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Universality of Measurement in Medical Sciences

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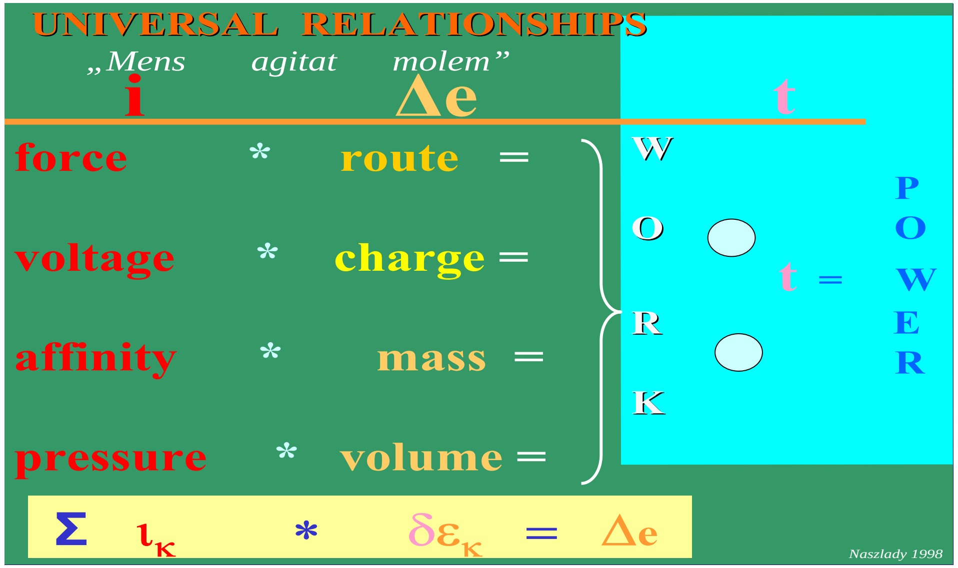

Fig.1

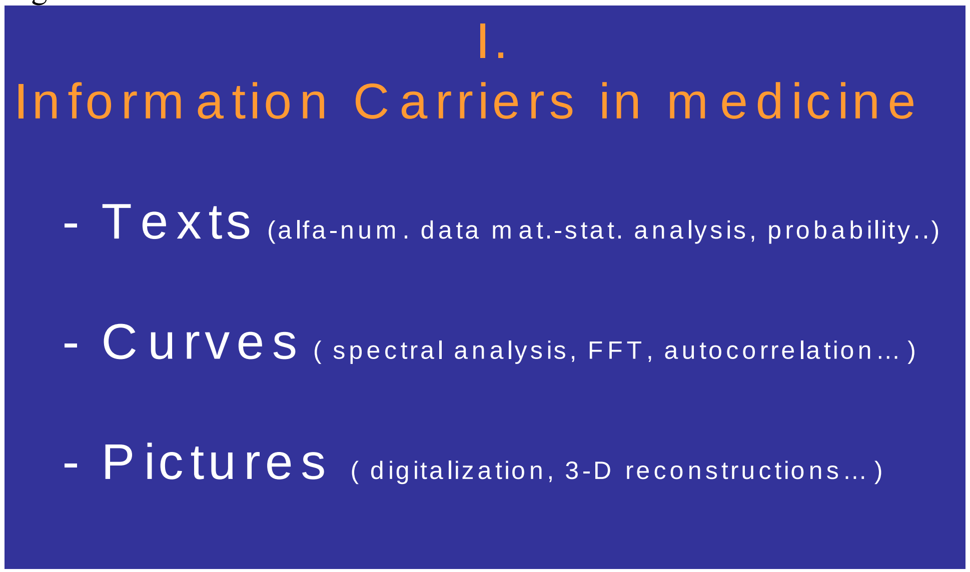

Fig 2.

This presentation contains three main points:

1.What are the measurable variables in medicine.

2.Which are the possibilities for transporting the measured data from one provider to the others.

3.How can we process the data to construct information from the quantitative as well as qualitative relationships among them.

The different information carriers are texts as the patient' s History. These **textual** informations can be processed by matematical-statistical methodologies and exress the state of the patient at the time of investigation. The **curves** are usually amplitude/time functions and after having processed express the adaptivity of the patient. The **pictures** the structural conditions, and allow us to forcast the outcome of the disease.

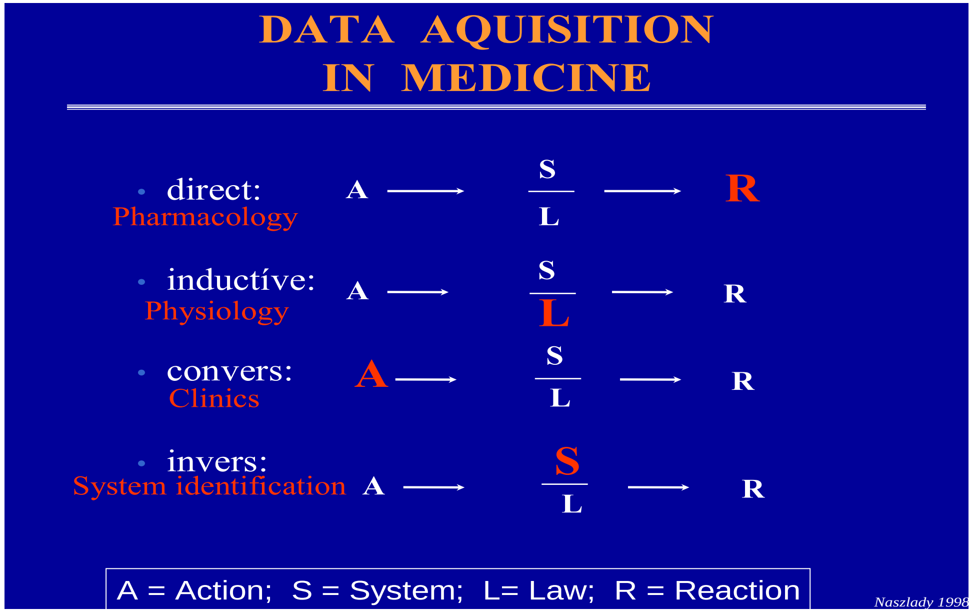

Fig.3.

The data aquisition in medicine is the same as in any other sciences. If three of the four other components have been identified and measured, then the fourth unidentified can also be determined.

The unknown variable is indicated by red colour on the Fig. No.3.

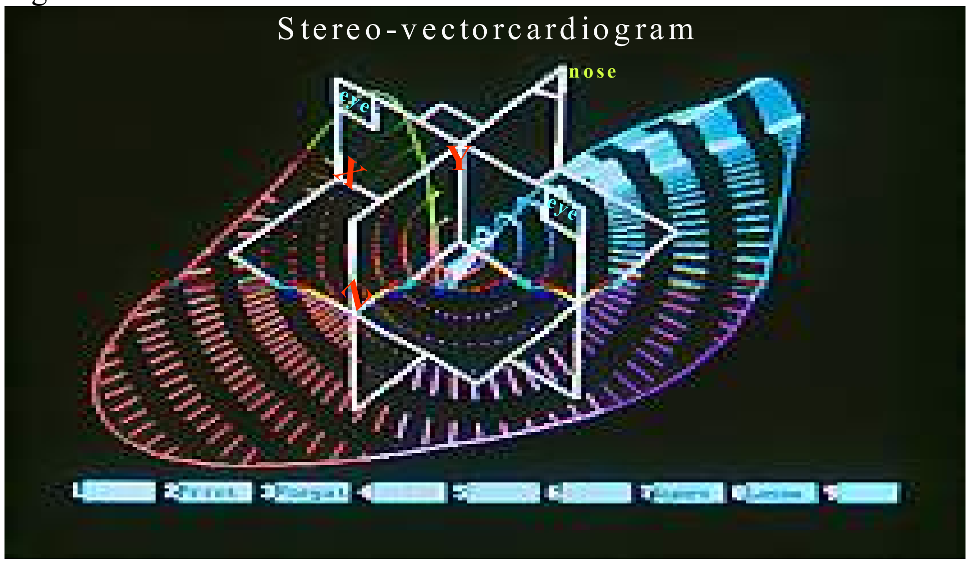

Fig 4.

The traditional ECG takes only 12 voltage samples from the body surface. From the Frank – **spacial orthogonal leads we succeeded to reconstruct the whole electrical field** around the heart. The small bars represent **time in msec**, their high density means conduction disturbances. Red colour shows the left and the blue one the right side of the heart. Normally the borderline circle is convex to outside.

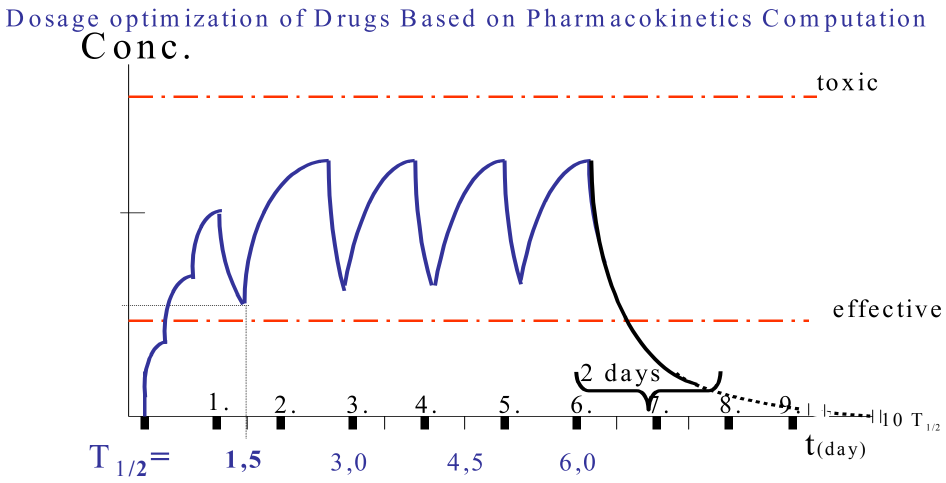

Fig.5.

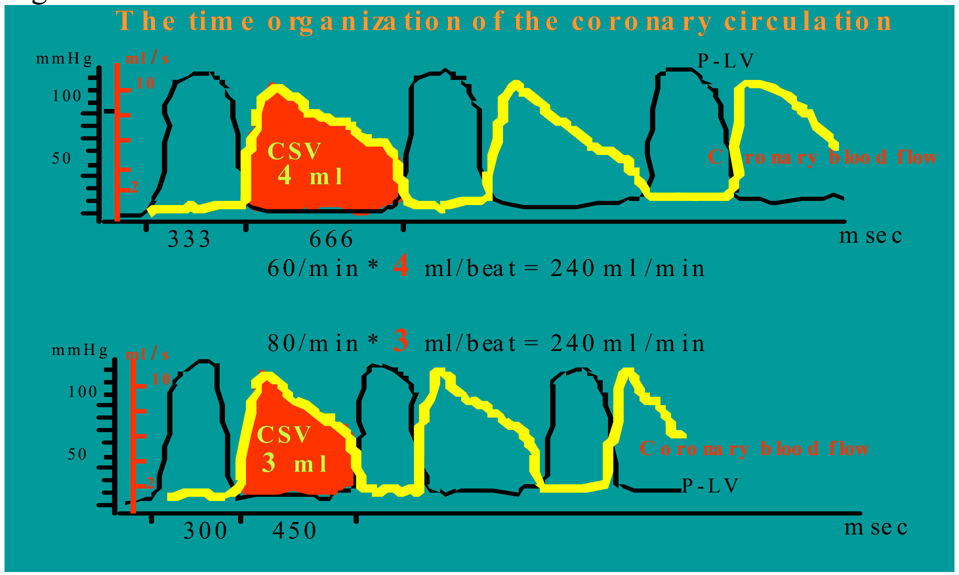

Fig. 6.

The **dosage calculation** is frequently very complicated, if we want to administer drugs individually. That is the reason for ordering them as e.g.: *three times a day* irrespectively the individal parameters of the patient. By **computer modelling** of the pharmacodynamic process of the drug within the body so we can determine the individually optimum dosage of the medicaments.

Coronary blood flow is **measured** regularly in ml/min. As one can observe on the Figure 6. at the same blood flow *per minute*, differs from blood flow *per beat* (CSV). On the computer model there have not been changed neither pressure nor vascular conductance (cross sectional diameter). The alteration of blood supply in the heart is the consequence of *time organization* only.

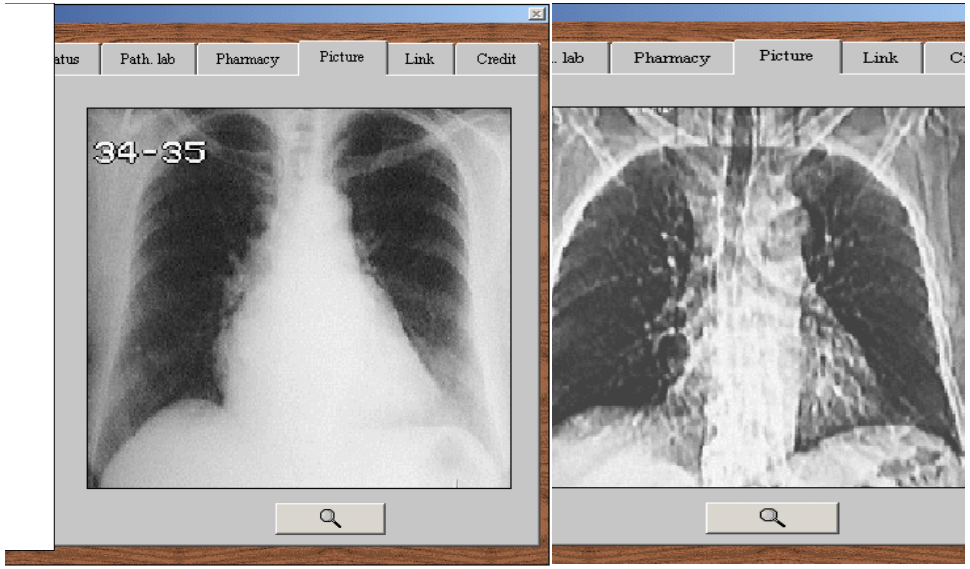

Fig.7.

On the routin chest X-ray picture the main airways are Not well visible. By **postprocessing** the same picture as it can be seen on the right side image, the main respiratory tract (the Trachea) can be seen more clearly. The **8 bits/ pixel** image representation proved to be enough for this medically important distinction. Inversally it is possible to set the gray scale so that mainly the bones (ribs) appear more intensively.

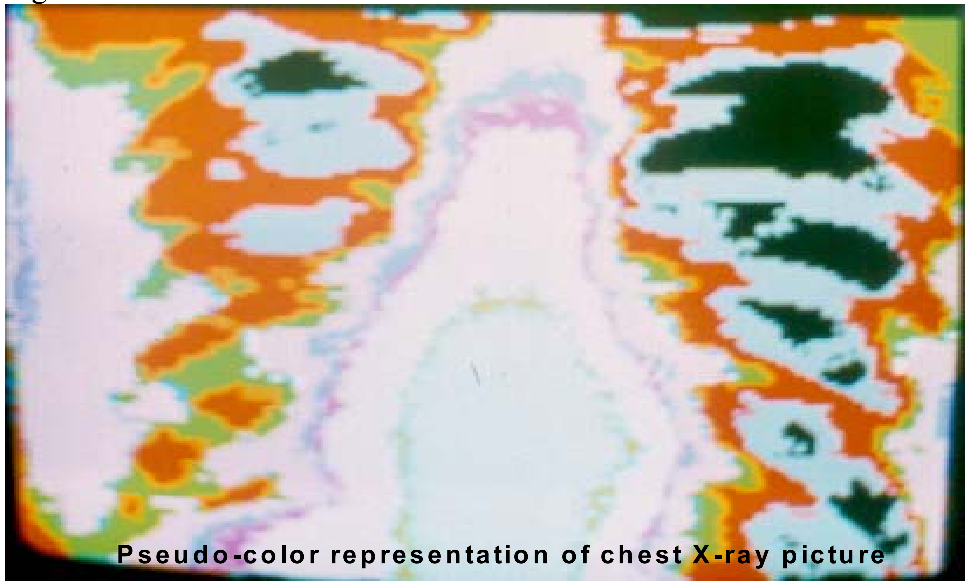

Fig 8.

The **8 bits/pixel** resolution image has a 256 levels gray – scale, the distinction of that by human eye is almost impossible. Transforming, however, to pseudocolour representation of the different darkness of gray levels helps in disdinguishing them. So the air filled bubbles, (blebs) not visible on the original picture in the lungs became identificable even for medical students as well.

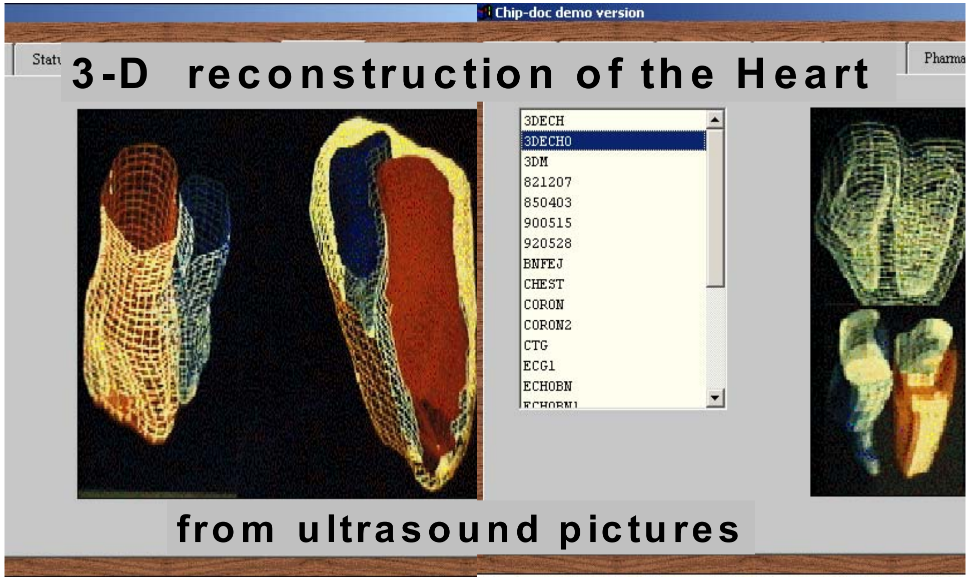

Fig. 9.

By means of ICT application the two-dimensional (2-D) ultrasound images (e.g. echocardiograms) can easily be reconstructed to **3-D images**, as one can see on the Fig.9. The red colour indicates left ventricle, the blue colour the right ventricle of a patien's heart. At the apex of the left ventricle myocardial postinfarcted sac (aneurysma) can be **quantitatively measured** in ml. So surgical intervention became possible and has been performed.

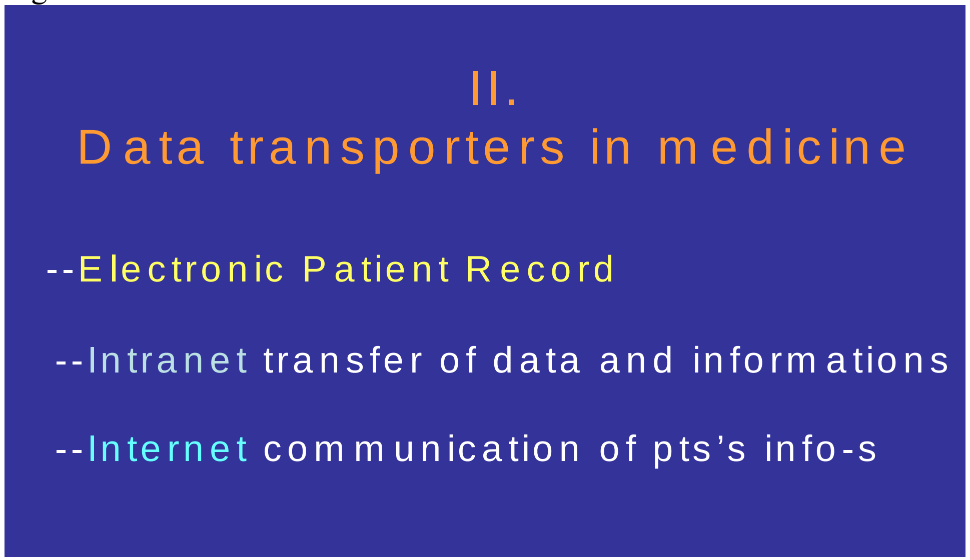

Fig 10.

The **measured data** transport is unavoidable when the specialisation has become extremely graded and therefore the patients have to have *shared care*. ICT offers for that purpose three main modes: Electronic Patient Record, Intranet communication within the health institution, and Internet data and information transfer among remote health providers. Privacy protection, however, is a „must".

Fig.11.

Fig. 12.

The extended mobility of population requires so called *shared care*. It means that all the medical information and insurance eligibility are accessible for the health provider. A *chip-laser hybrid smart card* is the best solution for this purpose. Safe, secure, confidential. We have developed such an *Electronic Health Care Record (EHCR)* in five EU languages with automatic translation from any to any other one.

This *Chip-doki system* contains the following sections with different authorized accessibility: Identification, Emergency, Patient's history, and Status, **Laboratory**, Pharmacy, Pictures, Jobs, and **Expenditure** sections. Being this *smart card EHCR* always at the patient, his/her reliable data and informations are available for authenticated providers at any place and any time.
(A palm-top W/R device is enough to use it)

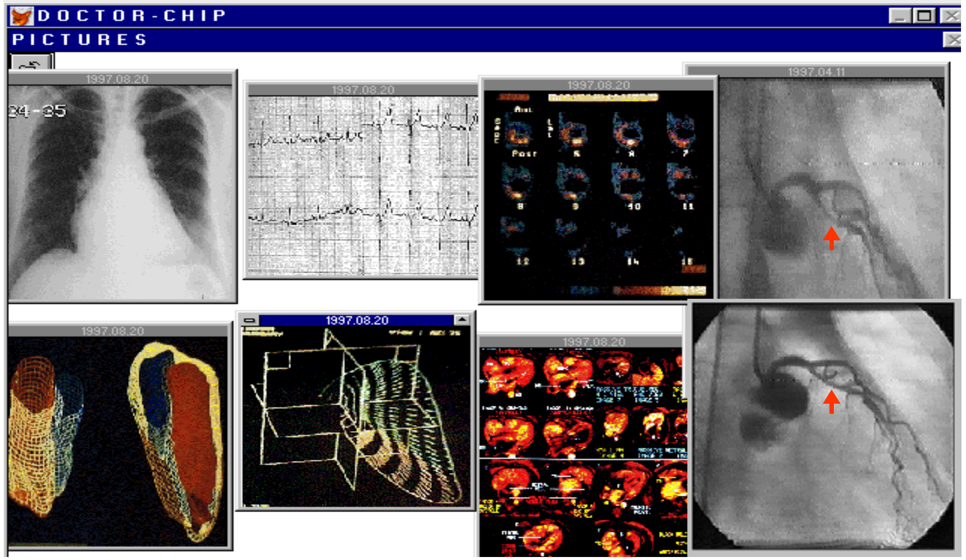

Fig. 13.

The storing capacity of this hybrid card is big enough to archive the patient's all textual, graphical (curves), and picture type informations. The card is **quatitatively unlimited database** because if needed a second ehcr card may be created for the same patient. On Fig 13. Chest X-ray, ECG, SPECT, 3-D echo, Stereo- VCG, MRI, and coronarographic images are shown allowing to compare these finding to each others.

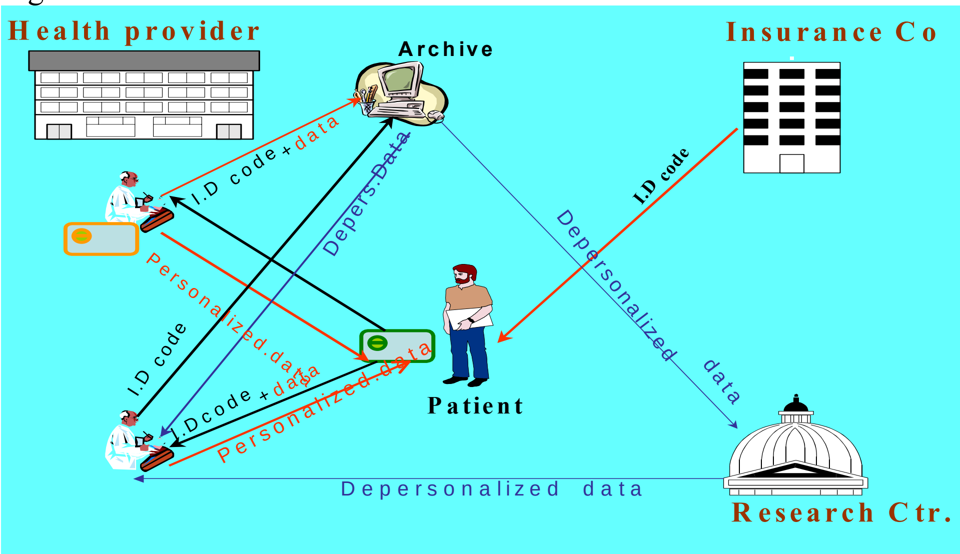

Fig. 14.

The work-flow is shown on Fig.14. starting with card discharge for the patient by the Insurance Company; the next step is filling up with data by the patient's doctor or doctors. Depersonalized data could be sent via web to a central electronic archive for retrieval either for care or scientific purposes. This system can satisfy medical, legal, privacy protective requirements.

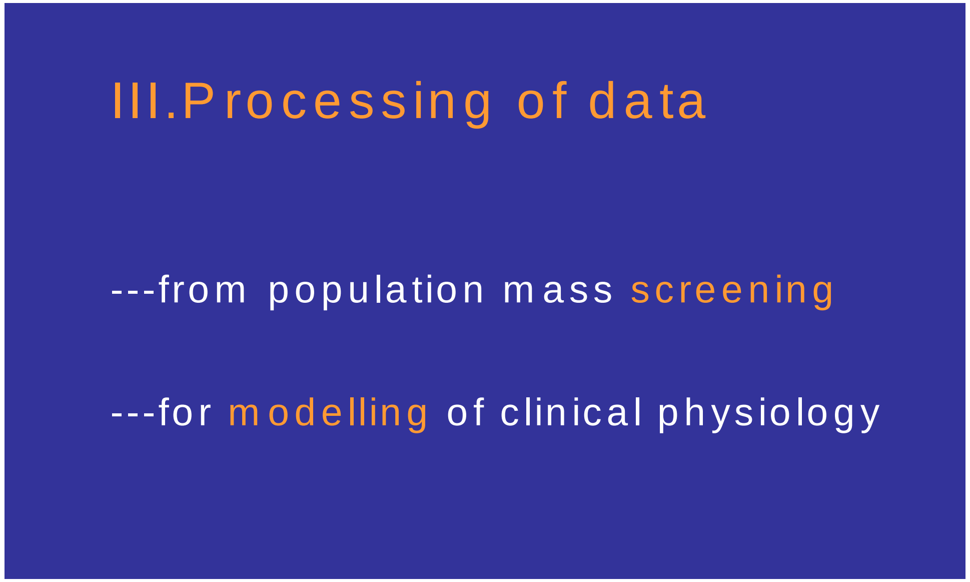

Fig. 15.

After having been data enough in number and quality health authorities may process them with **statistical-mathematical methods**, e.g. population mass screening; another important application of ICT in medical sciences is the computerized stuctural and/or functional model creation. In such a model there are no physical or ethical limitation to perform experiments which cannot or may not be carried out on human beings.

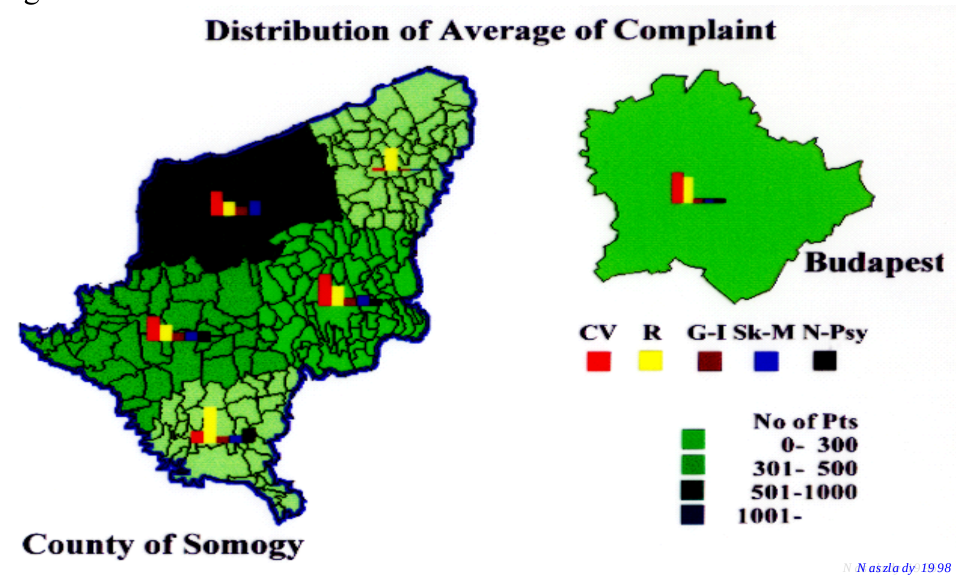

Fig. 16.

A part of results in a population health condition study which aimed at assessing complaints, signs and symptoms and was carried out by smart card in1995 are shown on Fig.16. The different coloured bars represent the **frequency distribution** of Cardiovascular(CV), Respiratory (R), Gastro-Intestinal (G-I), Skeleto-Muscular (Sk-M), and Neuro-Psychological (N-Psy) Complaints and number of participants is shown by GIS.

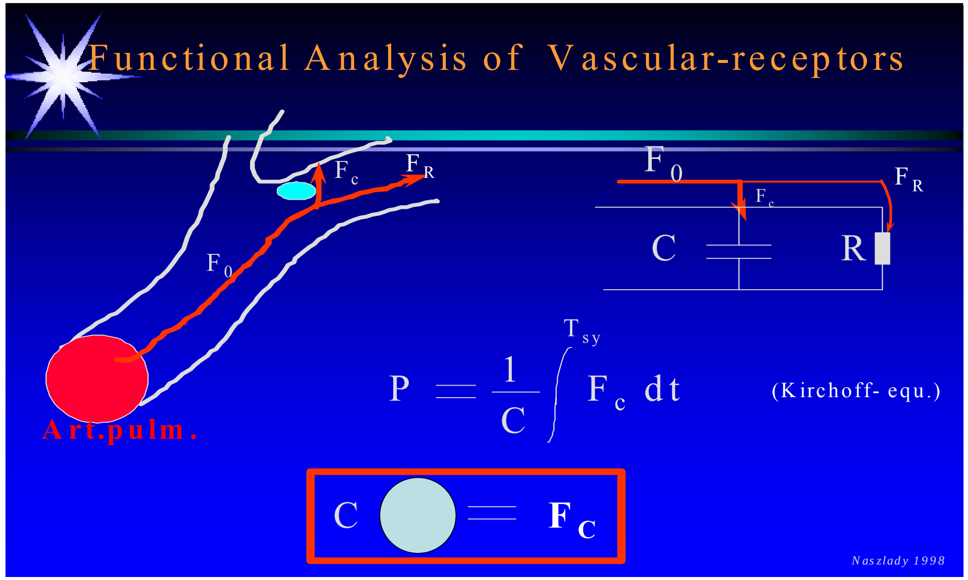

Fig.17.

At the bifurcation (branching) of the carotid artery a biological stretch receptor takes place in the neck., for regulating blood pressure. The electrical model simulating the biological structure could be described by loop-equation sec. Kirchoff. Rearranging the **integral equation** and completed by measured parameters it becomes clear for an expert in biology that it is not only pressure but *flow receptor* too.

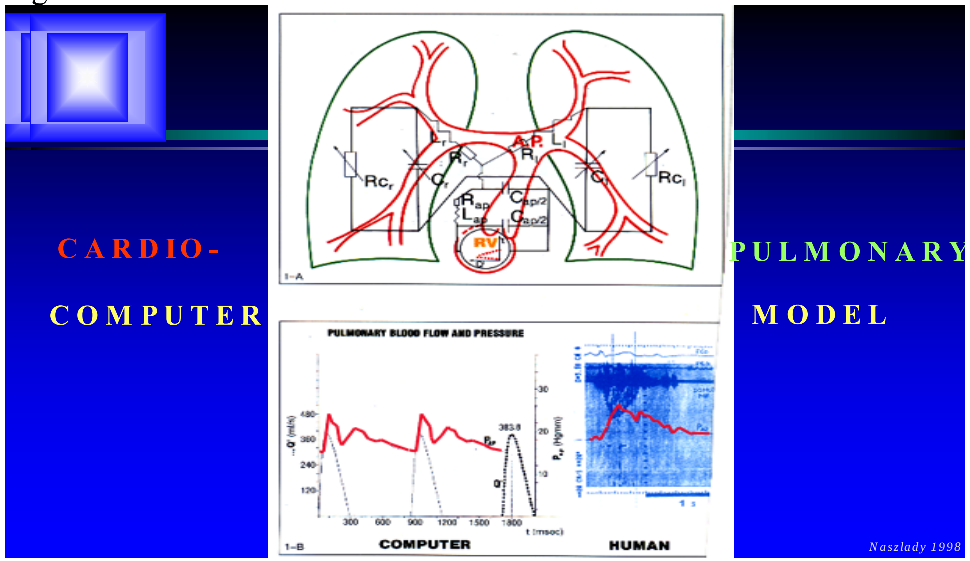

Fig. 18.

A complete cario-pulmonary **computer model** were constructed with *paper-and-pencil* method, discribed by Kirchoff equations. The heart was a flow-source (current-generator) , the other simulations were realized by parallel capacitive (vascular compliance), by ohmlike resistive (vascular resistance) elements. **Quatitative reliability** had been proved by comparing the virtual results to the real ones.

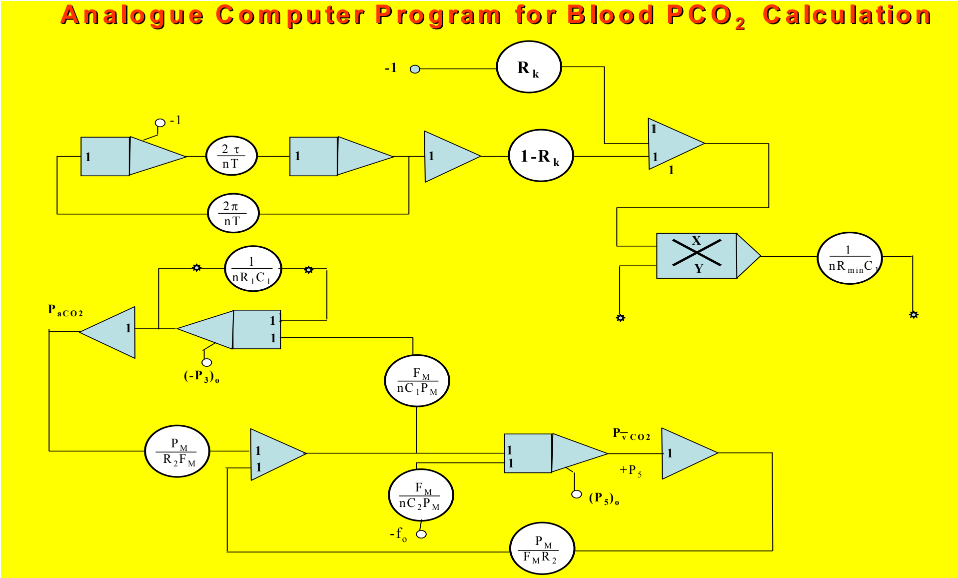

Fig. 19.

The cardio-pulmonary analogue computer model 's Program structure can be seen on Fig. 19. The symboles of the operational amplifiers are internationally accepted and used. These are integrators, summators, multipliers potentiometers, completely set with adequate, human, **real parameters measured** previously in clinical routin investigation.

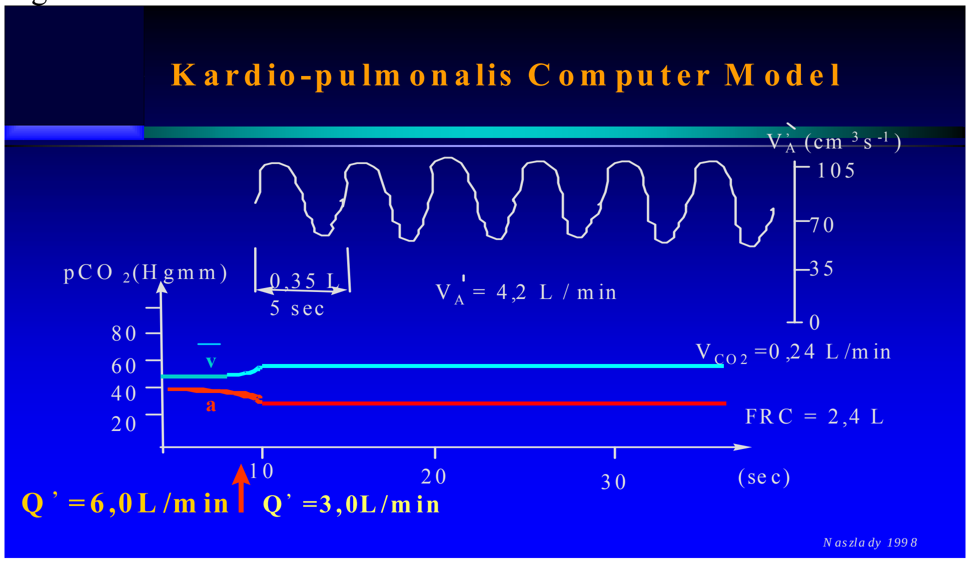

Fig. 20.

The periodical upper curve represents alveolar wave-like ventillation of the lung (V'_A), the lower two pCO_2 time-function curves show the partial pressure of the carbon dioxide in the arterial (a) and venous (v) blood. Q' is the cardiac output. When it is reduced from 6 to 3 Liter/ minute, the checked arterial pCO_2 decreased indicating „improvement", but the venous pCO_2 level is elevating and this means „secret" danger for the patient.

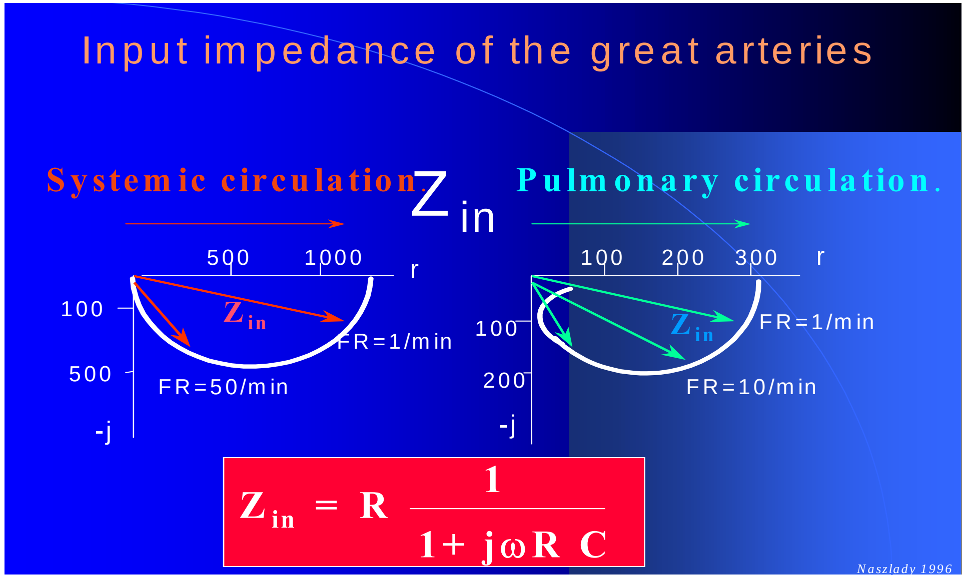

Fig.21.

Input impedance(Z_{in}) of the great arteries are frequency-dependent and the values of Z_{in} are decreasing with increasing heart rate. That is a good explanation for tachycardia when the heart is in trouble. From the formula it can be observe, that ω (omega) representing heart rate is inversally related to Z_{in} of both great arteries (aorta and pulmonary).

The higher the heart rate, the less the Z_{in} .

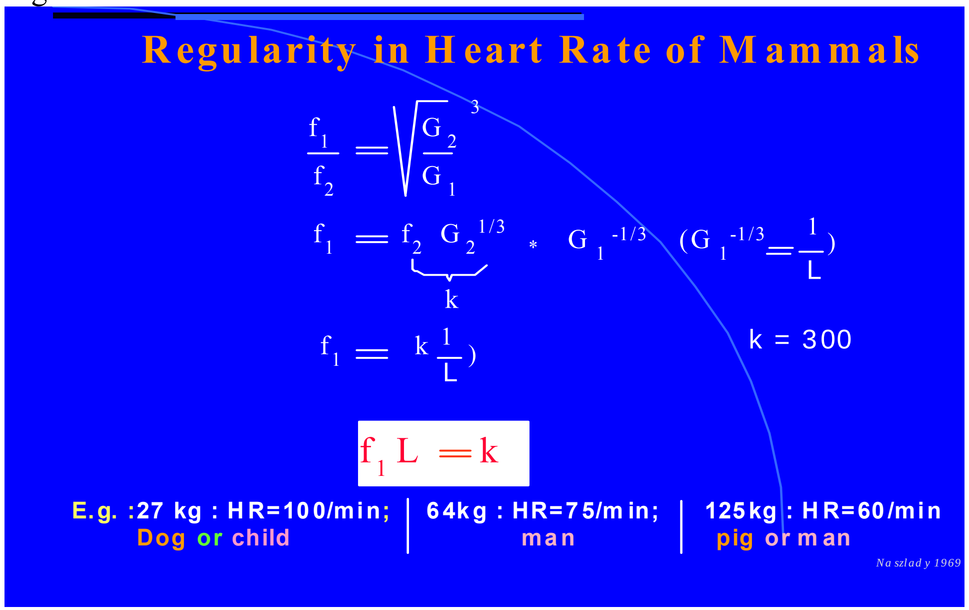

Fig.22.

The computer modelling of cardiovascular system resulted in discovering a rule of REGULARITY IN HEART RATE OF MAMMALS. That expresses an invers relationship between heart rate (f) and body size. The heart rate of two mammals are inversally related to the cubic root of their body mass (some length value L) Mathematical desciption revealed that frequency times length of aorta (up to main branching)is a constant (k).
(cf. Phenomenon of resonancy in physics)

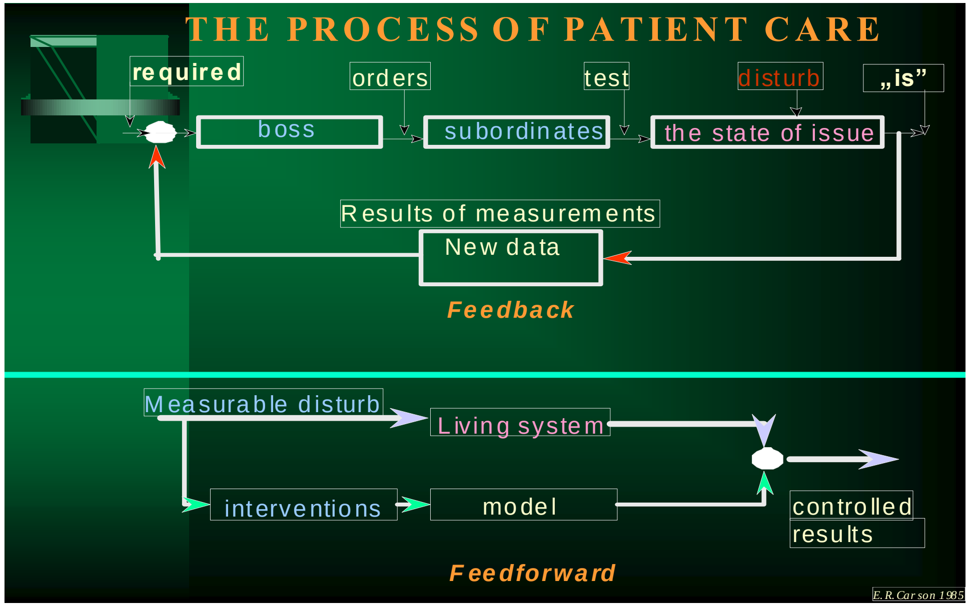

Fig.23.

The work flow of patient care may be descibed as a feed –back operation as one can see on Fig 23. Usually physision could not be able to achieve the best treatment at the first attempt, so each patient's care may be regarded as an investigation for the optimum. On a parallel computer model the doctor may be able to perform „experiments" to find the **quatitatively optimal treatment** to be applied to the patient.

Summary: Medical informatics started in Hungary at the early 60-ies of the XX-th century. Data collection was not allowed in our socialist regime that time, so we begun the application of ICT with **analogue computer modelling**. My first result was the recognition of analogy between the stroke of lightening in an electrical long distance transmission line and the heart beat in the arterial system, in 1964. The same phenomena could be observed in both structure: pressure-voltage wave propagation, wave reflections, lateral leakage of flow, etc. *Mathematica*l *computer models* have been constructed with branching lumped quadrupoles and their loops were described by Kirchoff-equations, in 1966. We discovered the ***Regularity in heart rate of mammals*** based on resonance theory, in 1969. **Coronary blood circulation,** cardio-pulmonary pressure-volume-flow interactions have been successfully studied this way as a virtual reality and produced a lot of new recognitions, in the 1970-ies. **Pharmacokinetic** computer models helped us to calculate individual dosage of various medicaments, in 1990. This should be introduced in patient's care for optimisation of treatment in the future. Another very useful application of ICT would be in data processing of **population mass screening** as well as in shared care. We have performed a GIS supported pilot study in this field, in 1995. We also had some results in **3-D reconstruction** and *volume calculation* of irregular-shaped heart ventricles. This would be usable in cardiac surgery especially combined with telekinetic manipulations. Worldwide initiations are observable in the field of making applicable the **chip-card** technology for Electronic Health Care Record containing complete patient's documentation:texts, curves, pictures. We also worked out one smart card, in 5 languages for cross-border application too.