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Present and Future of Artificial Intelligence in Pathology

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As in all fields of life, artificial intelligence (AI) has begun to create areas of use for itself in the field of medicine, especially in the last decade.[1] Although not widespread for now, it started to become one of the basic components of diagnosis and treatment in some special clinical subjects.[2] Before touching on its beneficial effects in medicine and especially in the field of pathology, it will be appropriate to make a brief definition of AI.

AI can be basically examined in two main parts; general AI and narrowed AI. General AI, which is our topic, is essentially concerned with the design of intelligent machines that can imitate human intelligence and thinking ability in order to create machines that can perform functions similar to humans, sometimes even exceeding the capabilities of a human. Machine learning, which is considered a basic discipline within the concept of AI, can detect patterns in the data taught to the machine and then make predictions with new algorithms that train itself using the new data it encounters. Machine learning algorithms are algorithms designed to develop different prediction models through a training phase in which the parameters of an artificial neural network model can be estimated.[3] "Deep learning", as a very important cornerstone in AI, can be defined as the latest evolution of machine learning and has taken its place within AI as an important sub-discipline of machine learning. Deep learning, which can provide decision-making ability and process large data sets with its more complex functionality than machine learning, can naturally perform all applications of machine learning.[3]

Even this brief information will be enough to understand how AI can find widespread use in medicine. Developments in the use of AI in medicine have been pioneered by medical fields such as radiology, nuclear medicine and cardiology, where digital imaging methods are in use extensively for a long time.[1,2] In addition to areas suitable to digital image analysis, AI has started take its place in diagnosis and treatment algorithms in areas where clinical data can be standardized.

Pathology has been subjected to a rapid progress in the last 3-4 decades with the introduction of novel histopathological and auxiliary diagnostic methods and molecular diagnostic technics into daily practice. On the other hand, although Weinstein first used the term "Digital Pathology" in 1986, the digitalization of images by scanning pathology slides dates back only 25 years ago.[4,5] Digital Pathology can be defined as the reporting and diagnostic process that includes digital images of microscopic slide scans and macroscopic photographs, clinical data and case-related information arriving to the pathologist through a data connection and the pathologist's interpretation of all images, information and data.[4] While 25 years ago it took 24 hours to scan a single slide, today this time has decreased to slightly longer than a minute. Despite digital pathology has still not taken the place it deserves in the daily routine due to the limited capacity of hardware and software, archiving problems and high-cost burdens, the pace of development in digital pathology seems promising to pave the way for AI to take its place in the pathology routine soon.[5]

Although the limited number of experienced pathologists and limited health resources are said to be among the reasons leading digital pathology and therefore AI remaining limited on a global basis, this does not appear to be a significant problem in terms of Türkiye's current health system conditions.[6] Another global problem in this regard is reported to be the increasing burden of existing health data, including clinical records and patient demographic information.[6] This problem has been reduced to a minimum level with the opportunities provided by the national health data recording system (e-Nabız), which has been used in Türkiye for the last 9 years.[7] Although pathology report information can currently be viewed via e-nabız, it is obvious that there is still a long way to go before digital images of pathology slides can be uploaded to this system.

Although it has not yet replaced the microscope, now a days developments in digital pathology have enabled AI to enter pathology life in some specific subjects. In breast pathology, which is one of the first areas of use of AI in pathology, in addition to providing diagnostic support for tumors, algorithms for quantitative analysis of estrogen receptor status, progesterone receptor status, detection of human epidermal growth factor receptor 2 (HER-2) expression

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and proliferation markers such as Ki-67 have become available.[8-10] Additionally, there are researches concerning detection of metastatic tumor cells in sentinel lymph node biopsies and researches aiming to identify and distinguish normal breast parenchyma, ductal atypia, ductal carcinoma in situ and invasive carcinoma via AI.[10]

Prostate carcinoma is an other target of interest for AI developers. Studies in prostate cancer have particularly focused on automatic cancer detection and standardized use of the Gleason scoring and grading system.[10] There are intensive studies on automatic classification of melanoma, definition of histological subtypes and scoring of tumor-infiltrating lymphocytes.[10,11] In addition, there are studies on the classification of ovarian cancer types, grading of glial tumors and survival prediction through AI.[10] It is not surprising that AI studies are particularly focused on lung tumors, as a result of the increasing acceleration in the treatment of lung cancers with the emergence of targeted therapy for some types of cancer, and the fact that molecular pathology methods and the parameters required for treatment have become an important part of daily workload. Researches focus especially on subtyping non-small cell cancers and performing molecular quantitative analyses in lung carcinomas.[10,11] There are also studies aiming to develop models to predict programmed cell death-ligand 1 (PD-L1) status in non-small cell lung carcinomas.[9] The diagnostic ability of AI emerges with uterine cervical fluid-based cytology, which is the area where it is most frequently used in daily routine and is especially useful as a valuable screening method.[10,11]

It seems that it will take at least a few more decades for AI to be fully integrated into the daily routine of pathology, due to the problems that still exist in the field of digital pathology, based on financial problems and technical problems such as archiving, long scanning time, data size and data redundancy. Although AI may contribute to pathologists and clinicians in terms of tumor diagnosis, grading and survival prediction in the near future, the most beneficial support of AI to pathology will be building up computational pathology on traditional histopathology.[6] Obtaining reliable numerical results in the analytical evaluation of parameters such as TIL count, mitosis count, Ki-67 indexing as well as assessment of immunohistochemical applications like HER-2, PD-L1, microsatellite instability and various in situ hybridization applications will be a great support to the pathologist. It is not difficult to foresee those numerical analyses, which consume much time in the daily pathology routine, will significantly reduce the pathologist's workload with ensuring full integration of AI to pathology.

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