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Significance of artificial intelligence in stem cell therapy

Abstract

With careful and systematic documentation of data in healthcare industry, an enormous amount of data has been accumulated in each discipline of medicine. This amount of data comes with at least a couple of consequences. On one hand, it helps better diagnose and treat a condition while on the other it is too big and very fast evolving to keep pace with for both researchers and clinicians. To help a clinician navigating the vast array of data even for one condition becomes very demanding. This article provides a guide to understand the fundamentals of AI technologies (i.e., machine learning, natural language processing, and AI voice assistants) as well as their applications/ implications in healthcare and stem cell therapy.

Keywords: artificial intelligence (AI), healthcare innovation, medical diagnostics, stem cell research, regenerative medicine, personalized medicine, machine learning (ML), clinical applications of AI, drug discovery, AI in medical imaging, AI-driven treatment planning

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Introduction

Fast evolution of Artificial Intelligence (AI) in recent times and its continuously increasing use in everyday life is helping people in a number of ways. AI has emerged as an immense help in different medical disciplines including managing everyday requirements like reminder for necessary activities to needy individuals like patients and their care givers. In healthcare industry, careful and systematic documentation of data has led to an accumulation of enormous amount of information across all medical disciplines. While this wealth of data enhances diagnosis and treatment capabilities and accuracies, it also presents significant challenges. The sheer volume of information itself can overwhelm clinicians, making it difficult to identify relevant insights while addressing a specific condition. At the same point, the rapid evolution of medical knowledge means that staying current is progressively becoming a daunting task, often referred to as information overload. As a result, navigating the vast array of data for even a single condition can become a challenge for healthcare providers. Finding effective ways to streamline data access and use it in improving decision-making processes is crucial to ensure that clinicians can deliver the best possible care without being dragged down by the complexities generated by the amount of modern medical data. To meet the challenge, The AI assistance for navigating the path for the welfare of patients is gradually becoming not only desirable but also unavoidable. The term Artificial Intelligence (AI) was coined by John McCarthy in 1956 during a conference held on this subject.[1] Since then, AI is evolving rapidly in the field of healthcare industry, and various AI applications have been and are being developed to counteract some of the most pressing problems that healthcare individuals and organizations are currently facing and which is likely to continue in coming future. It is crucial for healthcare individuals including leaders to understand the state of AI technologies and the ways that such technologies can be used to improve the efficacy, safety, and providing health services while providing value-based health care services.

Use of the AI is playing significant roles in different fields of medical practice which includes diagnosis, surgery, post-surgical management etc. Evolution of different AI means has made its use in to our daily lives in many forms like personal assistants (Siri, Alexa, Google assistant etc.), to patients. More recently, AI is being incorporated into medical practices to improve patient care by speeding up different processes with greater accuracy, and thereby paving the path to provide better healthcare overall. Reading and interpreting radiological images, pathology slides, and patients' electronic medical records (EMR) are being evaluated by machine learning which is aiding in the process of diagnosis and planning treatments for patients. These processes are augmenting physicians' capabilities in helping the needy patients. Herein we describe the current status of AI in medicine, the way it is used in the different disciplines and future trends.

In clinical set ups AI is already playing significant roles in a number of fields like Disease diagnosis, Disease treatment, and prognosis. The use of AI is greatly augmenting abilities of the researchers in Drug development, determining Biomarkers regarding development or recession of some pathological condition, Gene editing, and prescribing personalized medicine.

AI in disease diagnosis

Medical imaging has increasingly been playing key roles in diagnosing severe problems like fractures and tumours. Using that data including those recorded on plain X-ray films have been used as inputs in AI algorithms to teach them to diagnose a number of indications like bone fractures, lung conditions, such as pneumonia, emphysema, and tuberculosis or stones in kidneys or gall bladder. These abilities are also being used to detect bone age, maturity, and fractures.[2–6] AI programs equipped with data generated using chest computed tomography (CT) scans from normal individuals and smokers can identify chronic obstructive pulmonary disease, its stage, and prognosis.[7] Cancer diagnosis and prognosis following treatments is another field where AI has been tested and has proved to be as good as humans, including malignancy detection in pathology images, in screening mammography, in CT or magnetic resonance imaging (MRI) or positron emission tomography (PET) scans, and skin clinical images.[8–20] AI trained with data from endoscopic images and videos have reached human-like accuracies in gastrointestinal indications like detection of gastrointestinal neoplasms, or oesophageal cancers, gastric cancers, or large bowel polyps.[21–23]

Cardiologists are also using AI equipped with information sets obtained after processing data recorded from various data generating vehicles like electronic health records (EHR), electrocardiography, echocardiography, coronary artery calcium scoring, coronary CT angiography, and MRI in diagnosing, severity classification of cardiovascular diseases, and prognosis.[24–27] Use of AI models can also predict outcomes given specific diagnostic parameters such as pulmonary hypertension by 3D cardiac MRI processing.[28]

Studies in the field of neuroscience have demonstrated that AI can: (i) help predict the diagnosis of autism in high-risk children by processing brain magnetic resonance imaging (MRI), (ii) assess the progression of dementia by processing a single amyloid PET scan, (iii) detect intracranial haemorrhage on CTs, and (iv) diagnose schizophrenia and predict the risk of suicide by the processing of functional MRIs (fMRIs) and HER.[29–34] Also, timely diagnosis of infectious diseases in terms of pathogen identification and antibiotic susceptibility testing is feasible through ML processing of bacterial Raman spectra or bacterial and viral mRNA.[35,36]

Artificial Intelligence (AI) and stem cell medicine are two of the most transformative technologies in modern science, each with the potential to significantly impact healthcare. When combined, they promise to accelerate breakthroughs in regenerative medicine, personalized treatments, and the understanding of complex diseases. The intersection of AI and stem cell research is ushering in a new era of medical innovation that could redefine the future of healthcare.

Stem cell medicine: a primer

Stem cells, because of their totally undifferentiated or partially differentiated state, are unique in their ability to differentiate into various cell types, which makes them incredibly valuable tool for medical research and therapy. In the field of regenerative medicine, stem cells can be used to repair damaged tissues and organs, offering potential treatments for conditions like Parkinson's disease, diabetes, heart disease, and spinal cord injuries. Stem cells also play a critical role in drug discovery, disease modelling, and personalized medicine, enabling researchers to study diseases at a cellular level and develop tailored therapies.

Stem cells are a few resident undifferentiated or partially differentiated cells, present in almost all tissues of the body with varying number, which unlike other cells of the body, have ability to differentiate into almost all or at least more than one cell types depending on their undifferentiated state. In addition, these cells have paracrine ability, evident by their abilities of secreting a number of cell signalling cytokines and growth factors in response to surrounding environment. Which makes them incredibly valuable for medical research and therapy. In regenerative medicine, stem cells can be used to repair damaged tissues and organs, thus offering potential treatments for degenerative indications like Parkinson's disease,[37] diabetes,[38] heart disease,[39] IBDs,[40] spinal cord injuries,[41] and dermatological indications[42] to name a few. Mesenchymal stem cells (MSCs) have been shown to possess immune modulatory properties which helps reduce inflammation, many times the basic cause of a degenerative indication like arthritis.[43] These cells can modulate the function of the innate and adaptive immune response. Numerous clinical trials have been using MSCs for various indication like myocardial infarction, Crohn's disease, multiple sclerosis, diabetes, GvHD, amyotrophic lateral sclerosis, arthritis, neurodegenerative disorders, trauma, coronavirus disease 2019, and many more have shown encouraging outcomes.[44] Stem cells also play a critical role in drug discovery, disease modelling, and personalized medicine, enabling researchers to study diseases at a cellular level and develop tailored therapies.

AIs in drug discovery

Artificial intelligence-assisted drug discovery and development has accelerated the growth of the pharmaceutical sector exponentially, thereby, leading to revolutionary changes in the pharma industry.[45] AI-driven machines greatly help in deciphering 3D shapes of molecules which is a very computation intensive process. The understanding of the 3D shapes of molecules helps in designing inhibitors of molecules which are considered to be critical for developing an indication.[46] De novo drug design by AI helps create chemical entities based biological targets like receptors or its known activators or inhibitors (ligands or antagonists-ligand like molecules which do not dissociate and inhibit).[47] Major components of de novo drug design include 3D description of a receptor active site or modelling of its ligand pharmacophore, then synthesis of suitable molecules (sampling), and their evaluation to bring about the desired effects in clinics.

AIs help in stem cell research and clinical use

AI brings advanced computational power and data-driven insights into the complex field of stem cell biology as the uses of AIs, which possess the ability to analyse very vast datasets, identify patterns, help make predictions and, thus, help accelerate the pace of stem cell research in several key areas. A few of those are listed below.

Use of AI in stem cell culture: AI is playing very significant roles in cell culture. Automated incubators, cell counters, a number of other automated instruments are greatly reducing human inputs including manual work and, thereby, greatly helping the researchers and clinicians to grow a large number of stem cells for studies as well as for clinical usages.

Use of AI in stem cell therapy: One of the key challenges in using stem cells in clinics is directing those to respond to specific indication. AI has raised major hopes in this aspect for a synergistic approach that augments human expertise.[48] AI algorithms can analyse clinical data to identify the optimal conditions for differentiation, reducing trial and error in laboratory settings. By predicting how stem cells will behave under certain conditions, AI can streamline the creation of specialized cells for research and therapeutic use.[49] Similarly, AI can guide a clinician to use the type and amount of stem cells for any particular indication like arthritis, heart diseases, or diabetes. Also, AI can help clinicians in selecting the route and process of the administration of the cells.

Challenges and ethical considerations

AI could assist in identifying optimal stem cell therapies and predicting outcomes, but it's crucial that AI systems undergo rigorous validation. AI models must be designed to accurately assess the risks associated with treatments. Regulatory bodies like the FDA (or their international equivalents) need to ensure that AI-assisted medical decisions are backed by solid evidence and that these technologies undergo extensive clinical trials before being widely used. Furthermore, the integration of AI requires the collection and analysis of vast amounts of patient data, which raises concerns about data privacy and security. AI must operate within strict frameworks of regulatory agencies, such as the General Data Protection Regulation (GDPR) in Europe or HIPAA in the U.S., to safeguard patient confidentiality. Even though AI can process vast amounts of data and make complex predictions, it should not replace the role of human judgment. Medical professionals must still play an integral part in

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the decision-making process, using their expertise to interpret AI recommendations and to make the final decisions about treatment. It's essential that AI be used as a tool to support healthcare providers, rather than substitute them entirely, especially in a field as nuanced and personalized as stem cell medicine.

AI is increasingly involved in medical decision-making, there will be questions around accountability. If an AI system's decision leads to adverse outcomes, who is responsible? The designers, healthcare providers, or the AI itself? Clear guidelines need to be developed to ensure that responsibility for clinical decisions remains clearly defined and that there are mechanisms for accountability.

The future of AI and stem cell medicine

The partnership between AI and stem cell research is still in its early stages, but its potential is enormous. As AI continues to evolve, it will likely uncover new insights into the biology of stem cells, enabling more precise and effective treatments for a wide range of diseases. The helm of applying these innovations in clinical practice, the future of healthcare could see AI-guided stem cell therapies becoming routine, offering personalized, regenerative treatments that could extend lifespans and improve quality of life for millions.

In conclusion, AI and stem cell medicine are poised to revolutionize healthcare by offering ground-breaking solutions for previously untreatable conditions. Their combined power promises not only to speed up scientific discovery but also to bring about a new era of personalized and regenerative medicine.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

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