Artificial Intelligence for Response Assessment in Neurooncology

- RANO criteria for response assessment of brain metastases based on amino acid PET imaging
- Gradient-Based Radiomics for Outcome Prediction and Decision-Making in PULSAR: A Preliminary Study
- Joint EANM/EANO/RANO/SNMMI practice guideline/procedure standard for PET imaging of brain metastases: version 1.0
- Results of a patient-level pooled analysis of three studies of trastuzumab deruxtecan in HER2-positive breast cancer with active brain metastasis
- Artificial Intelligence for Response Assessment in Neuro Oncology (AI-RANO), part 1: review of current advancements
- Artificial Intelligence for Response Assessment in Neuro Oncology (AI-RANO), part 2: recommendations for standardisation, validation, and good clinical practice
- Diagnosing Progression in Glioblastoma-Tackling a Neuro-Oncology Problem Using Artificial-Intelligence-Derived Volumetric Change over Time on Magnetic Resonance Imaging to Examine Progression-Free Survival in Glioblastoma
- PET imaging of gliomas: Status quo and quo vadis?

Artificial intelligence (AI) is increasingly integral to neuro-oncology, particularly in assessing treatment responses. By automating and enhancing the analysis of medical imaging, AI offers more reproducible and standardized evaluations compared to traditional manual methods.

Automated Tumor Measurement and Segmentation

Artificial intelligence-driven tools can automatically detect and make tumor segmentation in imaging studies, such as MRI scans. For instance, deep learning algorithms have been developed to measure tumor burden in glioblastoma patients, providing bidimensional and volumetric assessments that align closely with expert evaluations. This automation not only reduces the time required for analysis but also minimizes interobserver variability, leading to more consistent treatment response assessments.

Radiomics and Imaging Biomarkers

Radiomics involves extracting quantitative features from medical images to characterize tumor phenotypes. AI enhances this process by analyzing complex imaging data to identify patterns associated with tumor grade, molecular characteristics, and treatment response. For example, multiparametric MRI combined with AI-based radiomic analysis has shown promise in distinguishing between different tumor grades and predicting treatment outcomes in brain cancer patients.

Integration with Clinical Decision-Making

AI's role extends beyond image analysis; it integrates with clinical workflows to support decision-making. AI-based decision support systems have demonstrated potential in providing more reproducible and standardized assessments of treatment response in neuro-oncology, particularly in patients with low-grade gliomas. These systems can assist clinicians in evaluating treatment efficacy and planning subsequent interventions.

Challenges and Future Directions

Despite its advantages, the implementation of AI in neuro-oncology faces challenges, including the need for large, diverse datasets to train robust models and the integration of AI tools into existing clinical workflows. Ongoing research aims to address these issues, with the goal of developing AI systems that can provide real-time, accurate assessments of treatment response, thereby enhancing personalized care for patients with brain tumors.

In summary, AI is transforming response assessment in neuro-oncology by automating tumor measurement, enhancing radiomic analysis, and supporting clinical decision-making, ultimately leading to more precise and individualized patient care.

The development, application, and benchmarking of artificial intelligence (AI) tools to improve diagnosis, prognostication, and therapy in neurooncology are increasing at a rapid pace. This Policy Review provides an overview and critical assessment of the work to date in this field, focusing on diagnostic AI models of key genomic markers, predictive AI models of response before and after therapy, and differentiation of true disease progression from treatment-related changes, which is a considerable challenge based on current clinical care in neuro-oncology. Furthermore, promising future directions, including the use of AI for automated response assessment in neuro-oncology, are discussed [1)].

Critical Review of Lancet Oncol. 2024 Nov;25(11):e581-e588. doi: 10.1016/S1470-2045(24)00316-4. “Artificial Intelligence for Response Assessment in Neuro Oncology (AI-RANO), part 1: Review of Current Advancements”

Introduction

The review article provides a comprehensive overview of the rapidly evolving field of artificial intelligence (AI) in neuro-oncology, focusing on the application of AI models for diagnostic, prognostic, and therapeutic purposes. It critically assesses existing AI tools for identifying key genomic markers, predicting patient responses to treatment, and distinguishing between disease progression and treatment-related changes. As neuro-oncology is an area fraught with diagnostic challenges, particularly in differentiating treatment effects from tumor progression, the promise of AI is highlighted as a key factor in improving clinical decision-making.

Strengths

1. **Thorough Review of Current Technologies:**

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 The article offers a detailed examination of AI tools currently in use,
including predictive models for assessing response before and after therapy,
which is a critical issue in neuro-oncology. This review is an important
resource for clinicians and researchers looking for up-to-date insights into
the landscape of AI applications.
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2. **Focus on Genomic Markers and Predictive Models:**

The authors discuss AI's ability to assist in the identification of key genomic markers, which are essential for understanding the molecular underpinnings of tumors. This focus on precision medicine is essential, as the field of neuro-oncology increasingly requires targeted therapies based on genetic information. Predictive AI models for response assessment are particularly relevant, as they may enable clinicians to personalize treatment plans based on patient-specific data, potentially leading to better outcomes.

3. **Addressing Challenges in Response Assessment:**

A significant portion of the review is dedicated to the challenge of differentiating true disease progression from treatment-related changes. This is an area of active research and great concern in neuro-oncology, and the article highlights AI's potential to reduce diagnostic ambiguity and assist clinicians in making more accurate determinations.

4. **Future Directions:**

The review identifies promising future directions for AI in neuro-oncology, particularly in automating response assessment. Automation has the potential to streamline clinical workflows, reduce human error, and ensure more consistent evaluations across patients. The authors suggest that AI could eventually contribute to a standardized, objective, and reproducible method of response assessment.

Weaknesses

1. **Limited Discussion of Clinical Integration:**

While the article offers a thorough review of the current advancements in AI models, it does not delve deeply into the practical aspects of integrating these tools into routine clinical practice. Despite the potential benefits of AI in improving diagnosis and treatment decisions, the barriers to clinical implementation—such as regulatory approval, physician training, and integration with existing clinical systems—are not sufficiently explored.

2. **Overemphasis on Potential Without Addressing Limitations:**

The review tends to focus more on the promising applications of AI and less on the current limitations of these technologies. For example, while AI models can differentiate treatment-related changes from disease progression, the accuracy of these models in real-world settings and across diverse patient populations remains a significant concern. The article does not fully address the challenges of dataset biases, data quality, and the potential for AI models to reinforce existing clinical inequalities.

3. **Need for Further Validation:**

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 Although the authors discuss promising AI applications, there is a lack of
critical evaluation regarding the validation of these models in large,
independent clinical trials. Many AI models in healthcare are still in early
stages, and their generalizability and reliability across different patient
populations and institutions have not been thoroughly tested. The review
could have emphasized the need for rigorous validation studies to ensure
that these tools are safe and effective for widespread clinical use.
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Conclusion

Overall, the article provides an important and timely review of AI in neuro-oncology, focusing on the potential for AI tools to improve response assessment and patient care. It successfully highlights key advancements, such as predictive models and genomic marker identification, that are at the forefront of this field. However, the review could benefit from a more balanced discussion of the challenges faced in integrating AI into clinical practice, as well as a deeper exploration of the limitations and need for further validation. As AI continues to evolve, its role in neuro-oncology will likely expand, but ensuring its successful and ethical implementation will require careful consideration of the hurdles outlined above.

Critical Review of Lancet Oncol. 2024 Nov;25(11):e589-e601. doi: 10.1016/S1470-2045(24)00315-2. “Artificial Intelligence for Response Assessment in Neuro Oncology (AI-RANO), Part 2: Recommendations for Standardisation, Validation, and Good Clinical Practice”

Introduction

In this follow-up review, the authors focus on the crucial aspects of standardization, validation, and the integration of artificial intelligence (AI) in neuro-oncology, particularly in the assessment of therapeutic response. They explore how AI, including radiomics and other computational approaches, can be better standardized to ensure generalizability, reproducibility, and scalability in clinical settings. The article also discusses the pathway for AI’s clinical translation, with recommendations for its future use in clinical trials and neuro-oncology practice.

Strengths

1. **Comprehensive Focus on Standardisation:**

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 One of the major strengths of this review is its focus on the essential
need for standardization of AI tools in neuro-oncology. Standardization is
critical to ensure that AI algorithms are universally applicable, reliable,
and reproducible across different institutions and populations. The authors’
investigation into the repeatability and reproducibility of AI models in
clinical settings is particularly timely, as AI’s potential in healthcare
will be limited if these aspects are not properly addressed.
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2. **Incorporation of Open-Source Data and Tools:**

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 The inclusion of open-source data and computational software tools
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facilitates accessibility and transparency in the field. By encouraging the use of open-source resources, the authors promote a more collaborative and inclusive approach to developing AI in neuro-oncology, which can help avoid biases that might arise from proprietary or closed systems. This openness could accelerate progress and foster innovation.

3. **Emphasis on Good Clinical Practice:**

The review highlights the importance of adhering to good clinical practice (GCP) when developing and deploying AI models in clinical settings. AI tools in healthcare must meet high standards of reliability and safety, and the article provides valuable recommendations for ensuring that AI tools are developed and tested in a manner that is consistent with established clinical practices.

4. **Pathway for Future AI Implementation in Clinical Trials:**

The authors offer a clear and structured pathway for the standardization and validation of AI in neuro-oncology, which is an important contribution to the field. By outlining the steps needed to bring AI tools from research settings into clinical trials and practice, the review provides a roadmap for AI's integration into neuro-oncology, ultimately aiming to enhance clinical decision-making and patient outcomes.

Weaknesses

1. **Overgeneralization of Challenges:**

While the review outlines significant challenges regarding AI's clinical translation, it could delve deeper into the specific limitations encountered during the development and application of AI models in neuro-oncology. For instance, challenges related to data heterogeneity, variations in imaging techniques, and difficulties in translating AI algorithms from one setting to another are briefly mentioned but could have been discussed in more detail, particularly in relation to the neuro-oncology context.

2. **Lack of Real-World Case Studies:**

The review provides a theoretical framework for AI standardization and validation but lacks real-world case studies or examples of AI tools that have been successfully implemented in clinical neuro-oncology. While theoretical recommendations are important, concrete examples of successful AI integration would add credibility and help illustrate the practical feasibility of the proposed standardization protocols.

3. **Limited Discussion of Regulatory and Ethical Considerations:**

The review could have expanded its discussion on the regulatory and ethical implications of AI in healthcare. Issues such as patient consent, data privacy, the potential for algorithmic bias, and the role of human oversight

in AI-driven decision-making are increasingly relevant as AI tools are deployed in clinical settings. While the article touches on some of these points, a more thorough exploration of these aspects would have been valuable.

4. **Challenges in Achieving True Trustworthy AI:**

Achieving “trustworthy AI” in neuro-oncology is a central theme of the review, but the article could benefit from a deeper exploration of how AI models can achieve the necessary transparency, interpretability, and accountability to gain the trust of clinicians and patients. AI in healthcare is still an evolving field, and while the authors discuss trustworthiness, they do not sufficiently address how to overcome the technical and societal challenges of ensuring AI's trust in clinical practice.

Conclusion

This review is a significant contribution to the ongoing dialogue about the future of AI in neuro-oncology, particularly in the context of response assessment. The article’s emphasis on standardization, reproducibility, and good clinical practice offers a valuable framework for the successful deployment of AI tools in clinical settings. However, the review would benefit from a more nuanced discussion of the real-world challenges faced during the development of AI models, as well as a deeper exploration of regulatory, ethical, and trust-related concerns. As AI continues to make strides in healthcare, this review serves as a helpful guide for advancing the field of neuro-oncology, with the hope of ultimately improving patient care [2].

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Bakas S, Vollmuth P, Galldiks N, Booth TC, Aerts HJWL, Bi WL, Wiestler B, Tiwari P, Pati S, Baid U, Calabrese E, Lohmann P, Nowosielski M, Jain R, Colen R, Ismail M, Rasool G, Lupo JM, Akbari H, Tonn JC, Macdonald D, Vogelbaum M, Chang SM, Davatzikos C, Villanueva-Meyer JE, Huang RY; Response Assessment in Neuro Oncology (RANO) group. Artificial Intelligence for Response Assessment in Neuro Oncology (AI-RANO), part 2: recommendations for standardisation, validation, and good clinical practice. Lancet Oncol. 2024 Nov;25(11):e589-e601. doi: 10.1016/S1470-2045(24)00315-2. PMID: 39481415.