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Artificial intelligence and cancer: Applications and prospects in cancer diagnosis and treatment

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Introduction

Cancer is a major public health concern and the second most common cause of deaths globally behind cardiovascular diseases [1]. According to estimates from the World Health Organization, in 2018, cancer accounted for 9.6 million deaths or one in six deaths worldwide. As per American Cancer Society estimates, in 2020, 1,806,590 people are expected to get cancer and 606,520 will succumb to this disease in the United States [2]. The burden of cancer is continuously elevating and exerting a huge emotional and financial burden on communities. Despite the significant scientific advancement made in the management of cancer during past decades, inefficacy of treatment strategies and resistance to classical chemotherapy and/or targeted drugs continue to be a major challenge in the desired outcome. Heterogeneity between individual tumors and intrinsic and/or acquired resistance attribute to the poor clinical outcomes of cancer. Mechanistic insight into therapy resistance and the development of personalized or precision therapy is crucial to achieving better results. Precision cancer medicine implies the recognition of anticancer drugs for individual patients after analyzing the molecular profiles of the tumor, and associated tumor microenvironment factors. Improved understanding of genetic profile and/or pattern that could promote the pro-

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gression of the cancer is important to advance the therapeutic efficacy. Next-generation sequencing, also known as deep or high-throughput sequencing can decode the genetic profile of the individual tumor [3]. However, the extraction of valuable information from massive data is cumbersome and requires computational algorithms. In recent years, artificial intelligence approaches have been identified and recognized for their capability to analyze the complex data to determine the diagnosis and treatments [3].

Artificial intelligence (AI) is the ability of a computer or computer-controlled machine to perform complex tasks that are usually handled or performed by intelligent beings. AI can be divided into three categories: artificial general intelligence, artificial narrow intelligence, and artificial superintelligence. With the support of computational biology and machine learning, AI can transform the complex data into usable knowledge that can result in the prediction of molecular behavior of the disease leading to drug development. Artificial neural networks, machine learning, and deep learning are the subfields of AI [4]. Machine learning is a data-driven learning approach whereas artificial neural networks support vector machines, random forest, and linear discriminant analysis. Deep learning can identify unique genetic patterns, variations/mutations in the tumor from large genomic data sets and medical records. Machine learning that involves data filtering, model fitting and evaluation can draw the inference from past observation and predict the outcomes. Identification of genetic variants and mutations is one of the important applications of machine learning.

Early and precise diagnosis of cancer increases the chances of successful treatment. Image analysis is a vital tool for cancer detection. Convolutional neural network-based diagnostic system developed to detect gastric cancer showed high efficiency with clinically relevant diagnostic ability [5]. The system is based on Single Shot MultiBox Detector architecture which is trained using 13,584 endoscopic images. The authors of this study suggested that this AI system can correctly diagnose gastric cancer lesions with an overall sensitivity of 92.2 % [5]. To develop a proof-of-concept for the prediction of liver cancer a convolutional neural network was engineered and trained using 494 lesions. The system was shown to achieve a 76.5 % positive predictive value and 82.9 % sensitivity in the identification of hepatic lesion [6]. Diagnostic ability of AI was also tested in the detection of esophageal cancer using 8428 images of 384 patients to train the convolutional neural networks based AI system. The AI system analyzed 1118 test images in only 27 seconds with 98 % sensitivity [7]. Computer-assisted diagnostic system developed for real-time automated diagnosis of precancerous lesions and early esophageal squamous cell carcinoma has demonstrated high sensitivity and specificity for both endoscopic images and video datasets [8]. The model was trained using 6473 narrow-band images, including precancerous lesions, early esophageal squamous cell carcinomas, and noncancerous lesions. The model demonstrated 95.03 % image detection specificity and 98.04 % sensitivity, suggesting that a real-time computer-assisted diagnostic system has a promising potential in cancer diagnosis [8]. AI has great potential in the assessment of image in terms of qualitative interpretation, volumetric delineation, and prediction of treatment outcome. Potential high-value of AI applications including model-based assessment of diagnostic and the ability to identify novel features of the disease are significantly improving the prognosis. AI can analyze the pattern, help in identifying the high-risk populations and can suggest personalized screening tests.

AI demonstrated huge potential in several areas of healthcare, including data analysis and drug discovery [4,9]. The process of drug development and efficacy analysis is tedious. AI-assisted drug identification and virtual screening for safety and efficacy are timesaving and cost-effective. Importantly, AI algorithms can also predict the impact of gene mutations on the sensitivity of chemotherapy or radiation therapy. Results obtained from pre-clinical and/or clinical studies, medical images, and genomic profiles are potential sources for drug development. Availability of resources including Protein Data Bank, The Cancer Genome Atlas and the integration of advanced bioinformatics techniques with sophisticated computational algorithms further expedited the process of drug development.

The past few years have witnessed a remarkable increase in AI applications to a wide range of areas including cancer care [4,10]. Following diagnosis, choosing the therapeutic modality is crucial for cancer prognosis. Cancer care has a unique set of challenges that include heterogeneity of the disease, stage and, the patient's ability to receive treatment. Besides, the disparity in assessment from one oncologist to another complicates the process of treatment. In such circumstances, AI can perform complicated tasks like detection, characterization, and monitoring of tumor progression that helps in the therapeutic efficacy analysis. Further, AI can bring different aspects of cancer biology including diagnostic, radiographic images, genomics, electronic health records, pathology at one platform, which is highly beneficial in decision making. However, the requirement of a large amount of data for training and validation, and computerized trust and privacy are several concerns that need to be addressed with the priority. Overall, the AI is helping in cancer diagnosis and improving the therapeutic efficacy which is crucial for better clinical outcomes. The integration of AI into cancer care is expected to transform the field of oncology in the coming decade.

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