

**THE ROLE OF ENDOSCOPIC ULTRASONOGRAPHY IN
DIFFERENTIATING OBSTRUCTIVE PATHOLOGIES OF THE DUODENUM**

Karimov Z.B.

Samarkand state medical university

ANNOTATION. Objective: to improve the quality of endoscopic ultrasonography (EUS) in the diagnosis of obstructive pathology of the major duodenal papilla (MDP) using fuzzy diagnostic models. Materials and methods. The study included 189 patients treated at the Kursk Regional Multidisciplinary Clinical Hospital in 2013-2023 . 134 people (70.9%) were diagnosed with stenosis of the BDJ, 24 (12.7%) were diagnosed with single benign tumors of the papilla, and 31 (16.4%) patients were diagnosed with malignant tumors of the BDJ. Based on the analysis of treatment results, the possibility of differential diagnosis of BDK pathology based on EUS data using fuzzy diagnostic models was studied. Differentiation was carried out using the methodology of synthesis of hybrid fuzzy decision rules, within which the lack of statistical data is filled with the clinical knowledge of experts, which determines the possibility of constructing a membership function for the pathology being differentiated. Results. As part of the methodology, informative echographic criteria for diagnosing various pathologies of the BDK based on endosonography data have been developed , systematized and presented in the form of standard endosonograms and reference diagrams, which reflect the characteristics of the diagnostic object as fully as possible. Based on expert assessment data, confidence coefficients in decisions made were determined, which are the basis of the diagnostic algorithm. The results of mathematical modeling showed confidence in the correct diagnosis of pathological changes using synthesized fuzzy algorithms over 0.85, which is an acceptable result for clinical use. Conclusion. The use of the developed fuzzy model in combination with visual inspection of the papillary zone (which is provided by the EUS method) brings the diagnostic accuracy of differential diagnosis closer to maximum values.

Key words: obstructive pathology; major duodenal papilla; endoscopic ultrasonography ; fuzzy mathematical models.

Introduction. One of the most relevant and difficult to diagnose localizations of pathology of the hepatopancreatoduodenal zone (GPZ) is diseases of the major duodenal papilla (MDP), the spectrum of which is characterized by significant diversity [1]. Localized at the narrowest point of the confluence of the ductal systems of the liver and pancreas, pathological formations of even small sizes have a significant impact on the functioning of all organs of the gastrointestinal tract. Of particular importance is the differentiation of pathological inflammatory, benign and malignant lesions of the BDDC, which consists in the fact that tumors of this localization are characterized by a less malignant course and are more often resectable . However, the success of treatment depends most on correct diagnosis at an early stage of the disease [2]. Endoscopy is the most valuable of the available imaging methods, since it provides not only direct visualization of the process, but also the ability to obtain material for morphological

examination [2, 3]. Significant difficulties arise with intra-ampullary localization of pathology, as well as with staging of BDDC neoplasms. The use of endoscopic ultrasonography (EUS) in clinical practice has improved the quality of diagnosis of BDK diseases [4, 5]. For intraampullary cancer, endosonography is most effective compared to other imaging methods [6]. EUS is also sensitive in differentiating tumor and fibrous stenosis of the BDK, sludge bile duct contents, microcholelithiasis, early stages of chronic pancreatitis [7]. Modern instrumental diagnostics are highly effective in determining the level and extent of obstruction, but of particular value is determining the nature of pathological changes in the early stages of the disease, which determines treatment tactics [8]. The lack of clearly formulated diagnostic endosonographic criteria for inflammatory and neoplastic changes in the BDDC is natural and is explained by the inability to use widespread statistical methods of data analysis to isolate and assess the informativeness of echo signs, since it is not possible to create representative homogeneous samples of patients with a statistically significant difference in each diagnostic criterion. Modern information and intellectual technologies make it possible to objectify and increase the accuracy of the assessment of medical information, including images. In this work, to implement such a task, the methodology for the synthesis of hybrid fuzzy decision rules (MFDR) is used [9]. The lack of representative statistical data in the MSGNRP is compensated by the clinical thinking of experts. This makes it possible to realize the natural intellectual potential of specialists to construct the membership function of differentiated pathology, taking into account practical experience and current theoretical information. Membership functions are the basis of the decisive rules of medical diagnostics, which concentrate the advantages of expert and statistical methods for processing complexly structured data [10, 11]. The purpose of the study is to improve the quality of EUS in the diagnosis of obstructive pathology of the BDK using fuzzy diagnostic models.

Materials and methods.

EUS was performed using videogastrosopes with radial and convex ultrasound scanning sensors GF UM160 and GF UC140P–AL5. The endoscopic video system EVIS EXERA II from Olympus (Japan) with an ultrasound processor EUME1 with a variable scanning frequency of 7.5, 12 and 20 MHz was used. The research methodology did not differ fundamentally from standard methods of endosonography of pancreatobiliary organs [12,13]. The study is based on the results of diagnosis and treatment of 189 patients with BDDC pathology who were treated at the Commissariat Clinical Hospital from 2013 to 2023. The age of the patients ranged from 24 to 82 years, the average age was 69 ± 6.3 years. Most of the patients were women - 119 people. (63.0%). In 134 (70.9%) patients, stenosis of the spinal cord was diagnosed, and we consider it appropriate to subdivide it into hyperplastic stenotic and sclerosing papillitis. Stenotic papillitis with an increase in the size of the BDK was detected in 20 (14.9%) people. Sclerosing papillitis, characterized endosonographically by a narrowing of the terminal segment of the common bile duct and thickening of the walls of the lateral bile duct, was found in 41 (30.6%) patients. In the remaining 73 (54.5%) cases, no direct echographic criteria for stenosis of the LBD were visualized, and the diagnosis of stenotic Papillitis was

diagnosed based on a set of indirect echo signs using a diagnostic algorithm developed and implemented in the clinic. Benign neoplasms of the BDK were diagnosed in 24 (12.7%) patients. The average size of the formation was 0.98 ± 0.11 cm. Malignant pathology of the BDK was detected in 31 patients (16.4%). In 16 (51.6%) cases, signs of infiltrative growth spreading to the pancreas, common bile duct, and duodenum were identified. The average tumor size was 2.0 ± 0.13 cm. Statistical data processing was carried out using Sigmaplot 11.0 software. Quantitative data for comparison of groups were presented in the form of the arithmetic mean of the sample population (X), standard deviation (SD), standard error of the mean (m), which made it possible to assess the magnitude of the differences and its clinical significance. To statistically assess the information content of diagnostic research methods, the operational characteristics of the test were used: sensitivity, specificity, accuracy as components of evidence-based medicine technologies. The assessment of the informativeness of EUS was based on a comparison of diagnostic results with the results of a morphological study in combination with a set of clinical and laboratory methods accepted as the “gold standard”. The final diagnosis was established based on the results of endoscopic punch biopsy, intraoperative biopsy, percutaneous aspiration biopsy with ultrasound and fine-needle puncture of focal lesions with EUS, with the condition of monitoring patients for at least 12 months. Biopsies were taken from 52 (38.8%) patients with BDDC stenosis and from all 55 patients with BDDC neoplasms. The vast majority of biopsies (96.1%) were informative. Within the framework of MSGNRP, for the differential diagnosis of obstructive pathology of the BDK, as the main elements of decision-making rules, as well as in the classical soft computing paradigm, functions of membership in hypotheses (classes) with basic variables determined by the essence of the problem being solved were used (informative features, complex and integral indicators calculated in various ways, including fuzzy inference rules, event confidence coefficients). The typical composition of MSGNRP included: a block of exploration analysis programs that allow studying the structure of multidimensional data in their clear and fuzzy representation; a package of application programs that implement methods for the synthesis of hybrid fuzzy decision rules, focused on their specific data structures; recommendations on ways to combine (aggregate) private models into private (intermediate) and final hybrid decision-making models; an interactive algorithm implemented as a user guide for the synthesis of hybrid fuzzy models for solving poorly formalized problems.

Results. Analysis of the structure of echographic signs characteristic of benign and malignant pathology of BDK showed that in a significant number of patients the diagnosis can be established only by a set of statistically insignificant signs for which it is impossible to identify reliable connections with differentiated pathology. Research by E.N. Solodinina (2016) showed that there is no strong correlation for any of the sonographic features describing BDDC neoplasms, which does not allow identifying clear criteria for the differential diagnosis of BDDC adenocarcinoma; in addition, such studies are often limited by a small sample size, heterogeneity of design, or limited comparative analysis of research results with reference diagnostic methods [14]. In such a situation of data uncertainty, the use of MSGNRP [15, 16], which is based on a

symbiosis of the intelligence of a medical specialist, a cognitive engineer and artificial intelligence, is justified to solve the assigned problems. At the same time, the missing formal and statistical data are filled with the knowledge of qualified ultrasound diagnostic specialists oriented in the pathology of the gastrointestinal tract, who, including on the basis of their own experience, differentiate the diagnosed pathology. In order to implement MSGNRP for the differential diagnosis of malignant and benign pathology of the BDDC, a detailed analysis of the echographic criteria of the BDDC pathology was carried out, which we presented in the form of two groups. Criteria for malignant pathology: hypoechoic formation in the projection of the BDDC with uneven, unclear contours, irregular shape, hypoechoic infiltration of surrounding tissues, spread of the formation to the common bile duct, main pancreatic duct and duodenum, tumor size more than 2 cm, lack of differentiation of the BDDC layers, “duct breakage”, double duct sign, metastatic lymphadenopathy, large vessel invasion. Signs identifying a benign formation of the BDDC include: homogeneous, homogeneous, hypo / isoechoic formation in the ampulla of the BDDC, smooth and clear contours of the formation, correct shape of the formation, intact structures surrounding the BDDC, preservation of differentiation of the layers of the BDDC, smooth contours of the BDDC, lymphadenopathy without signs of malignancy lesions, the size of the formation is less than 2 cm. We presented the systematization of echographic criteria for the pathology of BDK in the form of reference sonograms, which most fully reflect the echographic characteristics of the object, which will most accurately allow the user to identify the desired pathology. Reference endosonograms were selected from the entire array of digital video materials of the results of endosonography of patients with obstructive pathology. Prospective and retrospective analysis of video images generated a series of endosonograms that structurally display the diagnosed pathology. Sonograms were formed from video tracks by storyboarding to select the most optimal images. Reference endosonograms were placed in a series of images of structures in order of changes in the pathology of the BDK from benign to malignant. The scale of images for differential diagnosis of the pathology of the BDDC included the following reference endosonograms: the structure of the normal BDDC, the structure of the BDDC with sclerosing papillitis, structure of the BDK with hyperplastic stenosis papillitis, structure of BSDE adenoma, structure of BSDE cancer without infiltration of surrounding tissues, structure of cancer with infiltration of surrounding tissues. The determination of the initial system of signs used to solve the task of forming a space of initial informative signs for the differential diagnosis of BDK pathology was carried out by ultrasound diagnostics (USD) experts, since there is currently no regulated algorithm for solving such problems. A collegial analysis of endosonograms by ultrasound doctors and competent specialists in the field of visual information processing regulated the possibility of synthesizing diagnostic models using two types of images: reference endosonograms of the structure of a pathological formation and their reference diagrams. This double visual detailing of the pathology was chosen to improve clinicians' visual perception of the observed pathology. As an example, Figures 1, 2, 3, 4 show pairs of reference and reference sonograms for the structure of a normal BDK, with stenotic papillitis and cancer with infiltration of surrounding tissues.

Conclusions.

The widespread development of ultrasound technologies in combination with visual examination, implemented in endosonography technology, has brought the diagnosis of pathology of the ampullary zone of the duodenum to a qualitatively new level. Endosonography allows you to visualize in detail the papillary area of the duodenum and determine the nature of the pathology. The development, systematization and objectification of the assessment of echographic symptoms using artificial intelligence technologies increases the reliability of endosonography results and the accuracy of their interpretation. The use of MSGNRP for the differential diagnosis of obstructive pathology of the BDK eliminates the lack of statistically reliable data due to the productive interaction of the intelligence of diagnostic specialists, a cognitive engineer and artificial intelligence. Thus, the resulting model for the differential diagnosis of obstructive diseases of the BDK, based on the results of EUS and synthesized hybrid fuzzy decision rules, made it possible to objectify and increase the efficiency of EUS diagnosis of the pathology in question, providing confidence in decisions made at the level of 0.9. Supplementing the developed fuzzy mathematical model for the differential diagnosis of the pathology of the duodenum with information about the state of the regional lymph nodes and great vessels, as well as taking into account the possibility of visual inspection of the ampullary area of the duodenum, provided by the EUS method, brings the diagnostic accuracy closer to maximum values. These circumstances allow us to recommend the resulting diagnostic model for practical use.

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