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Artificial intelligence in Laboratory medicine – let's talk about it

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Abstract

Medicine is a science, an art, and a trust between the doctor and the patient. In the times of digitization and artificial intelligence, new relationships between the human being and the machines are establishing. The concept for using computers to stimulate intelligent behavior and critical thinking is firstly described by Alan Turing in 1950. Nowadays, it is time to talk about digital transformation in medicine. AI consists of Machine learning (ML), Deep learning (DL) and Computer vision (CV). New terms appear in medical terminology in the context of digital health and digital transformation, as a new reality, extended reality literally. The purpose of this article is to present some fundamentals of AI and its application in Laboratory medicine in accordance with clinical needs and ethical standards. The way of digitization in human life and in medicine is clear and the process has been started, but there are still many things to be introduced in the same practice.

Keywords

artificial intelligence, digitalization, laboratory medicine

Medicine is a science, an art, and a trust between the doctor and the patient. Healthcare always arise respect and is a part of everybody's life. Despite of the pragmatic spirit of the modern era, the current healers are persons with ideals and the highest ethical principles and professional knowledge. The father of medicine, Hippocrates, described the doctor's desirable appearance, acceptable manners, and professional skills [1]. The Hippocratic Oath is still pronounced in the graduation ceremonies of many medical schools and is updating through the years. In the times of the computer science, with digitization and AI in almost all fields of people's lives, new relationships between the human being and the machines are establishing [2]. Isn't it a time to reconsider the ethical and moral aspects of this interaction, along with the scientific possibilities that come as a result of the technological development? Could the human intelligence be replaced by a machine? The purpose of this article is to present some fundamentals of AI and its application in Laboratory medicine in accordance with clinical needs and ethical standards.

The concept for using computers to stimulate intelligent behavior and critical thinking is firstly described by Alan Turing in 1950. In the book "Computing Machinery and Intelligence", he presents very simple test known as "the test of Turing for artificial intelligence" [3]. Six years later, John McCarthy introduces the term "Artificial intelligence" as "the science and engineering of creating intelligent machines" with the idea about the machine as a thinking. Oxford Dictionary defines the AI as the theory and development of computer systems capable of performing tasks that normally require human intelligence, such as visual perception, speech recognition, decision making, and translation between languages. Although AI has gone so far away in recent years, it still lacks basic characteristics typical for humans: emotional behavior, object identification, and handling them smoothly [4].

Nowadays, it is time to talk about digital transformation in medicine [5] and dramatically changes in medical practice as a consequence of applying the digital health with different digital devices and platforms, mobile health apps, AI, wearable biosensors, medical extended reality and all of it with the aim to improve the medical patient-focused care [6]. AI provides better patient result quality and diagnostic efficiency, with possibility to make an optimised prognosis, with a progress in the treatment, with reduced costs, shared decisions and personalized patient care. AI is involved in the most areas of science and medicine, including Laboratory medicine. Overview in the Pub Med database depicts more than 2500 papers on this matter in a year. Some of them declare essential role of AI in diagnosis, for example in snakebite identification [7].

Artificial intelligence, as a part of the digitalization concept, consists of Machine learning (ML), Deep learning (DL) and Computer vision (CV). Machine learning is focused on the manner by which the computers learn using "big data". AI as a tool combines capabilities of statistics, mathematics and computer science to create algorithms based on a huge amount of accumulated data [8]. An update form of ML is DL. It is a developed algorithms creator, an artificial neural network that can learn and make decisions on its own, in similarity to the human brain. The structure of neural networks is organized in multiple layers, which allows them to cope with complex tasks [9]. Computer vision is a field of AI by which the computer extracts and understands an information using images or videos and according to that could take actions or make recommendations [10].

New terms appear in medical terminology in the context of digital health and digital transformation, as a new reality, extended reality literally. These terms and concepts are needed to be understood and refined, possibly specifically to each identical language. For example, in a publication 2021, the term "digital public health" is commented on, and it is found that there is no single definition [11]. Wen X. et al. suggested a new definition for the link between Laboratory medicine and AI called Clinlabomics [12]. The clinical laboratory in the coming era of "big data" could be named Clinlabomics in similarity to other "omics" technologies (proteomics, genomics, metabolomics) because of extremely large and detailed professional profiles directed to advanced laboratory systems. Clinlabomics is a new concept aimed at achieving a valuable information and conclusions obtained from the processing the routine laboratory test data. Clinlabomics is applied for clinical prediction, disease diagnosis and monitoring, and laboratory management.

Artificial intelligence is used in various fields of medicine, all specialties and diagnoses, especially in socially significant diseases. In laboratory medicine, opportunities for digitalization are at every stage of the total testing process. In general, training, legal norms and ethical considerations in the new digital realities are needed.

Recently, Laboratory medicine is facing a big transformation because of the expansion in the advanced technologies as digitalization, Big Data, ML and AI. The labs generate huge amount of data especially in the pre- and post- analytical phases of Total Testing Process (TTP). They are only partially covered by Laboratory Information Systems (LIS) and Hospital Laboratory Systems (HIS). There are problems about integrating of healthcare data and extracting an information from LIS/HIS. It is a time for more appropriate management of data interpretation. According to the concept "Garbage in, garbage out" the wrong or nonsensical inputs produce nonsensical solutions. This view stimulates the improvement of the result reliability by minimising erroneous conclusions [13].

The revolutionary impact of AI in medical science and practice outlines the key role of laboratory medicine in healthcare systems with possibility for rapid and adequate diagnosis. Special benefits are orientated to strategies for reducing the errors in all steps of the TTP which are with harmful consequence for the patient safety. In this viewpoint, with big potential are the detection of the wrong patient identification and not-properly chosen tube for blood collection, the mixed-up samples, much higher accuracy for identification of pre-analytical errors than the lab staff, integrative approach of Patient-based Real time Quality Control [13].

Opportunities in pre-analytical phase are suggestive for areas with intensive manual work, large variability and since- a high risk for errors. AI in combination with robotics allow high automation in clinical labs, effective evaluation of specimen quality, reduced abnormally high variability, elevated productivity with high efficiency and faster generation of ready patient results. New aspects can be incorporated into laboratory and hospital information systems as "expert rules" [14].

Information software programs (Demand Management Tools) use specific for the patient characteristics matching them with knowledge base by rule-based algorithms. They can optimize the numbers and the types of lab tests, suitable for specific clinical situation and assist the physicians to plan test orders by predefined time intervals for repeated examinations. The adaptivity is directed to the specificity in the organisation of the same lab or to the healthcare facilities performed by the lab. Possible blocking of the test request could be irreversible or flexible. The use of the tools permits practically beneficial and financial effective use of the lab resources with possibility to reduce by 80% of theoretically non-proper lab tests and by 13% of common expenses for the lab [15], [16].

In the context of health care, the relationship between the patient and the doctor is special - it is trusting, caring, interpersonal contact with no sharing data. The faster development of the new technologies rather than this of the regulatory processes could arise sensitive considerations about the confidence and communication between the patient and medical professionals. Some efforts are already made to dissolve possible discrepancies. To put light on this matter, European Commission issues certain regulatory documents - First Project "Ethical Guidelines for

Trusted AI" April 2019, "AI White Paper" February 2020 and "Suggestion for Law about AI" 2021. The patient line is associated with sensitive data processing and information use. The patient issue is also related to provide autonomy with specifying the right place of the cured individual. The patients should have their own results for the health status, but not for the other people. The efficacy of AI depends on the quality of the entry data and this consideration is strongly related to the analytical reliability of the methods for testing. The laboratories are with a key role in validation process both of entry data and clinical decisions based on specified algorithms.

Access to good healthcare systems is a basic human right along with the maintenance of high ethical standards when providing the cares. It should never be taken for granted that consent of the patients to use their personal health data for getting certain treatments is itself consent to use the same data for other purposes, including solidarity. The question here is if the patient should know that the medical decisions about his/her status are supported by AI [17].

The recent ideas are related to Integrated Diagnostics with combined collection of all data to aim the most likely diagnosis. Such approach requires effective collaboration between medical professionals. This new model of healthcare, based on the integration of different data coming from multiple and often independent sources, can enable a faster, more efficient and accurate clinical decision-making process, thus ultimately ensuring better clinical and economic outcomes. Advanced computer technologies and AI guarantee up-building of Personalized Medicine. Clinical decision support through expert systems and algorithms based on ML and AI will become inevitable and is central to the education and training of the new generation clinicians. The future perspectives belong to "Information Specialists" bringing together laboratory and imaging specialists [18]. These new professionals will manage AI-derived information in the clinical context of every individual patient. This modern reality will combine the machine learning with human expert evaluation in medicine practice [18].

Increased demands for modern healthcare systems induce improved organization and optimized efficiency in Laboratory medicine by digitalization, automation and AI. Laboratories need to resolve some points – management of "big data" with easy access and accurate in-depth analysis; complex algorithms and computer programs that mimic human understanding of complicated clinical and laboratory data provided by diagnostics, medical records, claims, clinical trials; clinical decisions following the models of human thinking but with no direct human intervention. The rapid expansion of AI is also focused on the optimization of the work flows with improved financial outcome and replacement of repetitive manual activities. Initially high investment costs are responsible for potential current limitations: a gap between the development and clinical application of algorithms and delayed accumulation of evidence for their utility and economic efficiency in clinical practice [19].

Conclusion

A number of challenges are posed to the transforming medicine - cyber security, protection of personal data and technological development. There are a number of unknowns as the long effect of virtual reality on the human mind, the development of addiction and other potentially negative effects [20]. However, we are faced with the opportunity to use the big data together with computer science and digitization. The path of digitization in human life and in medicine is clear and the process has been started, but there are still many things to be introduced in the same practice.

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