Medical Information and Decision Supporting Computer System

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Abstract:- The paper presents new concepts of cooperating computer medical information systems: the control of dialysis and decision supporting system (CDDS), and the Integrated Information System (IIS) which uses information produced by one or several CDDS-systems. The main computer technology used is component or object oriented modeling and programming applied to implementation of control algorithm, modeling of dynamic dialysis processes, multimedia data-base and decision supporting unit.

Key-Words: - Medical information systems, optimal control, decision supporting system, modeling of hemodialysis process, modeling of information systems, dialysis' adequacy. CSCC'99 Proceedings, Pages:3361-3365

1 Introduction

To be of real usefulness, medical information systems cannot avoid considerable complexity. The reasons for that complexity are numerous: multimedia nature of data (numerical data, text, pictures, graphics, sounds, etc.), databases of distributed character (external and internal laboratories, databases of medicaments or transplants, previous hospitalizations), knowledge that does not easily submit to mathematical formalism. On the other hand, the need for support assured by information technology is increasing. To manage the complexity of medical tasks of the present time, the modern "soft-technology" is pressingly asked to help.

In this paper the control of dialysis and decision support (CDDS) of physicians is in focus of attention. The system realizing these tasks has been described and its role in the more general Information System has been pointed out.

2 Medical background

Kidneys are part of urinary system. The basic activity of kidneys is producing and dismissing of urine which consists mainly of water and substances dissolved in it. Due to its dismissive function, kidney contributes to the maintainance of stable capacity and appropriate ingrediency of intraconstitutional liquids. The constancy of this internal environment is an indispensable condition for regular functioning of cells, tissues and organs of a human organism. Thanks to kidneys, dehydration or overhydration of organism is prevented. Kidneys regulate also the ingrediency of constitutional liquids.

Dialysis centres deal with treating people whose kidneys do not act properly, which means that they do not regulate the capacity or the ingrediency of the intraconstitutional liquids. In result, their organisms are being distroyed by toxins, urea and other substances superfluous to organism.

Actually, treatment of incapacity of kidneys is rather more of maintaining lives of patients than of liquidating reasons. It consists in replacing the work of natural kidneys with interventions called dialysis. Dialysis is an intervention simulating the work of a natural kidney. Intraconstitutional and metabolic activities still remain handicapped or there is an absolute lack of such activities. Dialysis is the only form of maintaining an ill man alive. It gives him the possibility of awaiting kidney transplantation. At present, in medicine two kinds of dialysis are applied: hemodialysis and peritoneum dialysis. Here the hemodialysis is of particular interest. Hemodialysis is a way of clearing blood of substances toxical for organism (urea toxins, urinary acid, creatinin, urea), dismissing excess of water and providing substances necessary for functioning to regenerate the intraconstitutional environment. During dialysis, blood clearing takes place beyond human organism and is carried out with the help of a device called artificial kidney.

Rehabilitation, quality, and efficiency of the dialysis interventions, and accessibility of services within this domain is an important problem in health care. Appropriate dosage of dialysis intervention causes optimalization of use of apparatus and financial means, as well as maximal prolongation of the lives of ill people who are object to treatment.

Hemodialysis, as every medical treatment, should be individualized, i.e. performed relevant, to the needs of every patient. Only in this way the dialysis can be optimal from medical and patient point of view, and due to the optimal use of the apparatus the cost can be significantly reduced [1].

3 CDDS System

The task of the system supporting the work of dialysis department is gathering and making accessible information about the patients, the medical staff, the courses of individual dialysis processes, the apparatus and the medical materials gathered at the department. On the basis of this information, the system supports estimation of the health condition of a patient and help to determine an individual course of the next dialysis for each patient. The system registers patients with protracted incapacity of kidneys and supports the decision of a doctor about accepting or rejecting a patient for dialysis in given centre. The system supports also the care of the doctors over patients after kidneys transplantation. An important part of the CDDS system are the modules of the data protection and of communication among the kidney transplantation centres – the IIS system. The basic task of the cooperation between the two systems is to support decisions and provide effective communication, which aims at bringing about the intervention of the kidneys transplantation, and taking care about a patient after the transplantation is executed.

Development of intranet technologies, distributed databases and algorithms of machine – intelligence create new possibilities of supporting and automation of work in spheres demanding great experience, knowledge and intellect, one of which is medicine as well. Dialysis departments should be computerized because of their specific form of the patient's contact – three times a week for a few hours.

3.1 Information flow

The doctors at the dialysis department perform internistic care over the patients with kidney incapacity and over the patients after kidneys' transplantation. To this end, they gather information about the patients and the results of clinical and laboratory research (Fig. 1). Each patient's file contains information on his illness history, his health condition, and includes precise data describing the dialysesalready performed. Information about the condition of a patient serves for estimation of his health condition and adequacy of the dialysis processes. On this basis the doctor, supported by a decision system, can determine an optimal algorithm for individual dialysis process for each patient.

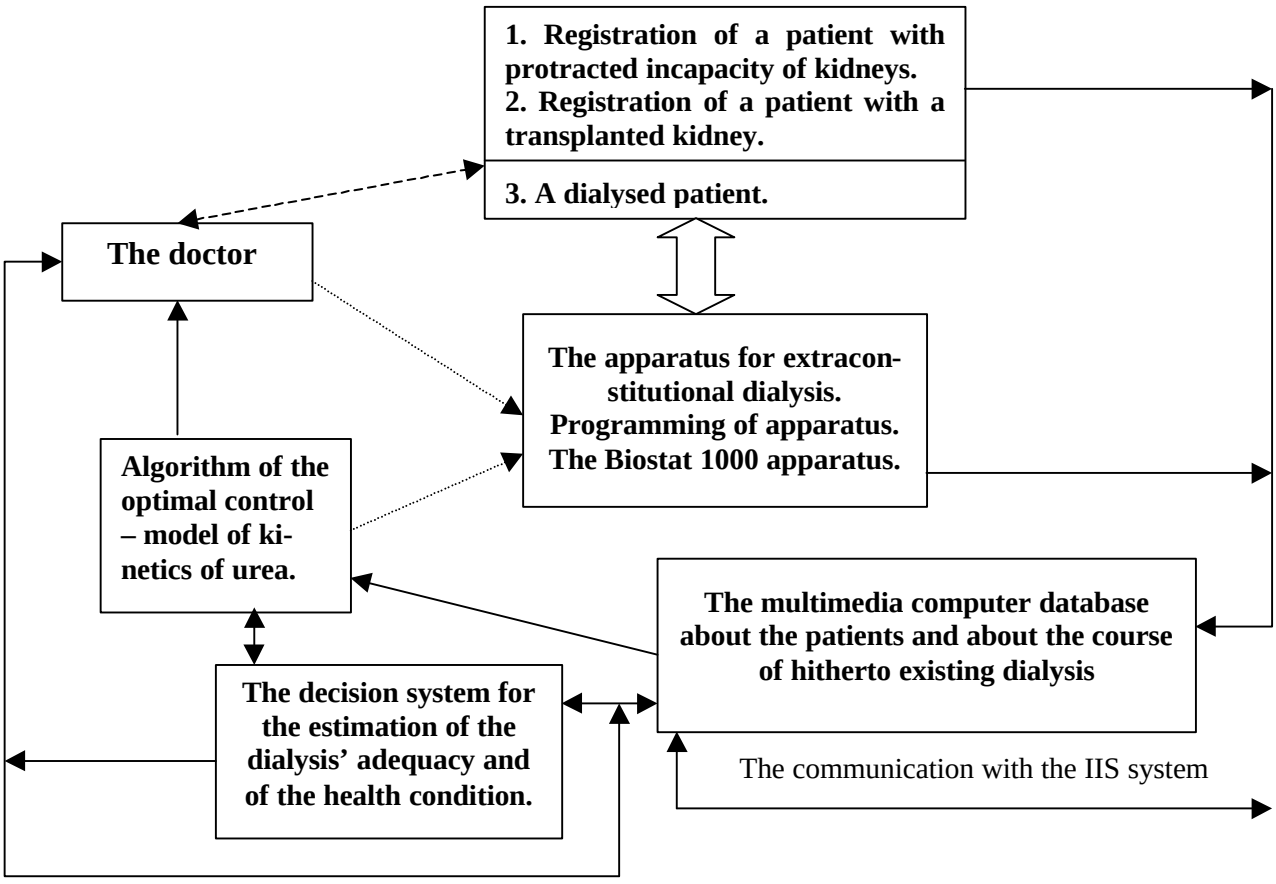

Fig 1. Control of dialysis and decision supporting system (CDDS)

3.2 Tasks and design of the system units

The basic part of the system is a distributed database with information described in multimedia form (X – rays, the examination results in the form of graphs, diagrams and descriptions in the form of sound files). The optimal control of the dialysis process is based on the

clinical knowledge given in the form of rules used for concluding about the health condition of a patient.

Apart from the clinical methods, dialysis estimation employs also parametrical methods based on mathematical modelling of urea kinetics of the dialized patient [5]. There are two basic groups of techniques of such modelling: the first – direct, estimating urea dismissing with the dialysis liquid; the second – based on the indirect determinations on the basis of the changes of urea concentration in the patient's serum. The direct methods are of one section or of two sections – those regarding fast increase in urea concentration in serum immediately after the dialysis. The elaborated twosection model is verified on the basis of the method of direct determination of the amount of urea dismissed in the dialysis liquid. In our research it is possible to improve the accuracy of the identified mathematical model by performing the research not only during one dialysis in a weektime (f.e. in the middle of the week), but by gathering the information during all three dialyses performed in a weektime [3]. It is possible due to the use of the method of the direct determination of urea in the dismissed dialysis liquid, which is not connected with the necessity of receiving blood from the dialysed patients. Progress in the field of mathematical identification methods and modelling as well as the computer algorithms from the scope of machine intelligence, is presently giving a chance for a new, unconventional approach to solving the problem of estimation of dialysis' adequacy.

Another part of the decision system supports also the care over the patients after kidney transplantation and it supports the doctor's decision about accepting or rejecting the patient's request to enrol him on the list of patients dialysed in the given centre. This is an extremely responsible task, since protracted incapacity of kidneys and the lack of possibility of dialysing the patient can lead to his death.

4. Integrated Information System

Apart from the optimization and the estimation of adequacy of the dialysis process, another method to increase the possibilities of dializing a greater number of people with protracted incapacity of kidneys is to increase the number kidney transplantations. The time from the moment of the donor's death to the kidney transplantation cannot exceed several hours. Because of the number of examinations which are due to be done in the immunological laboratory on the donor's organ and because of the different time of the day when the donor's death might occur, this time must be used at the optimum level. The scattering of intensive therapy departments, dialysis departments and the place of residence of the person being subjected to transplantation puts forward the problem of speed of information flow and decision taking. All these factors advocate the introduction of computer support and the computer integration of actions of all the subjects taking part in preparing the dialized patients, the departments of intensive

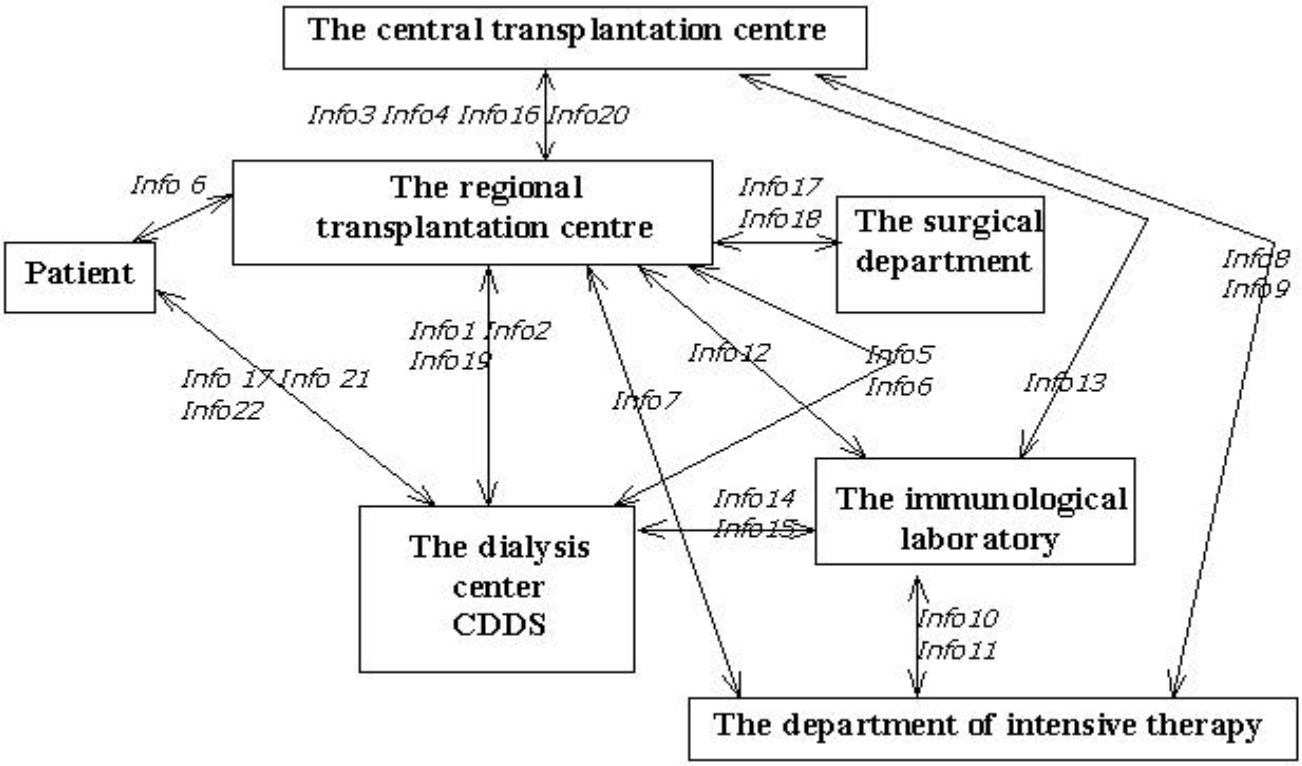

Fig. 2. Integrated Information System

therapy and the teams of doctors participating in kidney transplantation.
The basic knowledge that should be described in the IIS system concerns cases of use of the system by various users, the flow of information inside and among the centres. Figure 2 represents the diagram modelling the flow of information among the departments discussed. The tasks in which the designed system takes part include among the others:

Info 1 – Creating of a new object of *Patient* type and locating it in the object of *The list of patients* type. This object is sent from the dialysis centre to the regional centre, where it is located in the object of *The regional list patients* type.
Info 2 – Periodical up-dating of the information about every ill person from the list of patient of the given dialysis centre. These data update the data concerning a suitable subset of the patients from the regional list.
Info 3 – Sending of the object of *Patient* type to the main centre of transplantation, where it is located in the object: *The central list of the patients.*
Info 4 – Periodical up-dating of the information about every ill person from the regional list of the given regional centre. These data update the data concerning a suitable subset of the patients from the central list.
Info 5 – Sending a demand for sending a patient from the given dialysis centre to the transplantation centre for the purpose of performing of kidney transplantation.
Info 6 – Sending a patient together with his history of the illness to the transplantation centre.
Info 7 – Sending the information about the donor of the organ from the department of intensive therapy to the regional transplantation centre.
Info 8 – Sending the information about the donor of the organ from the department of intensive therapy to the main transplantation centre.
Info 9 – The information telling whether the donor had reserved the right to not receiving his organs.
Info 10 – Sending of the samples of organs for the immunological examination.
Info 11 – Sending of the results of the immunological examination from the immunological laboratory to the department of intensive therapy.
Info 12 – Sending of the results of the immunological examination from the immunological laboratory to the regional transplantation centre.
Info 13 – Sending of the results of the immunological examination from the immunological laboratory to the main transplantation centre.
Info 14 – sending of the dialized patient for the examination in immunological laboratory.
Info 15 – Sending of the results of the immunological examination to everyone.
Info 16 – Communication between the regional centres and the main centre regarding the best person to be subjected to transplantation. It is always an ill person from the central list.
Info 17 – Sending of the ill from the regional centre on the operation to the surgical department.
Info 18 – The return of a patient after the operation from the surgical department for the regional transplantation centre. The results of post – operation examination of the given patient are also sent.
Info 19 – In the case of death of the patient – sending of the information from the dialysis centre to the regional centre.
Info 20 – In the case of death of the patient – sending of the information from the regional centre to the main centre about the removal of the patient from the central list.
Info 21 – Rejection or acceptance of the patient for the dialysis.
Info 22 – Registration of the patient after of the kidney transplantation.

According to the state-of-the-art designing and to the demands imposed by the clients, the project of the system allows performing of changes in its structure. To assure the velocity of the changes performed, a method of information system modelling based on the language of modelling UML as well as on the methods of Jacobson, et al. has been used [2], [4], [7], [9]. At the stage of specification of the clients' needs, hypertext documents and various forms of diagrams have been applied.

5 Conclusion

The research performed aims at creating a new generation of computer systems using the latest achievements of medicine, health care over the patient, rehabilitation of the dialized persons and of the persons after transplantations, as well as intelligent computer systems.

The range and the aims of the scientific and development research cover:

1. the research in health rehabilitation, as well as in psychological and social ones, the improvement of the quality of life, increase in the acceptance of the treatment performed and creation the possibility to return to the professional activity of dialized persons and of the persons after kidney transplantation (handicapped people);
2. the research in the epidemilogy of the chronic incapacity of kidneys;
3. the estimation of the life quality of the patients dialized or after kidney transplantation;
4. the improvement of the quality and efficiency of the dialysis services, the investigation of the influence of the quality of dialysis services on the patients' survival;
5. computer modelling of the biochemical blood changes in the dialysed patient;
6. minimization of the dialysis coasts and increase of their accessibility;

7. the estimation of efficiency of the treatment with the kidneys transplantation method;
8. comparison of the costs of the treatment of extreme incapacity of kidneys with the hemodialysis and kidney transplantation methods;
9. computer, intelligent methods of information filtration and knowledge acquisition of intelligent computer algorithms and intelligent multiagent environments.

The range of the implementation works – the products and the technologies:

1) Complex information system for the centres of dialysis and kidney transplantation centres.
2) Complex information system integrating the centres of dialysis and kidneys transplantation.
3) Computer models of the processes occurring in the dialized person's organism.
4) Efficiency estimation methods of effectivity for hemodialysis processes and of the kidney transplantations.
5) The knowledge and scientific information base for postgraduate education of doctors, nurses and technicians for dialysis and kidneys transplantation centres.
6) Information service about the Polish and foreign scientific research in dialysis and kidney transplantations for the needs of the dialysis centres (the transfer of technology).
7) Supporting diagnosing, therapy and transplantology.

The above work presents an essential part of the reaized system.

Acknowledgement
This research has been partly supported within a grant from no. I1/22/98/G the City of Lodz Office, Poland.

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