoning laws would enable superhuman performance in solving any problem. Many computer programs generated with such high expectations, however, did not fulfill their inventors' dreams. The evolution from general-purpose to special-purpose expert systems occurred with the development of DENDRAL by Feigenbaum at Stanford University. DENDRAL was designed to infer the molecular structures of unknown compounds from mass spectral and nuclear magnetic response data. This system used a procedural code to systematically enumerate all the possible molecular structures and then used chemical data to prune this list to a manageable size. DENDRAL was followed by MYCIN, a rule-based system developed by Shortliffe, also at Stanford University. MYCIN was designed to assist clinicians in diagnosing bacterial infections for patient management during the critical 24- to 48-hour period after symptoms manifested. Both DENTRAL and MYCIN performed well, at least at the level of human experts. [1-6] Since the mid-1970s, many expert systems have found commercial applications. Many ES for medicine and engineering were developed after that.

Structurally, ES usually comprise a knowledge-base, an inference engine and an interface with the user. The knowledge-base contains the raw material of the expert system; the rules and facts representing the expertise. The inference engine is a computer program which attempts to resolve the user's enquiries by operating on and interacting with the knowledge-base. Finally, the interface with the user serves two purposes: first, to make the system relatively easy to use and second, and very importantly, to provide an explanation and justification for the results, advice and suggestions obtained from using the system. There will be other parts to an ES which are used to refine and modify the knowledge-base. [2-6]

2.1 Expert Systems in Medicine

Since the 80's, ES have been widely used for applications in medicine and radiology and they are numerous and constantly increasing [2,4]. ES in medicine are knowledge data bases founded on patient data, literature searches and opinions of experts. With these systems it is for instance possible to test or to take clinical decisions. These systems are, among other uses, employed for quality assurance and documentation, as a teaching instrument as well as a knowledge base. The possibility of their use in the application of diagnostic and staging protocols seems particularly interesting. ES will enable specialist expertise (a rare commodity) to be available to non-specialists such as general practitioners. The development and commercial availability of ES programming tools (called shells) make it certainly easier to develop consultations systems, even to non-experienced users.

Many professions including medicine have standard operating procedures for the performance of their tasks. In the construction of ES, knowledge engineers have exploited this fact in devising heuristic rules that mimic the standard practice among such personnel (i.e., experts). Much medical knowledge is heuristic in nature; for example, an experienced doctor might use a rule in diagnosis such as: «If symptoms A and B are observed then C is plausible but certainly not D».

3 THE SCOPE AND MAGNITUDE OF THE IMPACT OF PREECLAMPSIA

Why did we choose preeclampsia as a good candidate to make an expert system?.

Preeclampsia, a hypertensive disorder of pregnancy characterized by vasospam and coagulation abnormalities, is a leading cause of maternal, fetal and neonatal morbidity and mortality, especially in underdeveloped countries (12). Thus its prevention would have a significant impact on maternal and perinatal outcome worldwide. Preeclampsia is associated with increased risk of abruptio placentae, eclampsia, disseminated intravascular coagulation, acute renal failure, HELLP syndrome and cerebral hemorrhage, intrauterine growth retardation, preterm birth, and perinatal mortality (12,13). The incidence of this condition is generally given as 3% to 13% of all deliveries(12,13) and 10% to 20 % among

nulliparous women(12). High-risk factors for preeclampsia include: nuliparity, previous preeclampsia, obesity, hypertension, less than 20 years old, diabetes, nephropathy, mean arterial presion above of 85 mmHg., black race, family history of hypertension or preeclampsia, twin pregnancy, and poor socioeconomical conditions. 30 to 50% of preeclamptic women require cesarean. In our hospital more than 3000 bed days are used to treat these patients (8 beds daily). Approximately 100% of preeclamptic women are limited in their activities.

Although this disease is very easy to diagnose and treat we have experience much trouble in classifying women at risk for preeclampsia, treating them with the preventive treatment, diagnosing and treating the disease among physicians at the Program for Preventing Preeclampsia. We have experience a very low accuracy in following the instructions of this program so we decided to create ESPRE to offer a better medical assistance while training physicians.

The initial goal of the clinician is to diagnose accurately and provide timely therapy while avoiding excessive diagnostic testing and unnecessary treatment. All pregnant women should be evaluated in a uniform, logical manner with a thorough history, a comprehensive physical examination, and appropriate laboratory testing. With such an approach and an adequate diagnosis can be made in all patients. A logical approach to the evaluation of pregnant women is used in ESPRE. A paramount objective during the initial encounter is to determine whether the condition requires additional evaluation or immediate therapy. Information derived from the patient's symptoms and signs allows the clinician to narrow the diagnostic considerations and assess the need for immediate diagnostic testing, therapeutic intervention, or continued observation over a period of time.

4 EXPERT SYSTEM FOR THE DIAGNOSIS AND TREATMENT OF PREECLAMPSIA

Our laboratory is responsible for development and maintenance of ESPRE, a ruled-based medical expert system that supports diagnostic and therapeutic decisions in the realm of preeclampsia. ESPRE includes the classification of women at risk, diagnosis and treatment of this disease. It comprises a selected and commented up-to-date review of the literature.

This system can guide the user to collect patient information easily, and based on those items of information that leads to the possible diagnose and treatment of this disease. It guides the user about the medical examination to be done on the patient, showing some definitions, images, sounds and videos of the signs associated with preeclampsia, and verificates that the physician does not forget any of the diagnostic criteria even if it is the first time that he/she sees such sign. Given patient data, diagnostic decisions are made on the basis of the medical knowledge stored. Data (i.e., symptoms, signs, laboratory results) are processed by the system using defined rules to obtain a set of differential diagnoses. Additional data, such as the presence or absence of certain clinical signs and symptoms, aid in making a final diagnosis. The rules in the current version of this expert system include the diagnostic criteria for all hypertensive disorders of pregnancy. Reasonings for the established diagnoses or diagnostic hypotheses are presented as well as plans for further examinations and treatment on the patient. Unexplained symptoms, signs or test results are also indicated. The system also allows the user to compare his/her description with that of the expert.

Unique features include the customizing of questions for each subject and the selection of information to be acquired, both based on answers to previous questions. Recommendations are highly person specific.

Most decision-support systems in medicine have been developed in hospital environments, but only few are designed for being used by general practitioners. ESPRE can be used by any general or specialised physician even without any knowledge about this diseases. It provides assistance in defining the diagnosis and therapy relying on diagnose, gravity, physiopathological conditions, and discriminates if other coexistent diseases and/or drugs taken by the patient could interact with management. It warns the physician about the possible interactions of the considered therapy. In case of contraindications, the system suggests another alternative therapy. It also advises about the control tests to follow-up the diagnose and the prescribed therapy, and about the indicated hygienic-dietetic suggestions.

It is useful as a teaching tool for students, residents and staff. ESPRE is being developed to support independent learning and decision making regarding the diagnosis of preeclampsia while physicians are actively engaged in clinical practice. ESPRE combines the facilities of a traditional expert system for clinical diagnosis with several modules designed

for educational purposes.

ESPRE was written in the Visual Basic® programming language, runs on IBM-compatible personal computers. The hardware environment is PC/ 386, or up with multimedia kit and super-VGA monitor. Requires Windows 3.1 or up.

The usefulness of ESPRE is demonstrated in various case study involving 500 patients and patient case records with various different diseases during the period of June 1998 through January 1999 and analyzed by a specialist.

5 CONCLUSIONS

We have proposed an user-friendly expert system that is a potential tool for computer-assisted diagnosis of preeclampsia. Systems such as ESPRE require careful evaluation and, if proven effective and accurate, present to practitioners a new tool for delivering high-quality and individually adapted health care.

At present this expert system in being used for medical training of general practitioners that assist pregnant women.

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