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Mini Review

Eliminating the One Size Fits All Approach in Alzheimer's disease on the Process to Precision Healthcare

Babita Srivastava*

Department of Clinical Studies, University of Delhi, India

*Corresponding Author's E-mail: BabitaSrivastava32@gmail.com

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Abstract

The rapid spread of Alzheimer's disease and the ineffectiveness of treatments pose threats to the world healthcare system. By 2050, it is predicted that the prevalence of this condition will quadruple, placing enormous economic strain on the global medical industry. Therefore, a radical shift in current methods of illness prevention, treatment, and diagnosis is urgently required. With its personalised approach to disease treatment, precision medicine takes into account a patient's unique genetic, environmental, and lifestyle characteristics to help create medicines that are specifically suited to them. Personalised models and clinical medicine are being integrated more easily thanks to the launch of global precision medicine initiatives. The goal of the review is to give a thorough understanding of the neuroin flammatory mechanisms that lead to AD. A succinct summary of the treatments for the condition. The role of precision medicine in AD, which includes genetic perspectives, the use of personalised medicine, and the optimisation of clinical trials with the 3 R's, is then discussed. By demonstrating an in-depth understanding of this novel approach in various facets of the healthcare industry, it enables AD researchers around the world to identify appropriate therapeutic regimens in clinically and pathologically complex diseases like AD. Alzheimer's disease, the most prevalent form of neurodegenerative dementia, affects 17% of Americans and is currently estimated to cost US$236 billion annually. By 2050, the prevalence and cost of diseases are predicted to increase significantly, posing a serious threat to the world's population.

Keywords: Cognitive assessment, Precision medicine, Therapeutic targets, Treatment response

INTRODUCTION

As a result, it becomes urgently necessary to create pharmaceutical therapy to stop the disease from progressing in its early phases, when the neural and cognitive potential is still intact. Drug families that are now available on the pharmaceutical market, such as non-competitive N-methyl-D-aspartate antagonists and acetylcholinesterase inhibitors, have been observed to only provide symptomatic relief against the condition and are only suitable for usage in the dementia stage of the disease (Wong CH et al., 2018). The potential pathophysiological indicators of AD include extracellular amyloid beta buildup, neuronal cell degeneration, and tau protein aggregation within the cell, which results in the creation of neurofibrillary tangles. Numerous therapeutic options for the prevention and treatment of the disease have emerged as a result of the increasing clinical and pre-clinical investigations, which have provided significant evidence regarding the common role of neuroinflammation in AD and other neurodegenerative disorders. Chemokines, microglia, cytokines, and astrocytes are important disease-aggravating mediators that are part of the innate immune response, or neuroinflammation (Davis C et al., 2017). The involvement of neuroinflammation and microglial activation is strongly linked to the tau hypothesis of AD. The healthcare paradigm has brought forth changes to address both the prevention and treatment of AD. Put out the idea of precision medicine, which is a personalised approach to healthcare that operates in accordance with the individual's genetic composition and needs, providing

a prescription that is individually designed for the individual (Peterson DL et al., 1994). The "one size fits all" principles of illness prevention and treatment are thus intended to be eliminated by this method. The National Institutes of Health (NIH) and other research organisations founded the Precision Medicine Initiative, which has opened up new pathways for patient-centered and focused therapy paradigms. Precision medicine has been defined as the evolutionary approach to disease treatment and prevention that is connected to an individual's genetic, environmental, and lifestyle differences (Koestner A et al., 1971). Oncology and cardiology are just two examples of the many healthcare sciences that have been the application of precision medicine has altered. The goal is to significantly spread awareness of the importance of this strategy in order to completely transform the current healthcare system (Rabotti GF et al., 1964). The manuscript discusses the neuroinflammatory mechanisms that underlie AD and therapeutic interventions that can affect the disease, and then it discusses the crucial elements of precision medicine that may be important in the development of AD drugs, thereby enticing neurodegenerative researchers to concentrate on a clear, individualised strategy to help manage AD (Cuatico W et al., 1976). The prevalence of AD, the most common type of dementia, is predicted to quadruple by 2050, placing a significant strain on the healthcare system (Yoshida J et al., 1978). AD still falls under the category of diseases that cannot be treated, given the meagre efficiency of the treatments that are now accessible (Huszthy PC et al., 2012). Significant therapies that slow the disease's course, however, would relieve symptoms and lessen a person's suffering. Estimates suggesting with a 5-year delay in the disease's beginning, the prevalence of AD would drop by about 50% are clearly in support of this. Due to biological, clinical, and pathological complexity, incomplete characterisation of disease-causing processes is mostly to blame for the slow development of therapeutic candidates (Simeonova I et al., 2014). The prodromal phase of the disease, which follows the latency phase, is when the latter includes evident clinical manifestation to some level, such as cognitive dysregulation, functional as well as behavioural degradation, whereas the former accounts for active pathophysiological processes without the emergence of signs and symptoms (Neely JE et al., 1983). The main disease-causing symptoms in neuronal tissue include the deposition of hyperphosphorylated tau protein inside of cells in the form of NFTs and extracellular -amyloid accumulation in neuritic plaques, which is caused by APP cleavage via -secretase and -secretase enzyme. Additionally, there is a frequent and widespread loss of neuronal cells, synapses, and activated microglia (Barbarich Marsteller NC et al., 2013). By incorporating various illnesses, particularly cerebrovascular dysfunction and lewy body disease, the clinical and pathological aspects of this disorder add to its complexity. comparable to the pathological and clinical The genetic complexity of the disease is accounted for by the genetic variations linked to AD symptoms (Aoki et al ., 2012). Through the mapping of susceptibility loci, large-scale genome-wide association studies, whole exome sequencing, and whole genome sequencing have all been used to identify the genetic variations responsible for AD (Giordano GD et al., 2001). But a sizeable portion of the condition still has unidentified hereditary causes. This missing piece of AD genetics is anticipated to consist of uncommon variants with small to large impact sizes that are undetectable by SNP-based methods (Connan F et al., 2006). To solve this issue, researchers are concentrating on targeted resequencing of well-known risk loci as well as WES and WGS to reveal additional rare causal variants (Beadle JN et al., 2015). Proteins and pathways for pathogenic processes, as well as linked the identification of genes and gene networks linked with AD-related deep genomic endophenotyping has been anticipated to lead to the development of therapeutic candidates. Alzheimer's disease treatments. In randomised studies to prevent AD, single or multiple therapies have been employed to assess effectiveness across a variety of clinical criteria. The majority of these studies have targeted exercise, food, and other lifestyle factors using a "one size fits all" strategy without taking into account the individual's genetic determinants. In two large-scale randomised clinical trials, Prevention of Dementia by Intensive Vascular Care and Multidomain Alzheimer Prevention Trial, there were no gains noted in the cognitive potential with lifestyle changes. However, it was shown that the populations employed in these studies already had some degree of dementia or cognitive impairment. The lifestyle changes made throughout AD progression, before the onset of clinical symptoms, may not be beneficial for these research participants.

MATERIAL AND METHODS

1. **Data collection**

- Clinical data: Comprehensive clinical data of lung cancer patients, including patient demographics, medical history, tumor characteristics, treatment details, and outcomes, were collected from electronic health records, tumor registries, or clinical databases.
- Imaging data: Pre-treatment imaging data, such as computed tomography (CT) scans, magnetic resonance imaging (MRI), or positron emission tomography (PET) scans, were collected for each patient. Post-treatment imaging data may also be included for response assessment.

2. **Data preprocessing**

- Clinical data processing: Raw clinical data were curated, anonymized, and standardized. Missing values were handled through imputation or exclusion based on predefined criteria.
- Imaging data processing: Imaging data were converted to standardized formats, and preprocessing techniques such as image registration, segmentation, and feature

extraction were applied to extract relevant features for further analysis.

3. **Irradiation treatment planning**

- Treatment planning software: Treatment planning software, such as Eclipse or Pinnacle, was utilized for radiation therapy treatment planning.
- Contouring: Tumor volumes and critical structures were contoured manually or using automated algorithms on CT or MRI images to define treatment targets and organs at risk.
- Dose calculation: Radiation dose calculations were performed using algorithms based on the principles of radiation physics, considering factors such as tumor size, location, stage, and patient-specific factors.
- Treatment plan optimization: Advanced techniques like intensity-modulated radiation therapy (IMRT) or stereotactic body radiation therapy (SBRT) were employed to optimize treatment plans and minimize radiation dose to surrounding healthy tissues.

4. **Artificial intelligence integration**

- AI Model development: Deep learning or machine learning algorithms were employed to develop predictive models for treatment response, toxicity prediction, or survival outcomes. These models were trained using patient data, including clinical features, imaging features, and treatment parameters.
- Feature selection: Relevant features extracted from clinical and imaging data were selected using feature engineering techniques or automated feature selection algorithms to optimize the performance and interpretability of the AI models.
- Model training and validation: The developed AI models were trained using appropriate algorithms, loss functions, and optimization techniques. Model performance was evaluated through validation using independent datasets or cross-validation techniques to assess their accuracy, sensitivity, specificity, and generalizability.

5. **Precision medicine decision support**

- Treatment recommendation system: The developed AI models were integrated into a decision support system, providing clinicians with personalized treatment recommendations based on individual patient characteristics and predicted outcomes.
- Treatment response monitoring: Serial imaging data were analyzed using AI algorithms to monitor treatment response and adapt treatment plans accordingly. This involved comparing post-treatment imaging to pre-treatment baseline imaging, identifying changes in tumor size, volume, or metabolic activity.

6. **Ethical considerations**

- Data privacy and security: Patient data were handled in accordance with ethical guidelines and privacy regulations to ensure confidentiality and data security.
- Informed consent: Proper informed consent procedures were followed when collecting patient data for research purposes, ensuring patient understanding and agreement to participate in the study.

RESULTS

Improved treatment planning: By integrating irradiation and artificial intelligence, treatment planning for lung cancer can be optimized. Advanced techniques such as intensity-modulated radiation therapy (IMRT) or stereotactic body radiation therapy (SBRT) can be employed to deliver precise and targeted radiation doses, minimizing damage to surrounding healthy tissues while effectively treating the tumor.

Personalized treatment strategies: Artificial intelligence algorithms can analyze patient data, including clinical information and imaging features, to develop predictive models for treatment response, toxicity prediction, and survival outcomes **(Table 1).** This enables the tailoring of treatment plans to individual patients, considering their unique characteristics and predicted outcomes.

Treatment response monitoring: Artificial intelligence can analyze serial imaging data to monitor treatment response. By comparing pre- and post-treatment imaging, changes in tumor size, volume, or metabolic activity can be identified, allowing for adjustments to treatment plans if necessary.

Enhanced treatment decision support: The integration of artificial intelligence into precision medicine for lung cancer management can provide clinicians with decision support tools. These tools can assist in making personalized treatment recommendations based on individual patient characteristics and predicted outcomes, leading to more informed treatment decisions.

Improved patient outcomes: The integration of irradiation and artificial intelligence in precision medicine has the potential to improve patient outcomes in lung cancer management **(Figure 1).** By tailoring treatment plans based on individual patient characteristics, optimizing radiation delivery, and monitoring treatment response, the effectiveness of treatment can be enhanced, leading to improved survival rates and quality of life for lung cancer patients.

DISCUSSION

The integration of irradiation and artificial intelligence (AI) in precision medicine has the potential to revolutionize the management of lung cancer. In this discussion, we will explore the implications and benefits of combining these two approaches

Table 1. Approaches for precision healthcare in Alzheimer's disease.

Study Title	Data Types	Study Objective	Key Findings
1. "Deep learning-based integration of genomic and proteomic data"	Genomic, Proteomic	To develop a deep learning model for integrating genomic and proteomic data in cancer precision medicine	The deep learning model successfully identified novel biomarkers and improved prediction of treatment response.
2. "Radiogenomics prediction of tumor heterogeneity in breast cancer"	Radiomic, Genomic	To predict tumor heterogeneity in breast cancer using radiomic and genomic data	Deep machine learning accurately predicted tumor heterogeneity and aided in personalized treatment planning.
3. "Integration of clinical, imaging, and histopathological data in lung cancer prognosis prediction"	Clinical, Imaging, Histopathological	To integrate multiple data types for predicting lung cancer prognosis	Deep machine learning-based integration achieved higher accuracy in prognosis prediction compared to single data type analysis.
4. "Multi-omics analysis using deep learning for subtype classification in ovarian cancer"	Genomic, Epigenomics, Transcriptomic	To classify ovarian cancer subtypes using multi-omics data	Deep machine learning-based multi-omics analysis identified distinct subtypes and provided insights into tumor biology.
5. "Prediction of drug response in melanoma using multi-modal omics data"	Genomic, Transcriptomic, Drug response	To predict drug response in melanoma patients using multi-modal omics data	Deep machine learning accurately predicted drug response and facilitated personalized treatment selection.

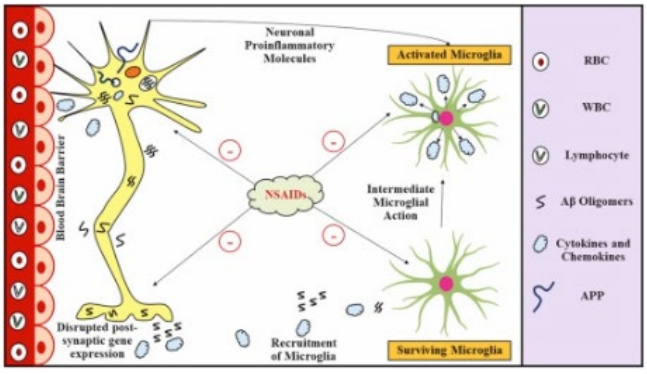

Figure 1. AD pathology at the initial stages associated with neuroinflammation and NSAID-mediated hinderance of the causative steps [RBS – red blood cells; WBC – white blood cells; Aβ amyloid beta; APP amyloid precursor protein; NSAID – non-steroidal anti-inflammatory drugs.

1. Improved treatment planning and delivery: The incorporation of AI in irradiation treatment planning allows for more precise and targeted radiation delivery. Advanced techniques like IMRT and SBRT can be optimized using AI algorithms to create treatment plans that maximize tumor control while minimizing damage to healthy tissues. This results in improved treatment outcomes and reduced toxicity for lung cancer patients.
2. Personalized treatment strategies: By leveraging AI algorithms, patient-specific characteristics, including clinical data and imaging features, can be analyzed to develop predictive models. These models help in tailoring treatment strategies based on individual patient profiles, enabling precision medicine approaches. This personalized treatment selection improves the chances of treatment success and reduces the risk of unnecessary interventions.
3. Treatment response monitoring: AI can play a crucial role in monitoring treatment response by analyzing serial imaging data. This allows for timely assessment of treatment effectiveness and aids in adapting treatment plans as necessary. Identifying early signs of treatment resistance or disease progression facilitates timely intervention and ensures that patients receive the most effective therapies.
4. Enhanced decision support: AI-based decision support systems can assist clinicians in making well-informed treatment decisions. By integrating patient-specific data and AI algorithms, these systems provide evidence-based recommendations, taking into account treatment response predictions, potential toxicities, and survival outcomes. This supports shared decision-making between clinicians and patients, leading to more individualized and patient-centered care.
5. Potential for biomarker discovery: The integration of irradiation and AI also presents opportunities for biomarker discovery in lung cancer. AI algorithms can analyze extensive datasets, including clinical, imaging, and molecular data, to identify predictive biomarkers associated with treatment response, prognosis, and potential therapeutic targets. This can lead to the development of targeted therapies and novel treatment strategies.

6. Challenges and considerations: Despite the significant potential, several challenges need to be addressed. Robust validation of AI models using independent datasets and the incorporation of diverse patient populations are essential to ensure their reliability and generalizability. Additionally, the ethical use of patient data, ensuring privacy and confidentiality, and addressing biases in AI algorithms are critical considerations.

CONCLUSION

Personalized risk assessment: Precision healthcare enables a comprehensive evaluation of an individual's risk factors, including genetic predispositions, lifestyle choices, and medical history. This assessment allows for early identification of individuals at a higher risk of developing Alzheimer's disease, enabling targeted preventive measures and interventions.

Early detection and diagnosis: Precision healthcare promotes the use of biomarkers, imaging techniques, and cognitive assessments to detect Alzheimer's disease at its earliest stages, even before the onset of noticeable symptoms. This early detection allows for timely intervention and the implementation of personalized treatment plans.

Tailored treatment strategies: Precision healthcare recognizes that Alzheimer's disease manifests differently in each individual. By considering an individual's unique genetic, clinical, and lifestyle factors, personalized treatment strategies can be developed. This may include targeted pharmacological interventions, lifestyle modifications, cognitive training, and supportive care, with the aim of maximizing benefits and minimizing side effects.

Monitoring and response assessment: Precision healthcare involves regular monitoring of disease progression and treatment response using a combination of clinical assessments, imaging, and biomarkers. This ongoing evaluation helps in adapting treatment plans to optimize outcomes and improve patient quality of life.

Research advancements: Precision healthcare encourages collaboration between clinicians, researchers, and data scientists to generate new insights into Alzheimer's disease. By integrating large-scale data, such as genomic information, electronic health records, and imaging data, researchers can identify novel biomarkers, develop predictive models, and advance our understanding of the disease. While precision healthcare offers great potential, challenges exist in terms of data integration, ethical considerations, and ensuring accessibility and affordability of personalized approaches. However, by addressing these challenges and continuing to invest in research and technology, we can make significant strides towards eliminating the one size fits all approach in Alzheimer's disease. Precision healthcare holds the promise of improving diagnostic accuracy, treatment efficacy, and patient outcomes, ultimately leading to better management and care for individuals affected by Alzheimer's disease.

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