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**The future of prostate imaging - artificial intelligence in assessing prostatic MRI**

AI in prostate imaging

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## Abstract

Prostate cancer is one of the most common cancers in men and one of the leading causes of death. In recent years, with the advent of multiparametric magnetic resonance, the diagnostic approach of the disease has significantly improved, but certain limitations have also been discovered. The diagnosis of prostate carcinoma requires a lot of experience in the field, and yet the lesions are sometimes difficult to detect. Artificial intelligence has entered radiology in recent years, with new software solutions being offered in the field of prostate diagnostics. Through artificial intelligence, precise mapping of the prostate is possible, which greatly improves accurate biopsy. With artificial intelligence, certain suspicious lesions can be attributed to a given group according to the PI - RADS classification. Artificial intelligence allows combining the data obtained from the clinical examination, the PSA levels, the result of the magnetic resonance imaging, the biopsy, and in this way new regularities can be found, which at the moment remain hidden. The introduction of artificial intelligence is an inevitable process in the future, which will significantly expand the possibilities of diagnosis and treatment of prostate cancer.

**Key Words:** Artificial intelligence, Deep learning, Machine learning, Multiparametric magnetic resonance imaging, Prostate cancer, Quantitative imaging.

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**Core Tip:** There are currently enough studies showing the possible benefits of using artificial intelligence in prostate cancer diagnosis. In addition, there are various software products to assist the radiologist in diagnosis in this field, created by leading companies. However, a new approach is needed in diagnosing prostate carcinoma due to the complexity of the disease.

## **INTRODUCTION**

Prostate cancer is one of the leading causes of death from oncological diseases, and it ranks second in men. Despite the high frequency of the disease, a screening program has not yet been presented, and specialists in the field rely on rectal examination and PSA testing. If a finding is detected, a TRUS biopsy is performed [1]. Prostate carcinoma is classified as clinically significant and non-significant, with the considerable carcinoma requiring surgical treatment due to the possibility of metastasis and the non-significant being followed up [2-4]

Multiparametric magnetic resonance imaging (mpMRI) is gaining ground as a primary method for prostate cancer diagnosis. However, the study creates certain difficulties and requires a profound knowledge of the field and serious experience with magnetic resonance imaging [1-3,5]. The presentation of the PI-RADS 2.1 system describes the findings detectable in prostate carcinoma, which aims to standardize the diagnosis of carcinoma [6-8].

Multiparametric magnetic resonance imaging (mp-MRI) has opened up new opportunities for PCa detection and diagnosis. It is specifically recommended for patients with elevated PSA levels but with negative biopsy results and biopsy naïve patients who are being monitored for PCa due to risk factors. In addition, Multiparametric MRI is considered a safer alternative to TRUS biopsy, reducing the rate of post-biopsy complications [4].

Three-dimensional images of the prostate gland, including high-resolution T2-weighted (T2WI), diffusion-weighted (DWI), and dynamic contrast-enhanced (DCE) images, are obtained using mp-MRI. Figure 1.

The results are combined to determine the level of risk for clinically significant cancer, following the prostate imaging-reporting and data system (PI-RADS), whose most recent version from 2019 is characterized by improved sensitivity and specificity [4].

American and European guidelines differ from each other according to the exact appropriate time of biopsy [9]. Gleason staging has proven to be an accurate method, but it also has significant limitations in diagnosis and quantification. For example, there is an underestimation of tumor size with the PI-RADS system, especially in patients with a low PI-RADS score [10]. In addition, the heterogeneity of prostate carcinoma, the limitation of mpMRI, and possible biopsy errors sometimes lead to inconsistencies in the overall assessment of the patient's condition.

Currently, the detection of prostate carcinoma depends to a large extent on the experience of the radiologist, and in some cases even experienced radiologists find it difficult to detect the carcinoma or the detected lesions are difficult to classify by PI-RADS. In addition, in many cases, due to the hypertrophy of the prostate in adult patients, it is impossible to accurately localize the lesion and, accordingly, it is difficult to perform an accurate biopsy. It is also necessary to unify the description of a given lesion in relation to generally accepted templates. All these limitations can be overcome thanks to the development of new modern software technologies based on artificial intelligence [11].

### **Challenges in assessing prostatic MRI**

The prostate cancer detection process has its weaknesses at present. Prostate carcinoma is often confused with prostatitis, benign nodules, or hemorrhagic nodules, especially in the transitional zone. This often necessitates unnecessary biopsies [12].

Another common mistake is the wrongly assessed tumor, leading to an inaccurate biopsy and a false negative result. Another possible error is in the mechanism of producing the pathological consequence, as well as wrong evaluation by the pathologist, who may miss or wrongly stage a carcinoma [13].

Artificial intelligence is applied to various diseases in the field of imaging diagnostics and pathology, most often to increase efficiency in evaluating results. Especially in mpMRI, different AI solutions are used, which allow accurate segmentation of the prostate, as well as an accurate characterization of tumors [14]. In the field of pathology,

an improvement in diagnostics has also been observed. Radiological-pathological correlation is required, increasing the need for AI, especially in combination with biomarker data. A mechanism is needed to support the analysis of patients in multidisciplinary teams – radiologists, pathologists, and urologists. Incorporating AI into disease diagnosis would improve discovering of hidden relationships between different biomarkers [15,16].

### **AI in medicine**

Artificial Intelligence is a computer system that performs actions similar to human intelligence. AI developed rapidly in Radiology in recent years due to the ability of AI to automatically extract information. Machine learning is an algorithm that is trained for specific tasks without human intervention, which means that computers can be trained from certain examinations that are previously described by the radiologist. As more research accumulates, the effectiveness of the software increases, and after human validation, calibration is performed, resulting in better sensitivity and specificity. A subtype of machine learning is convolutional neural networks (CNNs), where different systems interact with each other [17]. Namely, this type of system is the most frequently used in the development of artificial intelligence [18].

AI can improve the detection, characterization, staging and participation in adequately treating prostate carcinoma. Accurate prostate segmentation is particularly important when performing mpMRI, which is relatively conditional on the perceptions of individual specialists. AI can be involved in the primary detection and staging of lesions relative to the PI-RADS system. A study by Lidia Mata *et al* from 2021 shows a similar characterization of human *vs* AI findings [14]. In addition, AI can optimize the exact site for biopsy, as well as create a three-dimensional model to accurately represent the location of the tumor and its relationship to neighboring organs, improving preoperative preparation.

Publications from recent years have shown regularity between the findings in T2, the changes in DWI and the density of tissue composition, allowing the creation of radiopathological maps [19-21].

Artificial intelligence has already been proven important in some other fields in medicine. Machine learning has been used in patients with appendicitis, and its role as tool to predict whether the disease is acute or subacute. The AI showed 83.75%, precision of 84.11%, sensitivity of 81.08%, and specificity of 81.01% [22]. The growing role of the precision medicine, the future improvements of machine learning and deep learning, the expansion of robotics and radiomics may play a key role for a robust and reproducible MRI-based prostatic diagnostics [23].

### **AI challenges**

The greatest challenge to artificial intelligence at the moment is the need for large volumes of data to be integrated into the systems, which requires a large volume of work time for radiologists with expertise in prostate imaging. Another challenge is that the collected data come from different MRIs from different manufacturers with varying field strengths, and the studies were performed using other protocols. This means that studies should be grouped into different groups. A study by Gaur *et al* have showed reduction of the time of interpretation of studies with the help of artificial intelligence is possible. The sensitivity also improved from 78% to 83.8%, especially in radiologists with less experience in the field [24].

### **Current AI products available**

The diagnosis of prostate carcinoma involves initial detection and accurate classification of the finding, and it is to these processes that the forces of software companies are directed. Artificial intelligence systems are "trained" to detect cancer by inputting lots of data from leading experts. Several groups are reporting various AI models for prostate



segmentation, intraprostatic lesion detection and classification tasks with auspicious results [25].

Improvements are being sought in the detection of prostate carcinomas that are invisible to human perception, thereby increasing early diagnosis [26-29].

In table 1, current AI products in the prostate field are demonstrated [30].

"AI-Rad Companion Prostate MR" by Siemens aids fusion between MRI and ultrasound. Performing an ultrasound-guided biopsy alone carries risks such as hemorrhage, infection, and abscessation. Furthermore, the procedure may not provide an answer to the presence of carcinoma in the given patient if performed solely, without previous examination. At the same time, performing a multiparametric magnetic resonance imaging scan cannot give a histological diagnosis to the patient. The modern model of prostate carcinoma diagnosis includes an ultrasound examination in combination with a previously performed magnetic resonance scan. The lesions found on the magnetic resonance scan are described by a radiologist, after which the images are superimposed on the ultrasound machine and a fusion between the two methods is achieved. Artificial intelligence in this case assists the biopsy by applying automated segmentation of the prostate, thus saving time and increasing the accuracy of the biopsy. The collaboration between the urologist and the radiologist is improved, as it allows for additional targeting of the lesions detected on the magnetic resonance [31].

Another Siemens product is the Siemens Healthineers Prostate MR, which is available on the syngo.via workstation and is an artificial intelligence that supports the evaluation of the images obtained during a multiparametric scan. Analysis time needed for the AI is extremely short – between 3 and 10 s. Prostate MR supports the primary detection and classification of findings, and offers description according to pre-entered standardized report templates. The use of this type of software is extremely valuable for training radiologists without experience in prostate diagnostics. With the help of the software, a reduction of false positive results was achieved [32].



With the advent of multiparametric resonance, the amount of examinations performed has increased significantly. Radiologists today have to interpret multiple magnetic resonance imaging scans of the prostate, but this requires great expertise in this challenging field. New guidelines from the European Association of Urology and the American Association of Radiology suggest that an MRI be performed before any biopsy is performed, and currently the number of biopsies in the US and Europe alone is over 3 million [33]. Eventual involvement of artificial intelligence in the interpretation algorithm may improve the detection rate, accurate localization and risk stratification of patients with suspected prostate cancer. "Quantib® Prostate" offers fast and automated segmentation of the prostate and detection of findings on the most used multiparametric MRI sequences - T2, ADC, DWI, DCE. The software offers assistance in the PI-RADS classification of a discovery. Finally, with the help of the software, a standardized report can be written based on pre-created templates, thus saving time and improving the quality of the report.

The DCE perfusion software identifies tumors according to their vessel characteristics.

<sup>2</sup> The Pharmacokinetic (PKM) model used in "Quantib® Prostate" helps detect neoplasms and quantifies tumor neoangiogenesis to stage cancer aggressiveness. This suite supports the characterization of tumoral processes in the early detection, diagnosis, treatment response evaluation and follow-up of patients with cancer. The software assesses the characteristics of the tissues, obtains T2 mapping and depicts the changes according to the segmentation. The information obtained allows the assessment and monitoring of solid tumors, such as prostate, rectal, and liver cancer [31].

"JPC-01K" is a neural network-based software used to characterize tumors on mpMRI.

This software aims to reduce the time needed to evaluate the prostate examination and assist in the description of findings by providing quantitative analysis. It also aims to overcome the difficulties in image analysis, which is largely dependent on the radiologist and his qualifications and experience.<sup>4</sup> The system uses multiparametric MR images, T2, DWI, and DCE, as input and visualizes the location of prostate cancer and its probability. According to a study carried out in one center, the accuracy of the

method was observed to be 99.65% with a time required for analysis of only 2 minutes. The artificial intelligence at this manufacturer undergoes constant improvement through the addition of new data from leading experts.

"Prostate Intelligence<sup>TM</sup>" is software that allows prostate tumor detection on MRI images. It is intended to augment a radiologist's interpretation of prostate MRI by providing a risk score, prostate segmentation and aiding lesion identification and segmentation. The processing time for this software is between 1 and 10 s.

"Diffusion Weighted Imaging (DWI)" by Quibim calculates the ADC coefficient. The suite provides information on the cellular and microstructural organization of tissues and highlights the relationship between pathological changes and the diffusion of water molecules. In addition, this suite aims to characterize tumoral processes to support early detection, diagnosis, treatment response evaluation and follow-up of patients.

"Diffusion Weighted Imaging (DWI)" by Quibim is used to analyze the microstructure changes according to intra-voxel incoherent motion. The tool allows the differentiation of pure diffusion changes due to variations in the vascular component and offers additional information complementary to conventional ADC results. This suite aims to characterize tumoral processes to support early detection, diagnosis, treatment response evaluation and follow-up of patients [31].

For timely detection, accurate diagnosis and proper treatment of the patient, we offer the following algorithm presented in [Figure 2](#)

## Opportunities

Creating teams of radiologists and pathologists to jointly decide on the final outcome of patients with prostatic carcinoma would create a more efficient approach to treatment. With the help of AI, specialists from both fields can join forces, especially when making

decisions about suspicious lesions classified as PI-RADS 3. It is possible to bring together in one system all critical components - disease history, PSA levels, imaging studies, genetic tests, laboratory tests, previous tests, histological results and treatment performed. AI can provide the ability to analyze all these components and compare them to databases for risk stratification and better predictability [34,35].

### **PET - CT at prostate cancer**

In prostate cancer, unlike most other carcinomas, the use of  $^{18}\text{F}$ -FDG in PET - CT is limited due to low or missing glucose consumption by typical prostate carcinoma. This requires the use of specific targeting. Until recently, cholin markers were promising markers, but this radioactive indicator, originally used for re-staging after biochemical relapse and staging of high -risk patients, is practically abandoned due to its low sensitivity. Other markers such as  $^{11}\text{C}$ -acetate,  $^{18}\text{F}$ -oorocyclobutan-1-carboxylic acid and  $^{18}\text{F}$ -uciclovire have been tested without justifying expectations, presenting the same characteristics with choline. Prostate-specific membrane antigen (PSMA) currently dominates all other markers in PET scans of prostate carcinoma. PSMA, also known as glutamate carboxypeptidase II, is a transmembran glycoprotein, highly expressed in prostate cancer cells. PSMA expression tends to increase as Gleason increases. So far, several  $^{68}\text{Ga}$  ligand has been designed to target PSMA, *e.g.* PSMA-11 (known as Hbed-Cc or Hbed-PSMA), PSMA-I & T and PSMA-617. Therefore, a  $^{68}\text{Ge}/^{68}\text{Ga}$  generator with  $T_{1/2}$  of 271 days is widely used. However, in objects with cyclotron access PSMA-1007 Looks like a big breakthrough as it shows an advantage over  $^{68}\text{Ga}$  marked PSMA markers. Multiple studies show that PSMA PET/CT with PSMA has a moderate sensitivity, but a very high specificity of detecting metastases in lymph nodes and other organs. If the primary prostate cancer shows PSMA expression, the PSMA+ and PSMA-find will be characterized as a secondary lesion or will be treated accordingly as a minor/benign lesion in the fragment of imaging technique with high negative prognostic value. Due to the high cost of PSMA studies, a good selection of patients suitable for examination is required. MpMRI is superior for local assessment of the

disease, and PSMA PET/MRI has advantage in whole body scanning. In addition to the benefits arising from PSMA PET/CT, several restrictions are noted for patients suffering from prostate carcinoma. PET cameras are not always available and are missing in some of the nuclear medicine departments, especially in the remote regions for various reasons. PSMA also have to be included in international guidelines. Another important point is to clarify its role in monitoring of the disease. PSMA PET/CT showed indisputable results in the diagnosis of prostate cancer. The method outperforms diagnostics based solely on PSA, CT and TRUS biopsy [36-40].

Currently, only PYLARIFY AI™ is legalized software for support in PSMA PET/CT examinations, by quantitative and accurate reporting of the studies. The AI software allows automatic analysis of the CT examination, allowing targeting of the hotspots. [41,42].

## **CONCLUSION**

The increased incidence of prostate cancer in recent years and the improvement of magnetic resonance imaging have led to an increase in the number of the performed examinations. The larger volume of data combined with the insufficient number or insufficiently trained personnel creates difficulties in the diagnosis of the disease. Artificial intelligence is a powerful modern tool that offers time reduction, improvement in the quality and accuracy of interpretation of the prostatic carcinoma, according to the unified PI-RADS system. Artificial intelligence in the field of prostate imaging may revolutionize the approach to prostate cancer patients. However, it is

necessary to go a long way to calibrate the individual components of the new software solutions and carry out many recent studies in this area.

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