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MATHEMATICAL SIMULATION OF AN URGENT SURGICAL PATHOLOGY OF ABDOMINAL CAVITY ORGANS

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We developed a technology of creating computer models of acute surgical diseases of abdominal cavity organs on the basis of the pattern recognition theory and multifactor analysis of traditional symptomatology. We employed an algorithm consisting of the method of evaluating vectors and method of patterns that rests on special rules of extended production for solving medicinal problems.

For about three decades the results of treatment of urgent surgical patients in clinical medicine have remained approximately on the same level. This is attested to by the figures of postoperative lethality that have remained nearly the same over the period indicated: for example, according to [1] in Belarus the lethality reached the following values: 0.28% in the cases of acute appendicitis, 7.4% for perforating gastric and duodenal ulcers, 20–40% for peritonitis, 12.5% for intestinal obstruction, 10.1% for acute cholecystitis and pancreatitis, 20.7% for intestinal hemorrhage, etc. This situation was also observed in the former USSR [2, 3]. Such a high rate of unfavorable outcomes is attributable to different reasons. One of the reasons for lethality in the case of urgent surgical diseases is diagnostic and tactical errors that at different stages of rendering medical aid come to 8–54% and in some urgent conditions attain 95% [4-7].

A great number of tactical errors in determining the time of surgical intervention, amount of necessary technical means, selection of duration and qualitative characteristics of preoperative preparation, postoperative treatment, methods of treatment and diagnosis are attested to by statistical rate of lethality, number of postoperative complications, and by the time of stay of a patient in a clinic. Lately the number of errors in decision making has increased due to nontypical course of a number of diseases, and changes in the reactivity of an organism, especially in the zones that suffered from the accident at the Chernobyl Atomic Power Station.

The reasons for errors lie not only in the insufficient qualification of medical personnel. There are two main objective factors that lead to an erroneous solution of the logical problems of choice:

- subjectivism and the stereotyped nature of medical mentality that are connected with the specificity of logical constructions from a manifesting (explicit) symptomatology (or a symptom) through the search of supporting links to the final diagnosis (or decision). In this case hypobolization of separate symptoms (or logical symbols) is possible, as well as underestimation of other manifestations of a disease;
- a severe scarcity of time for making a decision on the problems of choice (diagnosis, examination, method of treatment, kind of assistance, etc.), which is characteristic for an urgent surgical service, in which even minutes can be decisive.

Under these conditions, the scarcity of time and information in the course of the treatment-diagnosis process at all the stages of rendering medical aid to patients with acute surgical diseases and injuries of abdominal cavity organs, as well as an insufficiently high level of the training of physicians for emergency service and surgical duty teams at clinics can be compensated by the application of computer technologies at the departments of urgent surgical service (medicinal expert systems of diagnosis and choice of the tactics of treatment, electronic reference manuals, and case records, systems of computer communication, etc.). Consequently, the development and

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application of computer technologies and in the first place in urgent surgery are very pressing. This fact is supported by an increasing number of scientific publications [8-13] in which the authors consider the possibilities of using mathematical methods and computing facilities in surgery. Computer technologies will aid in the diagnosis process and in the optimization of the process of decision making when rendering urgent aid to patients with an acute surgical pathology, as well as in training and advanced training of surgeons.

In what follows, we present the ideology followed by the present authors in mathematical simulation of emergent surgical pathology and creation of a computer system for diagnosing acute diseases of abdominal cavity organs.

The computing facilities and mathematical methods used for developing medicinal expert systems and other sets of programs require mathematical formalization of medicinal information.

Structure of Medicinal Expert Information. The medicinal expert information (MEI) forms a basis for developing medicinal expert systems and in formalized form represents certain characteristics of the model of the application domain. It can be conventionally divided into a descriptive and meaningful MEI. The first includes the structure of the class of recognizable diagnoses, the flow diagram of decision making, signs of the description of a patient, and the forms of collection of primary medicinal information; the second includes stereotyped patterns of diseases, instructing fetches from verified examination charts, and the results of their preliminary statistical processing.

A list of needed diagnoses is assigned by an expert proceeding from the knowledge of the application domain and the adequacy to it of the model used, as well as from the allowance for possible contradictions and failure situations when filling the initial information about a patient into a personal computer. Very often a diagnosis can be synthesized from separate interdependent parts. This procedure can easily be described in the form of the so-called diagnosis formula. In this case it is more convenient to present the list of diagnoses in the form of diagnosis formula and description of its separate parts.

The flow diagrams of decision making are developed on the basis of the knowledge about the application domain and the means of solving the problem in clinical practice, i.e., clinicodiagnostic experience of an expert. They reflect the course of decision making in determining diagnoses, communications, selection of therapeutic tactics, etc.

The signs of the description of a patient are summarized into a coded list on the basis of which a form of a primary medical document (examination chart) is being developed. For ease of use, each of such lists is divided into several groups that reflect a particular side of the examination of a patient. These groups form the main "menu" of the list. The information is introduced either from the disk (after the previous stored examination of the patient), or in the regime of an interactive dialog (editing). The signs used for describing a patient can be unified within the groups into certain subgroups called generalized signs by us. A generalized sign is a set of combined signs that reflect some side (function, organ or other) of the signs of the group. In the algorithms of decision making only discrete signs are used (i.e., those that take only one finite value). In the simplest case we deal with a binary sign that takes the value 0 (no or no information) or 1 (a sign is present). A continuous sign used in the dialog is sure to transform into a discrete one with the help of assigned transformation (scale) when it is used for decision making.

The forms of the primary medical information (examination chart) are developed on the basis of coded lists of the signs of description of a patient to collect the material for instructing and control fetches. The latter are used for determining the constants of the algorithms of recognition and control of the work of "stereotyped patterns."

The examination chart necessarily contains a column with empty cells for fixing the values for the signs of the description of a patient. In the case of a dynamic observation of a sign (or other similar case) there can be several columns.

The list of recognizable diagnoses in a computer diagnostic system for an urgent surgeon contains all the main surgical diseases and traumas of abdominal cavity organs as well as a number of therapeutic, urological, gynecological, and neurological diseases that simulate an acute surgical pathology of abdominal cavity organs. Thus, the recognizable diagnoses involve: incarcerated hernia, open and closed injuries of abdominal cavity organs, acute appendicitis (typical and nontypical forms), acute diseases of hepatobiliary organs, acute pancreatitis, acute ileus,

acute gastroduodenal hemorrhages, acute disturbances of mesentery blood circulation, perforating gastric and duodenal ulcers (typical and nontypical forms), perforations of intestine, some rare diseases and diseases complicated by peritonitis. The therapeutical pathology includes an acute myocardial infarction, acute pneumonia, acute attack of peptic ulcer, gastroenterocolitis, coprostasia and spastic colitis, acute respiratory viral infection, cirrhosis of the liver. Urologic diseases involve: renal colic, acute retention of urine, acute pyelonephritis, acute cystitis, acute orchiepididymitis, nephropathosis. The recognizable gynecological diseases include: extrauterine pregnancy, acute adnexitis, ovarian apoplexy, rupture of ovarian cyst, acute endometritis, pelvioperitonitis. The neurological diseases involve: intercostal neuralgia, discogenic radiocuboneuritis, herpes zoster. The flow diagram of decision making is constructed in the following way: first incarcerated hernia, closed and open traumas of the abdominal cavity organs, and acute gastroduodenal hemorrhages are differentiated. There is a provision for making one gynecological diagnosis (metrorrhagia) and the failure of the system in the case of the unconsciousness of a patient. Then we operate along the main branch of the flow diagram, and diseases are separated that are complicated with peritonitis, because the presence of the latter often veils the symptomatology of the main disease. Among the diseases not complicated by peritonitis we can discern 5 groups of diagnoses of acute surgical pathology, which then are deciphered into corresponding subsystems, and a diagnosis of a typical form of appendicites is made. Moreover, at this stage 27 nonsurgical diagnoses are made and the absence of surgical pathology is determined. All in all 14 surgical diagnoses are made at these stages (initial and main) (complicated and not complicated with peritonitis), including 5 group diagnoses. In the case of vague clinical manifestations and failure of the system to attain a specific stereotyped surgical or nonsurgical diagnosis, a cardinal question about the presence or absence of surgical pathology is solved in the flow diagram according to the standard stereotyped pattern. If a surgical pathology is rejected, then according to the nearness to the available stereotyped patterns the consultation of one of the specialist is recommended: a therapist, a gynecologist, a urologist, or a neuropathologist. If the surgical pathology is not excluded, then according to the probobalistic method the character of the pathology is determined for assigning it to one of the subsystems.

We developed coded lists of signs: the initial and the main one. The initial coded list together with the filled questionnaire contains 20 signs allowing one to isolate acute gastroduodenal hemorrhages, incarcerated hernia, traumas of abdominal cavity organs, or metrorrhagias, to state the absence of a surgical pathology, and forsee the failure of the system in the case of the unconsciousness of a patient.

The main coded list contains 294 signs selected from the data in the literature and on the basis of the available clinical experience. The signs are grouped into sections: characteristic of a painful syndrome, complaints, case history, past diseases, traumas and operations, objective data, laboratory and special methods of examination.

In the section containing the characteristics of a painful syndrome there are subjective and objective data on the localization and irradiation of pains, their duration and character. Complaints of patients can be described by main signs characteristic for surgical and nonsurgical pathology simulating it (feeling, respiratory disorders, dispeptic disorders, character of defecation, dysuria, gynecologic status). The case history contains 9 main signs, determining more accurately the reasons for the beginning of disease. The section of past diseases, traumas, and operations enumerates diseases, traumas, and operations that can help in making diagnosis and differential diagnosis of the available pathology, as well as complicate or change the clinical course of the pathological process. The section "Objective data" includes inevitable signs (symptoms and syndromes) for accurate determination of the state of a patient at the moment of examination; this is especially important for a correct diagnosis of a specific nosologic form. Auxiliary laboratory and special methods of examination include the results of the simplest examinations: rectal, total blood count and analysis of the urine, roentgenoscopy or roentgenography of lungs and abdominal cavity, electrocardiography emphasizing those signs whose presence or absence helps in giving a diagnosis and differential diagnosis of acute surgical diseases of abdominal cavity organs.

The developed technology of mathematical simulation of acute surgical pathology of abdominal cavity organs made it possible to create an intellectual diagnostic system with a high degree of validity of diagnosis, which serves for the support of decision making in complex situations of choice in surgery. A further application of the mathematical technology in clinics will help one to solve the problems of determining the tactics and prediction of

the course of disease and development of complications, and raise to a new level the quality of the treatment of patients.

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