Modern methods of diagnosis of gynecological diseases

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Abstract

The article discusses modern methods of diagnosis of gynecological diseases. In recent years, there has been significant progress in the application of artificial intelligence (AI) in medicine, including gynecology. This paper presents an overview of modern methods of diagnosing gynecological diseases using AI. The authors consider various approaches, such as machine learning and deep learning, and describe their advantages in the context of improving diagnostic accuracy and speed. Special attention is paid to the analysis of large volumes of medical data, which allow us to create more effective diagnostic algorithms. Additionally, the potential of integrating AI into clinical practice and its impact on improving the quality of medical care for women is being considered, opening up new prospects in the field of gynecology.

Keywords

Gynecological diseases, Artificial intelligence, Machine learning, Diagnostic algorithms.

INTRODUCTION

In modern medical practice, clinicians have to work with a huge amount of data to improve patient outcomes. Sometimes one clinician has to deal with thousands of ultrasound images or hundreds of documents with laboratory results. To increase the efficiency of this work, at the present stage, specialists use artificial intelligence (AI) resources [1].

Modern advances in artificial intelligence (AI) are attracting increasing attention in medical practice, especially in the context of diagnosis and treatment of diseases. In gynecology, where the accuracy and promptness of diagnosis play a critical role in successful treatment, the use of AI promises a significant improvement in the quality of medical care for women.

The methods of diagnosis of gynecological diseases used today largely depend on the doctor’s experience and interpretation of clinical data. However, the human factor can lead to errors or subjective outcomes, especially in complex incidents or ambiguous symptoms. In this context, the use of AI in the diagnosis of gynecological diseases represents a promising approach to improve the accuracy and speed of diagnosis.

The purpose of this article is to review modern methods of using AI in the diagnosis of gynecological diseases. The paper examines various machine learning and deep learning techniques, as well as their application to the analysis of medical data, in order to identify pathologies and determine the optimal therapeutic approach.

In addition, the advantages of using AI in gynecology are analyzed, such as increased accuracy and efficiency of diagnosis, as well as prospects for integrating these technologies into clinical practice.

MATERIALS AND METHODS

In the process of writing a paper on this topic, methods of preprocessing medical data were studied, such as processing text information, images, time series data, etc. The features of using machine learning and deep learning algorithms for the diagnosis of various gynecological diseases, such as cervical cancer, ovarian cancer, endometriosis, etc., as well as the possibilities of analyzing ultrasound, magnetic resonance...
and other medical images to identify pathologies are considered. In addition, the features of processing and analyzing textual data, such as medical reports, medical histories and test results, have been studied. The medical literature has been studied, demonstrating the conduct of clinical trials to evaluate the effectiveness of the developed diagnostic methods using AI resources on patients.

Results. In recent years, interest and research in the field of artificial intelligence (AI) technologies and their applicability in medical practice have increased significantly. Artificial intelligence-based systems have found their application in a number of different fields of medicine, especially in those where the visualization component is important, offering high prospects for more efficient and effective use of medical images [2].

The rapid development of AI has recently led to the spread of advances in artificial neural networks, which simplify the interpretation of multifactorial data using a mathematical system. The diverse advantages of artificial intelligence have allowed it to be widely used in the field of medicine to analyze huge amounts of data. This helps in monitoring the condition of patients, prognosis, diagnosis and prevention of diseases. Over the past few decades, there has been an increase in the use of AI in healthcare systems. In general, artificial intelligence helps practitioners and clinicians make decisions with a high degree of confidence.

In the last decade, there has been a lot of discussion about the position of artificial intelligence in the field of medicine, with special attention paid to big data management, algorithm evaluation and forensic problems. Researchers have written extensively about the benefits of artificial intelligence applications, which highlight the technology’s potential to improve the accuracy of diagnoses, the entire clinical treatment process, and therapeutic effectiveness [3].

The artificial intelligence system is able to provide specialists with medical information with consistent and continuous updates in real time, obtained from various textbooks, journals, clinical patients and practices, which allows them to conduct the necessary analytical work, improves patient care and helps to draw the necessary conclusions for predicting health outcomes and risk assessment.

Currently, AI is used in obstetrics and gynecology as the dominant interpretation tool that helps in determining complications of pregnancy and premature birth, as well as in analyzing discrepancies in interpretation among clinicians [4]. These benefits help clinicians reduce infant and maternal mortality and morbidity. In addition, artificial intelligence is an important tool for creating algorithms for identifying problems associated with a shortened cervix, thereby it is possible to achieve a reduction in the risk of premature birth.

The use of artificial intelligence in gynecology and obstetrics makes it possible to solve significant problems in diagnosis and treatment. Interpretation of CTG and fetal physiology can be facilitated with the help of AI, which will limit the adverse effects of the human factor [5].

Ultrasound examination using artificial intelligence has the potential to increase the turnover of the use of medical ultrasound in various clinical settings. Therefore, the use of artificial intelligence in ultrasound during pregnancy could help doctors diagnose the body of pregnant women. For example, in the case of ultrasound examination of the pelvic organs and echocardiography, where visual analysis and measurements are required, it will be possible to analyze the entire group of relevant structured data, allowing for spatiotemporal analysis [6].

Experts investigated the level of accuracy of ultrasound diagnostics based on artificial intelligence algorithms during pregnancy, used to diagnose a patient who had symptoms of a brain tumor. The accuracy of AI-based diagnostics was 94.50%, and the K-value was 0.99 [7]. Another group of specialists has developed an algorithm for processing ultrasound Doppler images, which could significantly improve the quality of ultrasound images, reduce noise and significantly expand the possibilities of clinical diagnosis of diseases at different stages of pregnancy, up to the birth of a child [8].

During pregnancy, images of the placenta of patients with hypertension, if identified, differ from images of the placenta in groups without hypertension. The results have proven to be a marker for predicting hypertensive disorders during pregnancy (GPB), as it is a non-invasive, cost-effective method. Here, the use of artificial intelligence is necessary to assess variations in the structure of the ultrasound image of the placenta in pregnant women with hypertension and normal outcomes. This lays the foundation for the development of a textural feature extraction module, which could make it possible to assess adverse preg-
nancy outcomes before detecting clinical manifestations of the disease [9].

AI-based diagnostic support tools have demonstrated higher performance in various fields of medicine. One group of specialists has put into practice a new graphical representation based on machine learning, which supports ultrasound screening of the fetal heart, characterized by a low level of detection of congenital heart defects at the stages of the second trimester. As a result, the effectiveness of screening using artificial intelligence in the second and third trimesters for the diagnosis of pregnant women using chart representation can be improved from 96% to 97.50% [10].

In addition, the plane of fetal ultrasound examination is changing rapidly, since fetal movement requires an algorithm capable of evaluating moving images in real time. For the development and validation of the AI system, specialists propose a system of prenatal ultrasound diagnostics AI conduct system (PAICS), which allows to determine various intracranial changes in the fetus, patterns of abnormalities in standardized sonographic reference planes to identify any congenital malformations of the central nervous system (CNS). Another group of specialists evaluated the effectiveness of the artificial intelligence method based on automated analysis of fetal brain morphology during standard ultrasound examination of the skull to predict the parameters of gestational age in the second and third trimesters of pregnancy [11].

The use of AI in gynecology is still at an early stage compared to other specialties. In fact, despite the fact that gynecology is one of the areas with the largest component of imaging, the impact of AI on practice is still in its infancy [12]. Nevertheless, there is a need to understand the limitations of available clinical imaging techniques, namely the workload of the clinician, as well as variability within and between observers, and AI has the potential to overcome these limitations while increasing diagnostic accuracy [13]. However, AI has huge and recognized potential to help with repetitive tasks such as automatic identification of good quality images and identification of image patterns.

**DISCUSSION**

Let’s consider modern approaches to the diagnosis of gynecological diseases using AI. For example, a pathology such as cervical cancer is diagnosed quite often: The cumulative incidence worldwide is 13.3 cases per 100,000 women. It is known that the prognosis of cervical cancer treatment is favorable if the disease is diagnosed in the early stages [13].

In everyday practice, cervical cancer screening is based on testing for human papillomavirus (HPV) and cytological examination. Therefore, it largely depends on the pathologist’s experience, which is also less accurate and has high variability between observers. Colposcopy is also an important component of the diagnosis of cervical cancer. However, due to the increased workload, visual screening leads to an erroneous diagnosis and low diagnostic accuracy.

In 2012, a group of researchers developed a computer diagnostic device (CDD) based on image processing techniques for automatic analysis of colposcopy images. The CDD system showed diagnostic accuracy of 80%, sensitivity of 85% and specificity of 75% in differentiating normal or cervical intraepithelial neoplasia of grade 1 (CIN1) from squamous intraepithelial lesions of high malignancy (HSIL) (CIN2 or CIN3). During colposcopy. A second study conducted by the same group confirmed the benefits of using CDD in evaluating colposcopy, demonstrating an increase in diagnostic accuracy when the examination was evaluated by a less experienced gynecologist [14].

Another group of specialists developed and trained a clinical decision support system (CDSS) based on an artificial neural network to properly sort 740 women before referral for colposcopy. For these purposes, cytological diagnosis data and the expression of various biomarkers were used [15].

Over time, methods for diagnosing cervical cancer using AI have been improved and currently, given the ability to exclude most of the normal cytological studies and increased sensitivity compared to manual cytology indications, the results confirm the possibility of using an artificial intelligence-based cytological system for primary screening of cervical cancer in a large-scale population.

New imaging techniques have been evaluated to improve the accuracy of diagnosis of cervical lesions. High-resolution endomicroscopy (HRME) consists of a fiber-optic fluorescence microscope capable of obtaining nuclear images in vivo. In 2022, a team of specialists used an image dataset of more than 1,600 patients to train, validate and test the CNN algorithm for diagnosing CIN2+ cases from HRME images. The proposed method consistently surpassed existing gold standard methods, achieving 87% accuracy, 94% sen-
sitivity and 58% specificity. Due to the inclusion of HPV status, the specificity increased to 71% [16].

Endometrial cancer is the most common gynecological malignant disease in developed countries, the prevalence of which is increasing. Usually, the disease is diagnosed at an early localized stage on the background of postmenopausal bleeding. However, cases with advanced disease have a poor prognosis at the time of diagnosis. In addition, endometrial cytology is not a cost-effective screening method because it has a large number of false negative results. In this context, artificial intelligence algorithms are a useful tool either for the automatic classification of hysteroscopic or histopathological images necessary for the diagnosis of endometrial cancer, or for preoperative prediction based on MRI [17].

The diagnosis of endometrial cancer is classically made after the analysis of histopathological material obtained during hysteroscopy. Thus, AI can play a role in simplifying anatomical and pathological diagnosis, while reducing the problem of variability of results between observers.

Endometriosis is a chronic disease that entails a significant economic and disease burden on society. It is defined as the extrauterine growth of endometrial-like tissue in various organs, namely the ovaries, small intestine, colon, bladder and peritoneum, causing pain and fertility problems. As a non-invasive and easily accessible tool, transvaginal ultrasound is usually used in clinical practice for screening, but laparoscopic examination with sampling of lesions and histological assessment remains the gold standard for the diagnosis of endometriosis [18]. Artificial intelligence algorithms can play a key role in early detection of the disease, namely by automatically evaluating imaging results that are usually difficult to interpret, or by developing predictive models for earlier diagnosis and better control of the disease.

In fact, endometriosis has many symptoms, often non-specific, which complicate its diagnosis. In fact, the absence of clinical and minimally invasive markers of the disease leads to an appropriate number of diagnostic laparoscopies performed in this clinical context. In 2022, an AI algorithm based on 16 clinical and individual symptoms was developed. The high diagnostic efficiency suggests that the algorithm is a potential replacement for diagnostic laparoscopy, and also provides general practitioners with a possible tool for minimally invasive diagnosis or suspicion of this disease [19].

The available data indicate that endometriosis is characterized by a change in the number of certain molecules (i.e. proteins, antigens) in the blood, which can be assessed using Raman spectroscopy, a non-invasive method for diagnosing endometriosis. In fact, colon damage in endometriosis is common, and there are published papers on the use of AI models in their diagnosis. Specialists tested several AI-based models during ultrasound diagnostics of endometriosis with intestinal damage [20]. They compared the accuracy of various methods, combining the age of patients with ultrasound markers, namely the presence of ultrasound signs of uterine adenomyosis, endometrioma, ovarian adhesions with the uterus, etc. The neural network algorithm demonstrated the best performance: accuracy 73%, sensitivity 72%, specificity 73%, PPV 52% and NPV 86% for the diagnosis of rectosigmoid endometriosis.

Several AI models (clinical, biochemical, and radiological) have been developed for earlier minimally invasive diagnosis of endometriosis. The main purpose of these algorithms is to reduce the number of diagnostic laparoscopies performed in this context, which are usually performed after months or years of onset of symptoms of the disease and repeated examinations with undiagnostic results [21]. However, all algorithms have been developed retrospectively and need validation in prospective multicenter studies to replace the current gold standard and obtain an earlier diagnosis of this high-burden disease.

The initial characterization of the suspicious formation of appendages is based on the imagological features of transvaginal ultrasound and can be supplemented by other effective methods such as MRI or computed tomography (CT) [22]. Despite advances in therapy, ovarian cancer remains the most lethal gynecological cancer, mainly because women are diagnosed at a late stage. Consequently, improving the sensitivity of diagnostic tools, standardizing imaging techniques, and developing prognostic models for the risk of malignant neoplasms can reduce ovarian cancer mortality, leading to early detection of this malignant neoplasm.

Transvaginal ultrasound is usually performed for routine screening of ovarian cancer or for clinical suspicion in the presence of symptoms (namely abdominal pain, pelvic discomfort or unexplained weight loss). In addition, this examination can be performed before surgery when evaluating an ovarian tumor.
In fact, distinguishing between benign and malignant ovarian findings is a difficult task. To simplify this classification, a classification model was developed and validated to automatically distinguish malignant and benign ovarian tumors using a dataset of 1,000 benign and 1,000 malignant ultrasound images. This model was characterized by 99.9% accuracy, 100% sensitivity and 99.8% specificity [23].

In addition, artificial intelligence can play a role in improving the diagnostic accuracy of MRI. In one study, the data set consisted of 55 sonographically indeterminate ovarian formations (27 benign and 28 malignant). Here, a prospective analysis of preoperative dynamic contrast-enhanced MRI was used to identify the best descriptive parameters for predicting the malignancy of complex ovarian tumors. The peak time and the flushing rate allowed the highest sensitivity and specificity to be achieved [24].

The use of artificial intelligence models can also be aimed at recognizing the types of ovarian cancer, and not only at determining the malignant nature of the formation of appendages. A preliminary study by one group of authors evaluated the ability of the radiomicro MRI model to distinguish benign from malignant ovarian diseases and to distinguish epithelial carcinomas of type I or II. To classify benign and malignant tumors, the radiomicro MRI model achieved a high accuracy of 87% in an independent validation cohort. For the classification of subtypes of type I and type II, the method showed satisfactory efficiency, demonstrating an accuracy of 84% in the cohort of independent validation.

On the other hand, it is necessary to consider the possibility of using AI models in the histopathological analysis of ovarian cancer. Another group of specialists has developed an SVM model for automatic histopathological subtyping of ovarian cancer based on a data set of 138 patients. Their model achieved significant agreement with six clinicians who evaluated the same dataset, with a diagnostic accuracy of 90% in distinguishing subtypes.

Finally, AI may also play a role in providing accurate prognostic information for ovarian cancer patients. Thus, another group of specialists focused on the development of a neural network capable of predicting the overall survival of patients with epithelial ovarian cancer, comparing it with a logistic regression model. The model made it possible to predict the overall survival rate with an accuracy of 93%. In the case of predicting the outcome of the operation (complete/optimal cytoreduction versus suboptimal cytoreduction), the neural network again showed good results with an accuracy of 77% [25].

Urogynecology is facing new challenges as we try to improve the diagnostic accuracy of various studies while reducing variability between observers. Some research has focused on the potential of artificial intelligence methods in urogynecology as a diagnostic tool by expanding the capabilities of well-known methods such as ultrasound, dynamic and functional MRI, as well as standardizing the interpretation of urodynamic tests.

Stress incontinence is a widespread condition associated with high morbidity. The disease is usually diagnosed using urodynamic tests, but other alternatives have been studied. A group of specialists has developed a CAD system based on a multilayer neural network of perception for the diagnosis of stress urinary incontinence based on the anatomical and functional characteristics of the bladder neck during perineal ultrasound. The proposed CAD system effectively identifies problems using perineal sonographic analysis with an accuracy of 91.7%, sensitivity of 94.4% and specificity of 83.3%. This study confirms the ability of artificial intelligence models to accurately identify patterns in images.

There have also been several studies evaluating the impact of artificial intelligence models on the evaluation of urodynamic research. Indeed, the use of artificial intelligence algorithms could reduce the variability between observers associated with the interpretation of the exam. Detrusor hyperactivity, a marker of an overactive bladder, is detected in urodynamic studies and often correlates with lower urinary tract symptoms requiring treatment.

Thus, artificial intelligence-based systems have succeeded in analyzing and interpreting images and over the past decade have become powerful tools capable of revolutionizing the field of gynecological imaging. In the studies presented above, AI was able to provide faster and more accurate forecasts and diagnostics, increasing the overall effectiveness of gynecological care. AI is actively integrated into clinical practice, helping in the decision-making process and reducing classification errors and variability between human observers, either because of their unstable nature or because of their unstable nature. Fatigue accumulated by medical workers due to the ever-increasing workload. In
the field of gynecological cancer, undoubtedly one of the most promising aspects is the ability to better analyze and, especially earlier, obtain more reliable results and, ultimately, which can improve patient survival.

In fact, the use of AI systems in gynecology is still at the start. This new healthcare technology relies heavily on a large amount of data, and its anonymization or re-identification is difficult and time-consuming. A large amount of information creates a problem in data management. The solution to this problem could be the generalization of blockchain technology in the data generated by AI. The blockchain allows you to locally store decentralized medical data that remains unchanged. Thus, the introduction of blockchain technology into the following artificial intelligence models is fundamental to ensure the integration of ever-growing information.

At the same time, it is important to consider the consequences associated with an AI-based solution. When faced with an error in AI forecasting, several factors must be taken into account, namely the quality of model training, the type of algorithm, and bias in data collection and analysis. However, patient safety should be a priority, and a model can be developed with a higher sensitivity priority, even in the case of an increase in the number of false positive cases.

The problem of legal responsibility for decisions made with the help of AI is also quite relevant. It is often difficult to identify the point in the algorithm at which the decision was incorrect, and doctors must be able to consistently interpret the output of the model at the risk of reducing patient confidence when they encounter errors caused by a decision based on artificial intelligence. To date, there are no clearly defined rules on the ethical and legal issues of the use of AI in healthcare, and this issue should become a priority for the standardization of best practices in the use of AI.

CONCLUSIONS.

The dynamic growth of AI exponentially has led to its application in various fields, including in the field of healthcare. Technological advances in the field of learning theories and algorithms, as well as the availability of processing huge amounts of data, have led to a breakthrough in the field of medicine using computing systems. Artificial intelligence has the potential to help clinicians and practitioners make appropriate decisions when managing patients and making a diagnosis, which is why its use is widespread in the field of medicine. Thus, computerized algorithms have made the predictions quite simple and accurate. In addition, subsets of AI, namely machine learning and deep learning methods, have helped to discover complex patterns from huge datasets and use such patterns in making predictions.

In the presented analysis, modern methods of diagnosing gynecological diseases using AI were considered. It is noted that the use of AI in gynecology has significant potential to improve the accuracy and efficiency of diagnosis, which is a critically important factor in the successful treatment of patients.

The use of machine learning and deep learning methods allows you to analyze medical data with high accuracy and efficiency. This includes the analysis of images, text information and other types of medical data, which provides more accurate identification of pathologies and determination of optimal treatment approaches.

In addition, the use of AI in gynecology provides new opportunities for integration into clinical practice. It allows you to create automated decision support systems that can help doctors make more informed and informed decisions. However, it is necessary to take into account the ethical aspects related to the processing of medical data and the introduction of AI into practice. It is important to ensure patient confidentiality and compliance with data security standards.

Thus, the use of artificial intelligence in the diagnosis of gynecological diseases opens up new prospects in the field of medicine, contributing to improving the quality of medical care for women and increasing the effectiveness of treatment.

REFERENCES