Main Problems of Modern Medicine in Diagnostics and learning: Ways of Optimal Solution

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Objective: 1. Selecting the key problems in medicine - I. Diagnostic problems, II. Didactic and training problems of medical education, III. Economical problems, IV. Communications technologies problems, V. Psychological problems, VI. Social problems, VII. Strategic problems. 2. Outline ways to optimal solution of these problems.
Methods: Innovative intellectual approach to medical diagnostic decision-making has been sugges-ted. Knowledge levels and didactic systems, its limitations have been described. The methodologies and computerized technologies are tools to overcome the obstacles.
Results: Series of didactic experiments were carried out with the purpose to evaluate comparatively conventional and offered innovative methods of diagnostics and professional training shows significant advantages of the innovations.
Conclusion: The above mentioned problems can be solved successfully by computerized diagnostics based on algorithmical evidence-based approach to disease recognizing, and mass professional education mainly based on eLearning. *(Ana Kar Der, 2001; 1: 166-178)*
Subject Keywords: *Diagnostic Decision Making-; *Diagnosis evidence based-; *Algorithm-; *Medical education-; *Didactic systems-; *Self learning-;
Used abbreviations: s/s symptoms and/or signs; DDM - Diagnostic Decision-Making; DDA – Differential Diagnostic Algorithms; DS – Didactic system; SLES - Self-Learning Expert System; ES - Educational System; MI - Myocardial İnfaretion

Main definitions:

1. The term **diagnosis** has two definitions: 1. The **intellectual process for a disease recognizing;** 2. The nosological meaning - determining the nature of a case of disease. To distinguish between these meanings, we use two different terms: **Diagnostics** – an intellectual process, leading to diagnosis. Diagnosis – the result of diagnostics.

2. Differential diagnostic algorithm (DDA) and algorithmization of DDM is a determination step-by-step operations for establishing diagnoses of all diseases, based on leading syndromes, major symptoms or signs, such as chest pain, fever, jaundice, round shadow on chest x-ray, etc.

3. In western medical literature the term syndrome means usually a disease named by the author describing it first, e.g. Reiter's syndrome, etc. Here the term syndrome used in it classical meaning as **"A group of symptoms that collectively indicate or characterize a disease"** (On-line Medical Dictionary, © 1997-98 Academic Medical Publishing & CancerWEB). Then "syndromic reasoning", "decision-making by syndrome" means a certain intellectual actions with diseases manifested by this given syndrome, e.g. a chest pain, jaundice, etc.

4. Didactic system (DS) is a certain complex of methods and tools of the management by cognitive activity of every several learner in given learner group.

5. eLearning, e-Learning, elearning. Below the definition from the Internet presented (http://www.idc.com Document #: 23283, Publication Date: October 2000, Published Under Services: Corporate eLearning)

eLearning is a well-used word these days. In fact, "e" - everything is becoming quite worn around the edges. eLearning has its place in the lexicon of training and education, but it will be a long time before the definition or practice of elearning lives up to the promise. A good, working definition for "e" -anything is "electronic" or "Internet-enabled." Most common and widely understood "e" - modified words are Internet-enabled interactions between people. The phrases emarketplace, ecommerce, and elearning make sense. Internet-enabled learning, or elearning, strictly means learning activities on the Internet. Those events can be "live" learning that is led by an instructor or "self-paced" learning whose content and pace are determined by the individual learner. The only two common elements are the connection to the Internet (either physical or wireless) and learning.

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Introduction

Among many hundreds of professions, there are some of them, which have been considered as dangerous due to an effect upon life and health of many people of the activity of such professionals. Professions of pilots of passengers' airliners, captains of marine, river passengers' ships, locomotive-drivers of passengers' trains, and even bus' drivers and profession of a physician could be assigned to the category of dangerous professions. Life and health of hundreds of million of people directly depend on diagnostic skill of practitioners. Therefore, a diagnostic skill of practitioners' and medical education significant optimization has a direct impact on the life and health of the population worldwide. It is obvious that representatives of dangerous professions need in the highest level of professional education, constant improvement (optimization) of their skills during their entire professional activity. In what way it could be solving the best? These problems have been considered here.

This article is based on a high innovative level in four major trends.

1. A new original paradigm of intellectual diagnostic approach and adequate effective learning (1-14)

2. A principally new computerized medical diagnostic expert systems based on this approach (15-21)

3. A complex of tools integrated into computerized medical self-training expert system based on the most efficient didactic system for individual distance eLearning (1,2,4,7,9,13).

4. Bi-directional transmission of multimedia information between knowledge bases and users anywhere located by wired and wireless communications technologies directly from a computer (a central server) without any human mediation (any teacher, consultant, etc.). The combination of eLearning with telematic applications and networks.

It is necessary to emphasize that all innovations mentioned below must be used not instead of a patient but only before of a clinical work with a real patient. Medical student and practitioner must minimize diagnostic errors' probability, maximizing his own diagnostic mastering by preliminary using innovative methodologies/technologies.

The author has vast experience in the first three fields development. The fourth trend has been developed already by other researchers and could be used in the new joint international project.

Modern medical science, practice and medical professional education could be generalized to following sixth great problems: I. Diagnostic problems, II. Didactic and training problems of medical education, III. Economical problems, IV. Communications technologies problems, V. Psychological problems, VI. Social problems, VII. Strategic problems. These problems are related to whole clinical medicine but for brevity here has been considered a situation mainly in clinical cardiology.

Social, economical, medical, educational strategic significance of the problems optimization can be defined by very simple consideration. 24 countries-members of Organization for Economic Cooperation and Development (OECD) have in total: population of 884.560.000 people, 1.947.840 physicians and 6.788.970 hospital beds (22, 23). 45 countries have 932 university medical schools, and 2.625.000 physicians. It is easily predict an overall impact of medical professional skill in disease diagnostics and treatment significant improvement related to the quality of life over the world.

I. Diagnostic problems

Dozens of millions of patients with cardiovascular disorders visit physicians daily. It is estimated that one out of four people in the USA suffer from heart or blood vessel disease, i.e. 68 million Americans. Half a million people dies from heart attacks yearly and nearly half of these people are younger than 65 (24). More than 3 million patients are hospitalized yearly in the US for chest pain. The cost is over $3 billion just for those found to be free of acute disease (25). However, only 10% to 15% have MI (26). Fast and reliable differential diagnostics must be executed in Emergency Department (ED) conditions. Here 4-7% of all patients have complaints to a chest pain (27). However, diagnostic errors encountered are in wide frames. Among patients with chest pain suggestive of IHD who are referred for coronary arteriography, up to 30% have no detectable major vessels disease (300,000 normal coronary arteriograms annually!) (28).

Dozens various diseases are accompanied by the same syndrome of acute chest pain (CP). Difficulties of differential diagnostics and diagnostic errors lead to subsequent non-optimal treatment tactics, etc. Therefore, seeking for earlier effective diagnosis and adequate treatment of these diseases by standard and non-standard solution of the problem is urgent.

Standard ways may be quite effective. They concentrate the best experts, source, etc. on the one

hand. For example, in the US many Chest Pain Centers were established (29). Nevertheless, diagnostic errors encountered are not infrequent. Twenty-five general practitioners made correct diagnosis only in 82% (30). Missed MI claims accounted for 25,47% (31). Even in the Emergency Department MI was missed in 27% (32). The misdiagnosis rate of pulmonary carcinoma was 76,7% (33), and in pulmonary embolism reached to 61% and even to 87% (!) (34). 76% of CP patients were discharged without hospital admission (27) on the one hand, but at 16% patients MI diagnosis was missed because did not fulfil the traditional criteria for MI. This caused 48% an in-hospital mortality and 59% a sudden death (35). Other data shows 4% to 10% of patients with CP and MI are discharged from ED without admission (36) In 24%, a MI was not diagnosed clinically and only in autopsy. In 33%, a heart failure was not diagnosed during the clinical stages but only in autopsy (37). Non-cardiologists ordered twice more tests than cardiologists (69,6% versus 36,2%) (38).

II. Didactic and training problems of medical education

Dissatisfaction by the existing diagnostics level is the cause why ways for improvement of healthcare and medical education seeking for permanently. Great hopes are put on modern medical equipment and contemporary communications. Among various technical innovations, special attention has been attracted to computerized distance learning – eLearning.

Last years enormous literature dedicated to distance education appears. Strong attention and efforts has been applied to initial and continuing medical education improvement, including eLearning. Here almost all technical modern tools are used – remote telephone- and video-consultations of very skilled experts, videoconferences, video-discussion groups for complicated patients diagnostics and treatment, presentation to users of appropriate special medical information on CD-ROM, via Intranet and Internet, computer-assisted instructions, etc. Local and international networks have been developing, and improved constantly.

Distance medical education has a high practical meaning. Near 80% of physicians are internists, mostly family doctors. Majority of them works in remote medical establishments located far from large university clinics and medical centres. For example, over 50 million people in the United States (about 20% of the population) live in rural areas, but only 9% of the nation's physicians practice in rural communities.

Enormous number of researches in the fields of distance education and large funding of these innovations allow expecting clearly manifested outcomes, demonstrating high quantitative and qualitative indexes of significant improvement of medical skill in professional activity caused by eLearning. Meanwhile, study of enormous new worldwide literature receiving from Internet and Medline-Express (1996-2001) shows quite unexpected and surprising situation.

Assumed high results of medical eLearning are almost absent or not clearly expressed. Convincing criteria of comparative evaluation between traditional and innovative technologies and methodologies are absent as well. What criteria the authors for impartial assessment of their innovative work have used? They distributed among users of prepared questionnaires for clarify of their subjective impression with appropriate appraisals from “low” to “excellent”, etc. Then they counted the percent of returning questionnaires, difference between appraisals of males and females, distance between learners and the centre for eLearning, impression of learners concerning a teacher-consultant, quality of image in teleconference, prolonged of visual CD-ROM demonstration, etc. Many authors note by themselves a low effectiveness of eLearning, other ones evaluated near percentage in various groups as very demonstrating ones indicated of eLearning preference. Unfortunately, most researches are addressed to middle medical personnel (nurses, midwifes, dentists), and dedicated to visual demonstration of appropriate professional activity.

Of course, such branches of eLearning are very useful and could provide better repetition of professional procedures, manipulations according to received visual animated pictures. However, the following is clear: pedagogic didactic efforts and methodologies, on the one hand, and modern expensive technologies of eLearning, on the other hand, must be directed first to the most difficult branches of dangerous professional activity of practitioners. There are two branches of this activity, the most important and the most dangerous for population diagnostics of a disease, and treatment of a patient. Just these two categories of the practitioners’ activity are the most difficult and dangerous for initial and continuing medical education. Just here, fatal errors have been accomplished. Just these branches must be

optimising first in general, and by eLearning means, in particular.

Then, why mentioned numerous researches were dedicated to improvement of various simple medical procedures but not to diagnostics and treatment optimisation? Really, why? Because between visible manual and invisible intellectual professional activity of a physician is the greatest difference in principle. Effective diagnostics and treatment are the products of intellectual activity. Therefore, for effective Learning, must be used different methodologies and technologies. Short theoretical outline needs for deeper penetrate to this problem. It is described in the "Innovative intellectual approach to didactic and training problems".

Methods

Innovative intellectual approach to medical diagnostic decision-making.

It is well known that diagnostics of diseases as a branch of science is based on three trends:

1. Medical diagnostic technology (engineering, equipment, etc.);

2. Symptoms/signs of diseases, their significance and value in a diagnostic process;

3. Peculiarities of clinical decision-making in intellectual diagnostic process.

Be considering in brief these scientific-methodological peculiarities.

1. Medical diagnostic technology. During the past few decades greatest achievements have been obtained in this branch (various X-ray applications, US, CT, MRI, various laboratory tests, biopsy, etc.). All these discoveries and inventions allow to obtain directly the most convincing signs of diseases. As a result a great improvement in the quality and accuracy of diagnosis was achieved, on the one hand, but significant increasing of the number of diagnostic examinations, their duration, and costs of diagnosis, on the other hand. A delay of the final diagnosis, many social problems, many difficult psychological problems both of patients, and of physicians, a general increase in the cost of health care, etc. are caused by this circumstance.

2. Symptoms/signs of diseases, their significance and value in a diagnostic process. This branch gives slow results, and is not effective enough, because medical literature describes all diseases traditionally: first a diagnosis (the disease's name) and then its description, in particular clinical manifestations (symptoms/signs).

Here in lies the greatest problem because many different diseases manifest by the same or similar symptoms and signs (chest pain, abdominal pain, headache, fever, arterial hypertension, etc.). So, the real work of the physician is doing the opposite. Clinical reasoning moves not from diagnosis to signs as in textbooks, monographs and lectures. It moves from the patient's revealed signs through differential diagnosis of all possible diseases with the same or similar manifestations to the most probable diagnosis, i.e. vice versa. Conventional diagnostic methodology assumes that each physician has in his mind a catalog of all diseases, all their manifestations, and all criteria for fast and precise differential diagnostics. It assumes as well that a physician has unlimited time for intensively analyzing of every patient's problem.

Thus in this branch, there are many unknown factors. The most valuable (decisive) signs of each disease must be identified for discriminating between of each clinically similar disease.

3. Peculiarities of clinical decision-making in diagnostic process. This branch is not highly developed in practice. However, these #2 + #3 two branches allow to realize the revolutionnaire optimization in the most complicated intellectual field of clinical decision-making.

The optimization of clinical thinking is based on very important transformations.The first transformation is moving from a conventional clinical reasoning to much more effective and more economical evidence based decision-making. The second one is a selection of minimum decisive s/s for each diseases. The third stage is a DDA developing using selected s/s for algorithmical decision-making. There is also very effective and promising the fourth stage – the transformation of previous three innovatons into a computerized diagnostic or/and training expert system.

Thus, three optimal principles of diagnostic decision-making used for the most effective diagnostics. This approach essentially differs from traditional diagnostic decision-making and provides optimal diagnostic outcomes (1-21).

a) Evidence-based diagnostic decision.

b) Minimum decisive symptoms and signs detection.

c) Algorithm of differential diagnostics for shortest and fastest differential diagnostics of ALL or majority diseases having given manifestation (syndrome). Only the combination of all three principles (a+b+c) provides the best results in the intellectual diagnostic process.

Evidence-based clinical thinking (Manifestation-based, diagnostics by syndrome) is very important and promising because many various diseases with different pathologic processes have the same or very similar clinical, laboratory, etc. manifestations. Moreover, the same disease may be present with different syndromes or large symptoms/signs e.g. chest pain, arterial hypertension, fever, cough, chest X-ray picture, etc. Therefore, in each case it is very important to select a so-called leading syndrome, for example, a chest pain, arterial hypertension, etc. From such leading syndrome starts a differential diagnostic process as evidence-based thinking. Of course, it is possible to begin the process of evidence based diagnostics with a combination of two or more manifestations, e.g., chest pain + ECG disorders, arterial hypertension + pyelonephritis + retinal changes, etc.

The nosological and three optimal principles are not antagonistic, but synergistic. The integrated clinical diagnostic decision-making (DDM) is the basis for optimal diagnostics of diseases manifested by any the same leading syndrome and for appropriates expert systems development.

1. Recognition of leading manifestations (evidence-based principle of DDM use);

2. Detection of decisive signs and symptoms (principle of optimal diagnostic advisability use);

3. Differential diagnostics and final diagnosis of a disease (algorithm of differential diagnostics use);

4. Confirmation of the disease diagnosis (nosological approach use).

The new methods directly lead to algorithmization of DDM (6-13) (see the definition above). Then minimum examinations and signs are necessary for precise diagnoses with significantly decreasing of the costs of diagnosis. The new principles and methods of clinical decision-making are ensuring the following main advantages (Table 1).

Presented data have a great clinical significance. The evidence-based approach has strongly expanded the list of differentiated clinically similar diseases. For example, in world known "Harrison's Principles Of Internal Medicine" are presented six groups and 28 diseases due to chest pain. After on, four pages follows very short nosological description with considerations for differential diagnostics.

By evidence-based approach, our list contains 8 groups and 112 diseases due to chest pain, i.e. four times more. My DDA, and later the pilot diagnostic expert system for 40 diseases contains only 40 decisive symptoms and signs providing a convincing differential diagnostics of all these 40 diseases.

Diagnostic problems solving will be achieved by the complex of above-mentioned:

1. Innovative intellectual methodologies to medical diagnostic decision-making.

2. Developing and mass using of various ES modules based on these innovative principles and methods of optimal diagnostic decision-making.

II. Didactic and training problems of medical education

Innovative intellectual approach to didactic and training problems.

According to the "black box" logic, if a final result (correct diagnosis) is not completely satisfactory then a cause must be sought on previous stages i.e. in the essence and organizations of medical education and physicians' professional training. Below these causes and the ways for improving the situation are considered.

What contradictions and problems are present?

1. A discrepancy between the diagnostic doctrines, which students learn in medical school, and gu-

Table 1: Comparison between standard and new methods of diagnostic decision-making (DDM)

Criteria	**Conventional methods**	**New algorithmic methods**
1. Approach to getting up DDM	nosological	evidence-based (by syndrome)
2. Required number of medical tests for getting up DDM	ad maximum	fixed on a certain minimal level (the most significant s/s are put into consideration)
3. Number of symptoms and signs demanded for getting up DDM	arbitrary, uncertain	fixed
4. Way of proofing diagnosis	by precedent	deductive (based on exclusion)
5. Ability of differentiation (between closed diseases)	with difficulties	easy-to-do (due to the own nature of the method)
6. Time taken for getting up DDM	a very long period	a very short time
7. Effectiveness of training for getting up DD	high	low (training may stretch up to decades)
8. Possibility of computerization for diagnosis	with difficulties	much easier

idelines used by doctors in real clinical practice. The conventional medical education and medical literature are based on the nosological intellectual system, which starts with disease diagnosis (disease name) and only afterwards goes to the details. In real life, a doctor always faces an opposite situation. From the patient's initial appearance and complaints, the doctor begins identifying signs of the disease, without yet knowing its diagnosis. Therefore, the optimal medical practice has forced to use switching from revealed s/s to diagnosis, i.e. vice versa. Thus, clinical reality required evidence based intellectual system for diagnostic decisions.

2. Different levels of knowledge and learning present in modern didactic science as well as different didactic systems.

3. Conventional didactic system of "a teacher - many students" existing in higher medical schools up today is ineffective and cannot provide a sufficient professional education to EACH student at the same time (3,9,12,13).

4. Great difference in principle exists between visible manual and invisible intellectual professional activity of a physician. Correct diagnostics and treatment are based on effective intellectual activity, which cannot be formed optimally by conventional didactic systems used in medical school and existing textbooks and guides.

5. Diagnostic professional skill significantly depends on many aspects, in particular on diagnostic and pedagogic skills of teachers in medical school. Neither every medical instructor nor any medical school has a highest quality.

The learning levels

There are various didactic classifications of human knowledge and appropriate learning methods. Four levels of knowledge/learning can describe a relatively simple, clear and correct one (Table 2).

The most important feature is that a classical conventional learning could provide only I-II levels of knowledge. Practical professional activity, in particular, effective intellectual diagnostic doctor's work, i.e.

Table 2a: The levels of a learning/knowledge

Study level	Name of study level	Specification of the learning activity (characteristics of the level)
I	Knowledge-acquaintance	Identification, recognising, distinguishing
II	Knowledge-copying	Reproductive activity (reproduction of Information by memory or meaning)
III	Mastering	Productive activity using knowledge for practice related to known objects and situations
IV	Knowledge-transformation	Innovative and creative activity

Table 2b: Classification of the Didactic Systems (DS)

Learning process	Information process	Management tools	Didactic systems management
No feedback	For all	Manual	1. Conventional (teacher - group of learners)
		Automatic	2. the same with technical tools of learning
	Personal oriented	Manual	3. "Bad" trainer
		Automatic	4. Textbook, personal TV, Audio-study
Two-ways feedback	For all	Manual	5. Small groups
		Automatic	6. Full equipped classroom, including computers
	Personal oriented	Manual	7. "Good" trainer
		Automatic	8. Algorithmic interactive learning including logic schemes, PC

knowledge of III level cannot be formed by methods of I-II study levels in principle, even theoretically.

Meanwhile, generally accepted professional medical primary and continuing education based on methodologies, which could ensure only I-II levels of knowledge/learning (lectures, seminars, etc.). It is obvious the unadequateness, disagreement, discoordination between the objective of a doctor's effective intellectual professional activity on the one hand, and a learning methodologies, which cannot provide such activity in principle, on the other hand.

Just here are hidden a main general problems of professional learning, and self-learning, in particular. Two main great problems present here: 1) Didactic problem, and 2) Communications technologies problem. Now, if main two problems are determined, then by what approaches and methods a solving of the problem could be find?

Main didactic problem of a professional education is to find adequate methodology of a learning, which could ensure a professional knowledge on III level. Especially we must emphasize that a main knowledge of III level for practitioner's is optimal intellectual diagnostic activity.

Didactic problems are very specific and are almost unknown to majority of scientists, doctors, computer experts, and businessmen. Therefore, very shortly about this problem (the "didactic system" definition is mentioned above).

The term every is the core concept and the obligatory condition of professional learning at all, and medical professional education, especially. It is axiom, every doctor must establish correct exact diagnosis, and successfully perform adequate treatment. Let's look to professional learning, which, reminding, must provide a III level of learning/knowledge from the existing didactic systems viewpoint.

Limited place of the description does not allow to consider the classification in detail. However, even at a glance to showed classification strategic conditions very important for mentioned both didactic and communications problems could be discovered. ##1-4 No feedback didactic systems cannot in principle ensure of professional learning on III level because here a feedback is absent. Just here is the explanation of a contradiction between the best newest eLearning technologies using, on the one hand, and unadequate very modest obtained results and criteria using, on the other hand.

For effective individual intellectual professional activity forming at every learner two actions are necessary. 1. To give an information, and 2. To check whether and how given knowledge is mastering, i.e. to ensure of a feedback. With no feedback proving that knowledge of III level is mastering a forming of professional intellectual activity is impossible.

Other possibilities of learning arose when cyclic two-ways ##5-8 DS used because here a feedback presents. Each of these DS could provide III level of learning, but here the contradiction between theoretical possibilities of the ##5-8 DS and real conditions appears. DS #5 and #7 are very limited for mass professional education on organizational, social, economical and demographic points of view because practically impossible to find in thousands times more good trainers who could realize the best individual learning with permanent feedback of hundreds million students. The DS #6 is oriented to all i.e. it can provide a direct information to mass learners simultaneously. However, each person has individual abilities. For one it is sufficiently to receive learning information once with minimal intellectual efforts, other will need in many repetitions, additional explanations, etc. Therefore, a DS #6 cannot ensure an effective learning on III level for every student.

Thus, only DS #8 is the best, and is the only that can ensure an intellectual professional activity forming. Just this is the main cause of above-mentioned unsuccessful state in disease diagnostics and medical education. What practical instrument could be used for realizing this possibility? Special computerized learning expert system completely providing of the DS #8 all functions will be independent and sufficient tool realizing this objective. Unfortunately, such ES is absent in the world up today. The author, experienced in developing of previous original diagnostic expert systems, is going to develop Self-Learning Expert System SLES for mastering of effective intellectual activity on III level based on the DS #8 in various fields of disease diagnostics.

Didactic and training problems of medical education solving will be achieved by a development and using of the most effective didactic methodologies and tools, based on the knowledge of III level and the DS #8 and inserted into the SLES. This will ensure to every learner a stable effective individual professional intellectual activity for a disease diagnostics.

III. Economical problems

The terms costs of diagnosis, cost-effectiveness diagnosis, cost-benefit analysis of diagnosis have been discussed constantly in world medical and econo-

mical literature for the last years. It is a great and painful problem, indeed. Costs of health care are very high and increasing constantly. The total annual costs of various health care programs vary from $ 415 million (31) to $US 56,9 billion per one year (39). Expenditures of health care related to a chest pain vary between $389 million and $3.9 billion that is equal at a cost of between $378,000 and $3,78 million per one life saved (40). Costs of several procedures per case vary from $2,106 to $63,424 per-patient (41). Only one percent (4 from used 410!) among tests was decisive for the primary tumour establishing (42). Unfortunately, constructive alternative ideas for overcoming this deadlock are absent.

The following arguments show the significance of the problem:

1. According to a popular opinion, the most reliable diagnosis is achieved due to maximum detailed examinations with maximum symptoms/ sings detection.

2. The desire of physicians to use new expensive examinations and tests without strong evaluation of real suitability of each test for the best diagnostic decision-making in each separate case.

3. Numerous consultations with the best (and the most expensive) experts usually are required.

4. Expensive numerous and multiple examinations are used usually at majority of patients. Therefore, a diagnosis of diseases is very expensive in medical practice.

5. A cost of diagnosis constantly and significantly increased in all developed countries. Therefore, a cost-effectiveness diagnosis optimisation is a vital problem worldwide.

6. Optimisation of diagnosis cost-effectiveness is especially sensitive in those regions where a health-care levels and welfare of population is lower then in developed countries.

7. Medical, organizational, methodological, social and financial alternatives must address the issue of lowering the cost of diagnosis while increasing the quality of disease diagnostics.

It is necessary to distinguish general combined costs of healthcare, on the one hand, and costs of diagnosis, on the other hand.

The cost of diagnosis is a sum of the separate elements as follows:

1. Each medical examination and procedure.

2. Each symptom and sign obtained for the diagnosis.

3. Time spent on various examinations.

4. Salaries of physicians.

5. Salaries of medical staff carrying out medical procedures.

6. The primary diagnosis reliability, and the necessity to perform additional tests, time spent, etc., if the diagnosis is wrong.

The first two issues are economically most important, the others depending on them. If the number of superfluous examinations and symptoms/signs is decreased while maintaining a high diagnostic level than economical problems could be significantly alleviated.

Economical problems solving will be achieved by training users to establish reliable diagnosis by minimum examinations and decisive signs. Such practical approach will ensure a very expressed economical effect (many-fold cheaper final diagnoses). The Diagnostic Expert Systems are real way to decrease the cost of diagnosis (See Fig. 1-4, especially 3-4). It will allow to optimise a health care budget, and to overcome the economical deadlock in internal medicine.

IV. Communications technologies problems

Why problem of communications is important? The biggest contemporary problem is globalisation of education. New unusual requirements to learn effectively of every learner are combined with exclusively complicated task to develop the SLES. Therefore, the best training ES should by presented on international scale and must be accessible to every learner in every country. The Internet/Intranet and wireless technologies will ensure this task besides distribution of the SLES on CD-ROM, etc.

Communications technologies problems solving will be achieved by free communucation with various SLES established on a central server providing a full independence from a workplace site, unsuccessful teacher, work time, etc. Any distance variant using the SLES via Internet/In tranet or modern wireless communications will be accessible to every professional. A user is free to provide the optimal professional self-training at home even tonight.

IV. Psychological problems

1. Not all medical students and doctors, and not everywhere have an experience of working with computer yet.

2. Psychological contradiction between interests of medical students and practitioners on the one hand, and medical instructors on the other hand could be encountered.

3. Students/doctors are interested for maximal fast improvement of their professional activity.

4. Teachers-clinicians accustomed to a) classical nosological principle of diagnostic decision-making; b) classical scheme at the bedside education; c) classical didactic system "a teacher - many students" are usually resistant to any innovations, which could infringe their habitual state.

Psychological problems solving will be achieved by the SLES offering the skilled diagnostic intellectual activity and the best outcomes in the self-training mode with a high motivation of learners and various psychological encouragements during work with the SLES. It will guarantee learning to every learner according to his individual abilities independently both of teachers and any other member of his group.

V. Social problems

1. As mentioned above, a physician's profession belongs to the category of dangerous professions.

2. A social impact of physicians' activity is very high taking into account that hundreds of million of patients' addressing to them daily, and patient's life and health directly depend on doctor's diagnostic quality.

3. Family doctors mostly work in remote medical establishments located far from large university clinics and medical centres.

4. Representatives of dangerous professions need the highest level of professional education, constant continuing improvement of their skill during the entire professional activity.

5. Improvement of medical professional skills will have an essential positive impact on health, life quality, and social state of a population.

Social problems solving is a long-term objective that will be realized by a wide practical use of the diagnostic decision-making principles inserted into the SLES and mastered during self-eLearning. Thus, the improvement of the quality of life and health safety will be achieved successfully. New and enhanced telecommunications links between community and academic hospitals promise a reducing the professional isolation of remote practitioners, and enhancing lifelong learning opportunities for rural health care providers.

VI. Strategic problems

The XXI century requires development and mass distribution of the newest technologies and maximum its using by medical professionals. Therefore, an appropriate strategy should be accepted.

1. Diagnostics of disease and treatment of a patient are the most important, the most difficult, and the most dangerous branches of medical activity because just here fatal errors often occur. Therefore, pedagogic didactic efforts and methodologies must be directed first to these problems.

2. Modern technologies of diagnostics, learning and communications should provide optimal transmission of multimedia information (text, pictures including movies, sound) to users both directly from the SLES established on a PC, and by wired (Internet/Intranet) and wireless technologies to remote users.

3. Optimisation of clinical diagnostics and eLearning based on III level of knowledge and DS #8 using the evidence based algorithmical decision making is the only real way to achieve the best medical professional intellectual activity.

4. Optimal arrangement of diagnostic, didactic and technical features of eLearning is a strategically paramount task.

5. A strategy of computerized diagnostics and self eLearning should be directed to the most convincing quantitative and qualitative comparative evaluation with existing conventional education in higher medical school and in daily medical practice worldwide.

Strategic problems solving. Usual way by writing of new textbooks, guides, and appropriate transformation of pedagogic process in medical school will be very slow, prolonged, with resistance of teachers, therefore, ineffective. The only real solving is eLearning based on mentioned methodologies and technologies inserted in the SLES modules. Then all mentioned innovations will appear simultaneously and will be accessible worldwide. Probable conservative resistance could be easily got over administratively, if a computerization of a healthcare and medical education will be realized. Just this way is realized in hospitals and outpatient clinics in Israel. Gradually the contents of the SLES will be extended by international efforts until the whole contents of clinical medicine and healthcare will be presented to learners.

Results and Discussion

The author's methodology of comparative evaluation between usual diagnostics and by means of DDA and ES always was the same according to the

principle "the other equal conditions". On the first stage conventional diagnostics was performed, on the second stage - diagnostics by innovative method. The time interval between both stages was several minutes. The other equal conditions were always observed, i.e. the same examinees, only written diagnostic conclusions, the same patients or their equivalents (clinical, X-rays, ECG and other diagnostic tasks, problem situations, training games), etc. Below some results are presented.

Decrease of diagnostic errors with algorithmic diagnosis from 71-100% to 6-0%, including the case with result from 100% errors to 100% correct diagnosis (Fig. 1a). Ten days after there was only one diagnostic error, all other diagnoses were 100% correct (Fig. 1b). At both stages, sudden diagnostics without any preliminary preparation was observed.

The first half of them (I) has completed course of the X-ray diagnostics without use of algorithms. The second half (II) will start their X-ray diagnostics course in the next semester. Independent traditional diagnostics by X-ray slides on large screen.

Each participant completed each stage with his written diagnosis that was submitted to the author immediately after termination of each experimental stage. If the participant was not sure in his diagnosis, he could write two or more of the most probable ones in his opinion or mark zero if no diagnostic idea was presented. The 1st stage was initial independent traditional diagnostics (1343 written diagnostic conclusions): correct diagnosis was 37%; wrong diagnosis 42%; absence of diagnosis 21%. The 2nd stage was with algorithm (3120 written diagnostic conclusions): correct diagnosis was 93% (both I-II); wrong diagnosis was 6% (I), -7% (II); diagnosis was absent 1% (I). The 3rd stage was repeated traditional diagnostics without algorithm after a single usage of algorithms within 20 min. (2226 written diagnostic conclusions). New radiograms with the same round shadow chest X-ray syndrome: I - Correct diagnosis was 87%; wrong diagnosis was 10%; absence of diagnosis 3%; at II - was 78%, 13%, and 9% accordingly.

Hence, even the single usage of the algorithm within a short time provides almost the same diagnostic results in the large group that did not begin the study of X-ray diagnostics in the comparison with the group that has already completed it (Fig. 2).

2. Diagnostic and economical advantages of algorithmical decision-making in comparison with free collective clinical considerations during the original learning game.

Unique experiment with 12 medical residents. Recording of diagnostic consideration by tape recorder and the time of consideration by stopwatch. On the first stage (I) was free discussion of diagnostic hypotheses and considerations during "patient with acute chest pain" teaching game. The second stage (II) was the same patient with all existing symptoms and signs but with appropriate algorithm. The same diagnosis "acute myocardial infarction" was established in the 1st stage after 220 thinking operations; in the II stage after 4 sings in algorithm (i.e. 55 times less). The time of diagnosis: I - 1704 sec, II–10 sec (170 times less), used prompts from the teacher, because diagnostic considerations were wrong I - 104, II – 0 (Fig. 3).

3. Comparative evaluation of traditional and computer-aided diagnostics at students obtained the classical western medical education

For usual traditional diagnosis of 4 diseases, 313 symptoms and signs were used including 183 clinical and 130 laboratory ones. By the FES in the same conditions used only 15 signs including 11 clinical and only 4 laboratory tests, i.e. 21, 17 and 33 times less respectively (Fig. 4). Decreasing of the examinations' leads to adequate decreasing the cost of diagnosis.

Presented data shows that DDA and AES provide radically better results:

1. Immediately after use;
2. Even after the single short training period;
3. The diagnostic and training results obtained by means algorithms significantly exceeds them at the same students and the same themes/objects in comparison with traditional training;
4. Professional knowledge acquired by means of algorithms has long-term relevance.
5. High effectiveness of DDA and ES has been acquired in various clinical fields. This allows extrapolate analogous results to future new trends and tools.

Fig. 1-4 shows unique results. In comparison with conventional diagnostics, algorithmical and computerized diagnostics decrease markedly medical exams, s/s and the time for a diagnosis establishing. It is important that methodologically the same experiments were performed both in the former USSR (Fig 1-3), and in Israel (Fig. 4), (7,9,13,21). Conditions and contents of medical education were different with undoubted advantage in Israel, where American system of medical education is used. The

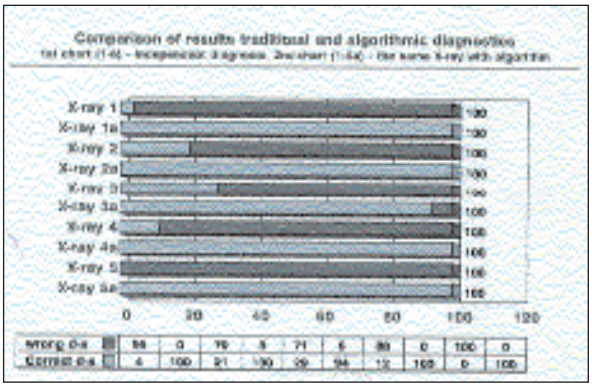

Figure 1a: Graduate medical students. Comparative evaluation between usual and algorithmic diagnostic interpretation of 5 chest radiograms, total opacity syndrome, 120 diagnostic conclusions.

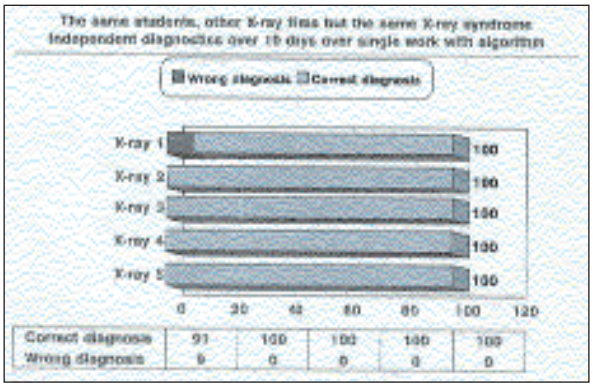

Figure 1b: The second experiment, 10 days after. The same examinees, other 5 chest radiograms but with the same X-ray syndrome of total opacity. Independent diagnostics without the algorithm using, 110 diagnostic conclusions.

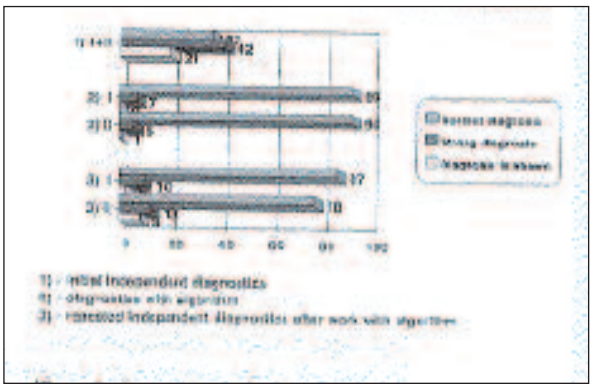

Figure 2: Comparative evaluation between usual and algorithmic diagnostic interpretation of chest radiograms with a round shadow chest X-ray syndrome. Mass experiment during the lecture. 412 medical 4th years' students. 6.689 written diagnostic conclusions.

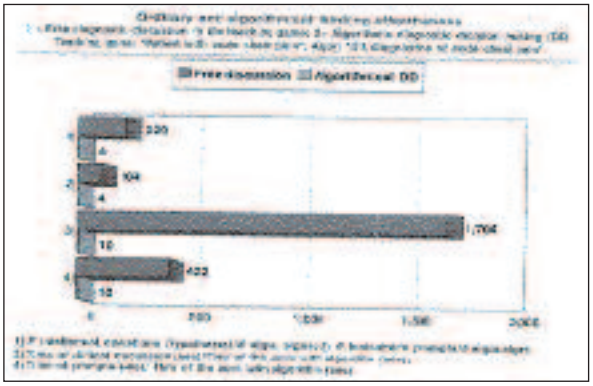

Figure 3: Comparative evaluation of original learning game "a patient with acute chest pain" and decision-making with the DDA for disorders manifested by acute chest pain.

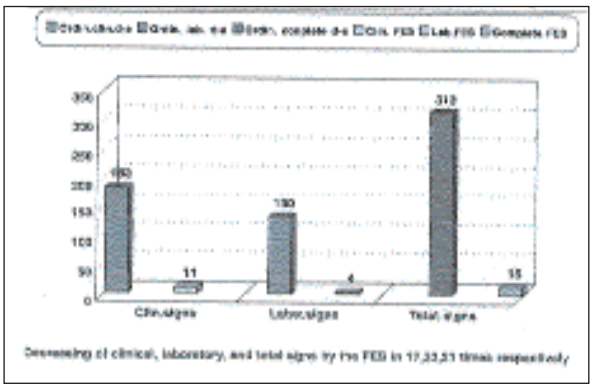

Figure 4: Recent comparative evaluation of conventional and computerized diagnostics. Usual independent diagnostics of problem situations for diseases manifested by fever, and computerized diagnostics by the original pilot Fever AES (FES).

same quantitative and qualitative outcomes have the only meaning. Diagnostic skill of students and physicians does not depend on geographic, financial, political and social conditions. It depends only on methodology of DDM (conventional or optimal). Therefore, primary and continuing medical education based on III level of learning and DS #8 could ensure many times improvement of disease diagnostics and hence treatment of patients worldwide.

Main Clinical and Educational Implications

The author's innovative diagnostic expert systems named the Aesculapius ES (AES) are dedicated to diagnostics of diseases in main clinical fields of internal medicine, and traumas. Hepatobiliary AES is complete to practical use and provides fast exhaustive diffe-

rential diagnostics of 97 hepatobiliary and other diseases manifested by jaundice (950 diagnostic conclusions based on data of history, clinical, paraclinical, laboratory, etc. examinations). AES dedicated to diagnostics of cardiovascular, pulmonary, gastrointestinal diseases, disorders accompanied by fever and all types of traumatic injures are under development. Each AES ensure the computerized diagnostics of all, at least, majority diseases of mentioned organs and manifested by all clinical laboratory, X-ray, etc. syndromes collection in the diseases of appropriate organ and system. All AES intended to direct work of a medical professional with a patient and could be established both at any desktop PC and portable computer from usual notebook to palmtop ones, like Cassiopeia, etc. The same possibilities have the SLES.

Conclusion

Complicated problems of contemporary medicine and medical education cannot be solved by conventional ways, methods and means. Above-mentioned shows that theoretical and practical solving of these problems can be performed by non-traditional ways. Such perspective is not a panacea but it opens the first initial steps for real practical solving mentioned problems of contemporary clinical medicine and medical education.

Thus, computerization of disease diagnostics and self eLearning based on original new paradigm realized by the most effective three optimal methodology of clinical decision-making, knowledge of III level and DS #8 are effective tools for the problems solution.

The principle "the least to obtain the most" will be observed. Offering innovations will provide the most reliable diagnosis in the shortest and the most efficient way, using minimum medical examinations, minimum signs, least efforts from physicians, the shortest time, efficient financial costs of diagnosis. The SLES will be intended to the most effective individual professional fast self-eLearning integrated with modern Telematic Applications and Networks (TAN) based on Internet/Intranet and wireless technologies.

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