GLOBAL COMPUTER MODEL OF ORGANISM FOR DECISION MAKING SUPPORT IN TELEMEDICINE

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KEYWORD

Combinatorial simulation, General system theory, Biology, Telemedicine, Education

ABSTRACT

Today there are many different medical organizations, but the medical knowledge is fragmentational and there is a big problem for applying medical knowledge in practical medicine. We propose a creation of the global computer model of human organism for informational unification of different contemporary medical knowledge. We are considering the combinatorial model of organism, where the main variables are the main systems of organism, and its application in telemedicine by means of computer network, special data bases and special decision making support system. The global model will allow us to investigate the organism of particular patient in any point of our planet as an integral system by means of geographically distributed specialists and integrated medical knowledge.

INTRODUCTION

Now the medical treatment is determination of illnes symptom and generation of corresponding actions. This methodology is based on the physician education and support by means of telemedicine. Computer has big possibilities for complex system simulation, but physicians do not use these possibilities now.

The main idea of global computer model of organism has three parts:

1. It is necessary to create the integral model of generalized organism of man on the basis of biology and medical science;
2. Physician must have the possibility to tune the generalized model of organism on the concrete parameters of patient;
3. Physician must have the possibility to simulate the different variants of treatment and to select the best treatment way by means of model.

Since Aristoteles, there have been a lot of attempts in this direction, but now we have computer for investigations of complex systems. We can use the combinatorial simulation method [1,2,6,9], which demonstrated good results for simulation of different problems - city simulation, technical systems simulation, living cell simulation.

STRUCTURE OF GENERAL MODEL OF ORGANISM

We have different levels of description of organism - organ level, cell level, molecular level, but for physician the organ level is useful and suitable. We can use the traditional system of organs :

1.The system of motion organs (bones, muscles, fasciae)
2. The digestive system
3. The respiratory system
4. The urogental system
5. The blood vascular and limphatic systems
6. The central nervous system
7. The peripheral nervous system
8. The ductless glands
9. The skin and sensory organs.

We can increase the number of organ systems, but for illustration of our approach we will use nine systems, which interact among themselves. The organism equation will consist nine variables:

$$A1*E1 + A2*E2 + . . .+ A9*E9 = 0 \quad (1)$$

where:
A1 - characteristic of motion organs, E1 - variation of this characteristic,
A2 - characteristic of digestive system, E2 - variation of this characteristic,
A3 - characteristic of respiratory system, E3 - variation of this characteristic,
A4 - characteristic of urogental system, E4 - variation of this characteristic,
A5 - characteristic of blood vascular and limphatic systems, E5 - variation of this characteristic,
A6 - characteristic of central nervous system, E6-variation of this characteristic,
A7 - characteristic of peripheral nervous system, E7-variation of this characteristic,
A8 - characteristic of dustless glands, E8 - variation of this characteristic,
A9 - characteristic of skin and sensory organs, E9 - variation of this characteristic.
The structure of equivalent equations of organism model will be (2)

E1 = U1*A2 + U2*A3 + U3*A4 + U4*A5 + U5*A6 + U6*A7 + U7*A8 + U8*A9

E2 = -U1*A1+U9*A3+U10*A4+U11*A5+ +U12*A6+U13*A7+U14*A8+U15*A9

E3 = - U2*A1-U9*A2+U16*A4+U17*A5+ +U18*A6 +U19*A7+U20*A8+U21*A9

E4 = - U3*A1-U10*A2-U16*A3+ +U22*A5+U23*A6+U24*A7+U25*A8+ +U26*A9

E5 = - U4*A1-U11*A2-U17*A3-U22*A4 +U27*A6+U28*A7+U29*A8+U30*A9

E6 = - U5*A1-U12*A2-U18*A3-U23*A4-U27*A5+U31*A7+U32*A8+U33*A9

E7 = - U6*A1-U13*A2-U19*A3-U24*A4-U28*A5-U31*A6+U34*A8+U35*A9

E8 = - U7*A1-U14*A2-U20*A3-U25*A4-U29*A5-U32*A6-U34*A7+U36*A9

E9 = - U8*A1-U15*A2-U21*A3-U26*A4-U30*A5-U33*A6-U35*A7-U36*A8

where U1, U2, . . . ,U36 - the arbitrary coefficients, which can be used for tuning of the model. System of equations (2) is full, this system covers all combination of interaction between different organs of organism.

According to combinatorial simulation method the number of arbitrary coefficients S will be in general the following:

$$S = C_n^{m+1}, \qquad n > m, \quad (3)$$

where n - the number of variables, m - the number of restrictions.

The number of arbitrary coefficients is the measure of uncertainty.
In our example n = 9, m = 1, S = 36.
In general we have the representative point of organism in parameters space, each organism has the zone of health,where the parameters correspond the health of concrete man. During illness the representative point of organism is found in another zone of parameters - in illnes zone. The process of treatment is the movement of the representative point from illness zone to health zone.

In our example the equation of illness organism will be

$$(X1 - X10)^2 + (X2 - X11)^2 + (X3 - X12)^2 + (X4 - X13)^2 + (X5 - X14)^2 + (X6 - X15)^2 + (X7 - X16)^2 + (X8 - X17)^2 + (X9 - X18)^2 = (X19)^2 \quad (4)$$

where X1,X2, . . ,X9 - characteristics of health organism, X10, X11, . . , X18 - characteristics of illness organism, X19 - the distance between health zone and illness zone. For system (4) we can create the equivalent equations system according to type (2) and can use the arbitrary coefficients for simulation of physician actions. The physician actions must decrease the variable X19 and return the representative point from illness zone to health zone.

THE EXAMPLE OF APPLICATION OF OUR APPROACH

The patients with spinal injuries and disorders need the participation of many specialists in different medical branches and usually undergo special methods of investigation. The reason for this is very complicated structure of vertebral column as

an organ and its function of containing and defending a spinal cord. The difficult cases of spinal disorders and injures require as minimum knowledge and practice in neurosurgery, orthopedics, general surgery. The full treatment complex of spinal patients may be provided only in special vertebrological centers. But the great territory of Russian Federation and not enough number of special centers need the acceptance of right medical tactic with such kind of patients in local unspecialized hospitals. The telemedicine and medical computer programs can greatly help in this cases. This systems can save health and lives of such patients at local hospitals or during the process of evacuation to the specialized centers. Example. Patient C, 13 years old had gotten an injury of cervical vertebrae. She felt down from 2 meters and stroked against a solid object. She also had loss of consciousness and retrograde amnesia that is why the mechanism of fracture was unknown. The patient was lifted to the nearest hospital for investigation and treatment. She underwent the examination of oculist -–no pathology. Neuropathologist – pyramidal muscular hypertension of the upper extremities, hyperactivity of the tendon reflex, feet clonus. She had active movements of the right hand and the right knee but with low strength and pathological exteroceptive sensation from the level of Th2. Deep sensation was saved in the lower extremities. Abdominal reflexes were absence. Involuntary urination and defecation occurred. X-ray examination showed the fracture of the odontoid process of CII with back dislocation on the breadth of the vertebral body and angle 135^0 (open to the back) and transdental dislocation of CI. Liquid dynamical analyses: with out block. Liquid: insipid, protein-0,25; cells-$4x10^6$ / L. Later joined vomiting, bradycardia, difficult breathing that's why she was transmitted to resuscitation and after 4 days of conservative treatment their she was evacuated to Pediatric Academy. In Academy she had neurological examination which showed the progress of neurological symptoms: absence of the active movements in the upper extremities, pathological exteroceptive sensation from the level C7-C8. The conclusion was tetraparesis with the broken function of pelvic organs as the result of compression of the spinal cord in cervical vertebrae. Under the results of liquor clinical analyses, neurological symptoms and X-ray films it was decided to replace odontoid process with HALLO – traction. We used stirrup (type CITO) –weight 3 kg, collar types Shanc to remove the dislocation of CII under X- ray control. On the 5^{th} day after reposition it should be noted positive neurological dynamic which included movements in the right hand and increasing the volume of movement in right leg. On the 15^{th} day the patient was transferenced from resuscitation with active movements of all fingers of the lower extremities and right hand. On the 41^{st} day the patient had movements in the right hand and lower extremities in full volume and self-dependent urination and defecation. Because of instability on the level of odontoid of CII (it was very difficult to immobilize the neck in such way to create the conditions for consolidation and to prevent the neurological complications) we made the operative stabilization of the cervix part of vertebrae. We used the metal construction to fuse the occipital bone and
upper cervix vertebrae. The patient was transferred for rehabilitation to sanatorium after 1 month from the surgery. She could easily walk on her own feet and had a small limit of movements in her left arm. She had no problems with the pelvic organs.

In the case of this patient we can select tree critical moments for taking the important tactical decisions.

1. I moment. The hospitalization in the local hospital. The hospital stuff was poor informed and had not enough experience in work with such patients. They did not make the adequate neck immobilization and used the "policy wait-and-see" without any attempts to make the reposition to reduce the neurological deficit. In this case Telemedicine may play a great consulting role.
2. II moment. Taking the decision of the way of reposition. In this case we can use the operative way of one –moment reposition or the functional method – the traction. The powerful analyzing computer system with full data of theory and experience can greatly help in taking the most right decision in tactic for best result.
3. III moment. Taking the decision of the way of cervix stabilization. It was possible to use the waiting tactic in a hope for the strong reserve opportunities of the young organism and consolidation of the fracture in neck immobilization. This would decrease the risk of the operative treatment but made the prognosis more indeterminate. Another way was to use the spine fusion with the help of the solid metal construction. The computer

program with full information as minimum in nerves system and orthopedics could determine the opportunities, risk and reliability of each method.

So, in all three moments we need full amount of information about all systems of human being because spine is a location of life-important control centers. The complex electronic human model with data integration of all systems will greatly help in quick taking of right medical decision.

The permanent changes of anatomical and physiological parameters of a child's organism during the growth is the most important feature of young patients. It increases the difficulties in estimation of child's condition, prognosis and treatment tactics. The basic problem when facing with hard spine abnormalities in children is the necessity of surgery, the optimal time for surgery, its volume and the tactic of patients follow-up with great probability of displastic changes in this kind of patients in the future during the growth. Anyway the Global Computer Human Model has to deal with the features of child's development.

For example. Patient B., a girl 9 years old. We have been following up this patient from her birth with diagnosis: congenital scoliosis, non-segmentation dextra on the level ThIX-LI. Diastematomyelia , fibrous form. Diastomatomyelia is a rare congenital division of the spinal cord and its intraspinal derivatives. There may be a septum of bone or fibrocartilage within the split which can extend in sagittal plane for variable number of segments. The growth of the spinal column passes ahead the growth of the cord during the childhood so this is the cause of neural damage when the cord is fixed by the septum and appearance and progression of neurological deficit. Otherwise there are some clinical cases of this abnormality in adults without any neurological syptomps. Dyastomatomyelia was found in them as usually after spine trauma and appearance of neurological deficit. But during examination of this patients the clinical symptomps of dyastomatomyelia such as local hypertrichosis are often found. This mark is a reason to suspect the disease in childhood. Patient B. had a congenital spine deformity and hypertrichosis on the same level. The X-ray showed the non-segmentation on the level ThIX-LI dextra, a widened interpedicular distance on the same level. A widened interpedicular distance and non-segmentation (which often correlate with dyastomatomyelia) with no opportunity of visualization the fibrous kind of septum by ordinary X-ray needs the use of myelography and later MRT . This methods confirmed the presence of long interspinal fibrous septum. The neurological examination: flaccid paralyses of the right lower extremity. It was no chance to stop the scoliosis progression without surgery. 7 years old the girl underwent the anterior spine fusion on the other side of the congenital block (level ThIX-LI). We didn't make the revision of the spine channel because of the great length of the septum and a hazard of polysegmental laminectomy which can be the cause of postoperative kyphosis. After this operation we have been using "the policy of wait-and-see." This tactic includes annual neurological, electromyographic and urodynamic examination. We expect that this measures will help to find minimal neurological signs of progression of the deficit which demands septum resection. Basically, mostly all disfunctions of human organs may be the result of the cord starvation. The Global Computer Human Model may greatly help in analyses of all this data for selecting optimal up-to-date tactics and taking the right decision in surgery.

CONCLUSION

25 yeas ago computer applications in medicine were novelty [4], today we have a lot applications of computer telecommunication [3,7,8], but we must begin to work in the field of simulation for physician decision making support by means of telemedicine. In Fig.1 we can see the scheme of interaction between scientific organizations for creation of general model of organism and interaction between particular patients and physicians during process of treatment. Models of concrete patients are imbedded in general model of organism. Famous medical and biological specialists must check, control and inspect the parameters of each organ in general model.

There is a good experience in creation of the international classification of diseases by means of WHO [5]. It is necessary to organize the next step of scientific cooperation to create of general model of organism and to provide the possibilities of each physician to access the general model of organism by means of telecommunications. It is very difficult problem, but successful implementation of it can be based on recent simulation technology advances.

It is necessary to decrease the number of mistakes made by physicians.

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University 1

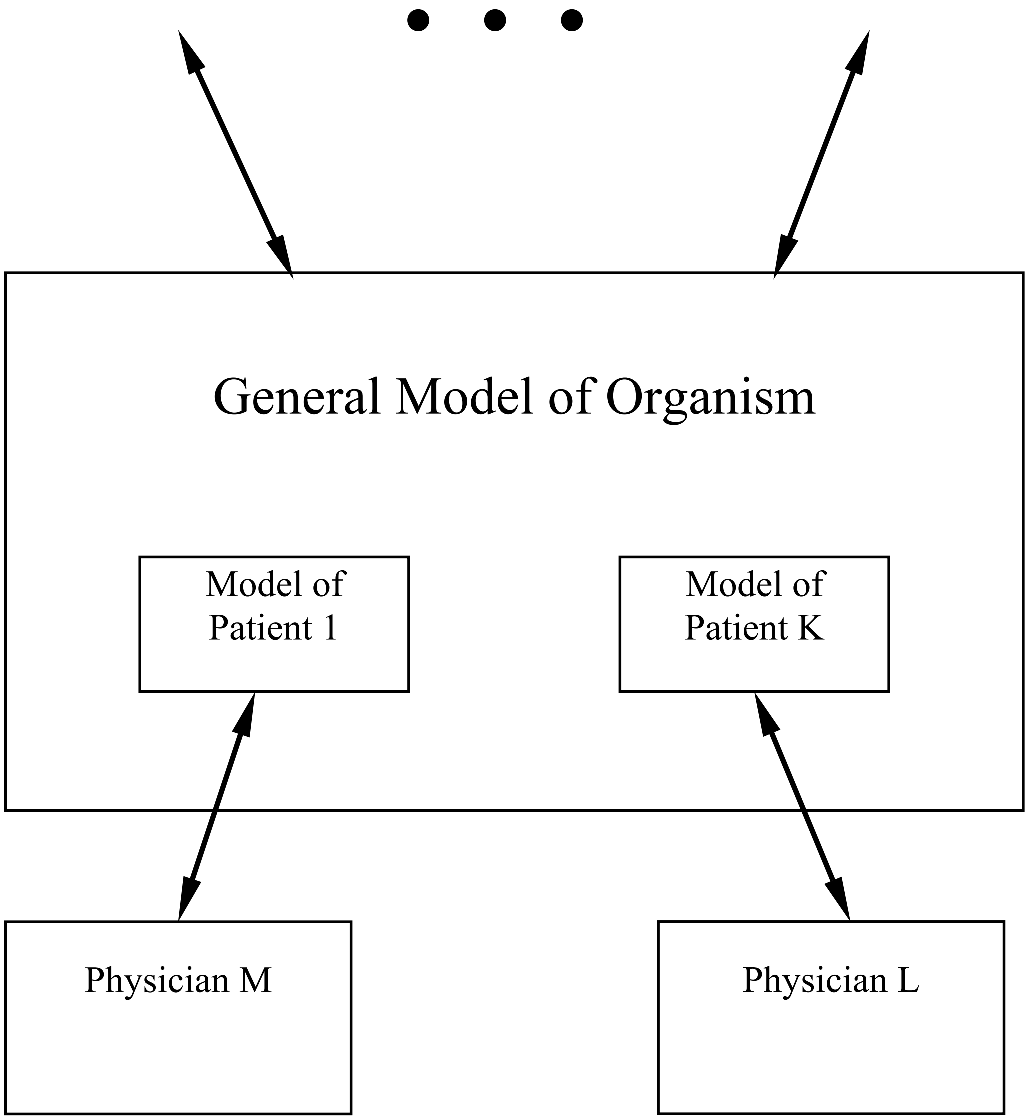

Fig.1. Interaction between scientific organization (University 1,... University N) and General Model of Organism.
Interaction between models of particular patients and physicians.