



Update on Molecular Imaging and Artificial Intelligence in Brain Tumors

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INTRODUCTION

Teaching Points:

- To assess current and future clinical applications of molecular imaging (MI) in the setting of diagnosing and treating brain tumors
- To compare the benefits and limitations of positron emission tomography (PET) with radiotracers in cases of suspected brain tumors
- To analyze potential roles artificial intelligence (AI) may play in tumor characterization and treatment

PET with Amino Acid Radiotracers

- Radiotracers such as 18F-FDG and 68Ga-DOTATATE are part of the current standard for successfully identifying neoplastic tumor and tumor extent
- Current imaging procedures utilizing 18F-FDG or 68Ga-DOTATATE are hindered by the general glucose utilization of non-neoplastic brain tissue
- New studies showcase the usage of these and other tracers to further characterize image findings and shape patient treatment plans

Use of Artificial Intelligence

- AI-assisted tumor segmentation can be used to reduce segmentation time and improve efficiency
- AI models and computer-aided detection (CAD) allow greater characterization than may be assessed by the human eye

METHODS

- MEDLINE, PubMed, and Google Scholar were utilized to perform a literature review between 2018 and 2023
- Key words included "radiotracers", "artificial intelligence", "brain tumors", "PET"
- Editorials, commentaries, and unpublished works were excluded

RESULTS

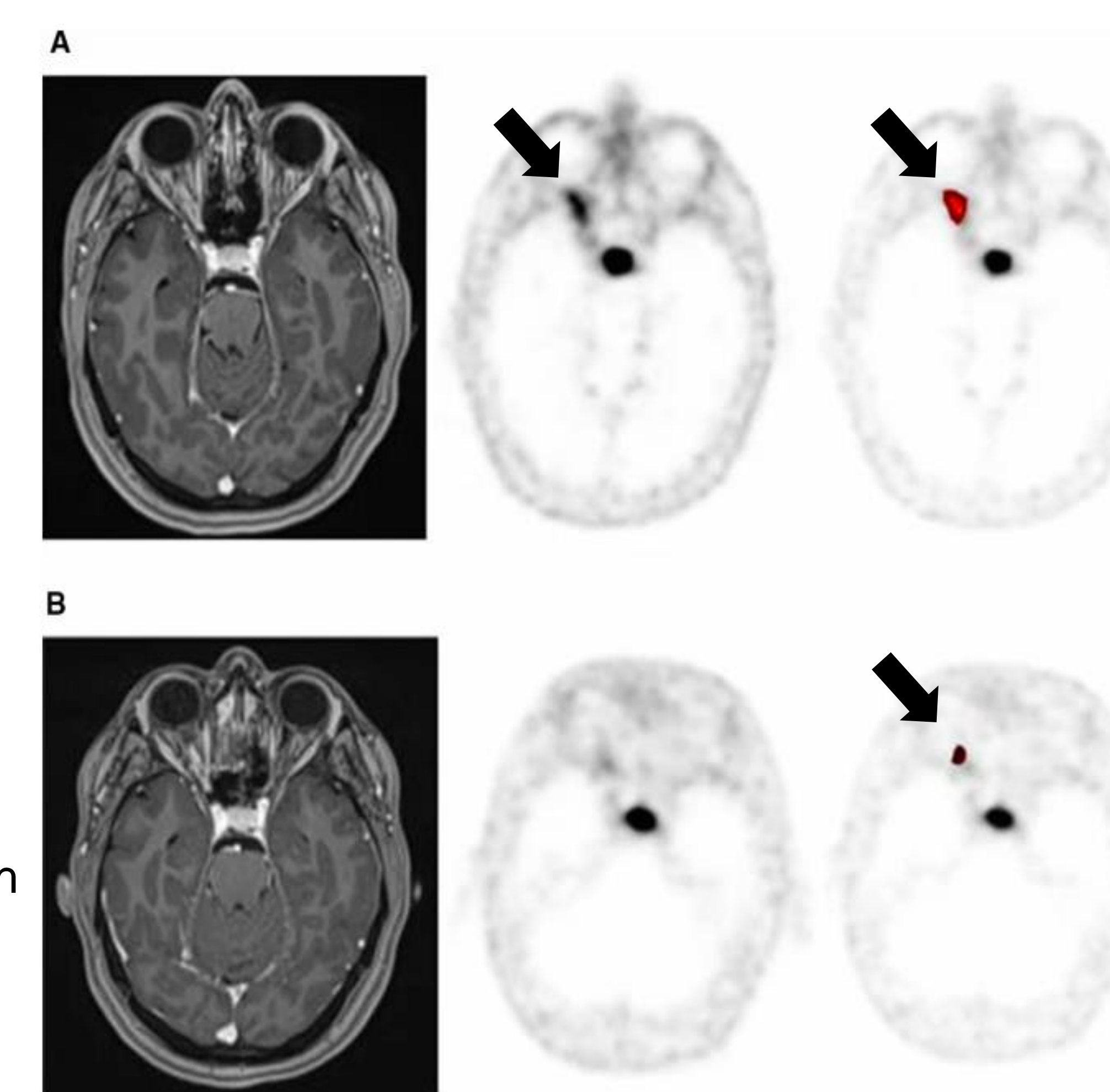
Molecular Imaging Advances

- The development of new amino acid tracers and somatostatin receptor (SSTR) ligands in PET allows greater accuracy of tumor diagnosis and visualization because they are not as highly metabolized by normal tissue
- SSTRs are expressed in nearly 100% of meningiomas, thus SSTR ligands induce a pathway for excellent tumor contrast
- SSTR PET with DOTATATE has demonstrated a higher sensitivity for detecting scar tissue vs. active tumor compared to standard MRI (90% vs. 79%)
- Amino acid tracers also show promise in the detection of low-grade gliomas as they achieved a sensitivity of 88% and a specificity of 85% in a recent meta-analysis across 23 studies (n=889 patients)
- [11C] MET-PET showed efficacy in detecting areas at high risk of tumor recurrence in 26 patients following radiotherapy, contributing to the assessment of treatment plans and further radiotherapy usage in necessary patients
- Other tracers such as 18F-FMISO have shown importance in evaluating hypoxia, a key means of treatment resistance and subsequent prognostic measurement in high-grade gliomas and glioblastoma multiforme
- MI advances also include the use of combination therapies that can better evaluate tumor delineation and treatment response (Case 1)

The Future of AI in Brain Tumor Cases

- Cè et al.
- While still in their early stages, AI and other CAD models show promise in increasing diagnostic accuracy and ability to obtain information with less invasive procedures in certain settings
- Deep learning domains such as convolutional neural networks (CNN) involves massive data aggregation that can quickly and accurately interpret imaging
- Detection and Diagnoses: Across several studies, various AI models were found to experience greater than 95% accuracy in correctly diagnosing and differentiating brain tumors
- Segmentation: The use of modalities such as CNN-associated models have produced results with nearly 90% accuracy and suggest that this rigorous process may soon allow semi- or full automaticity

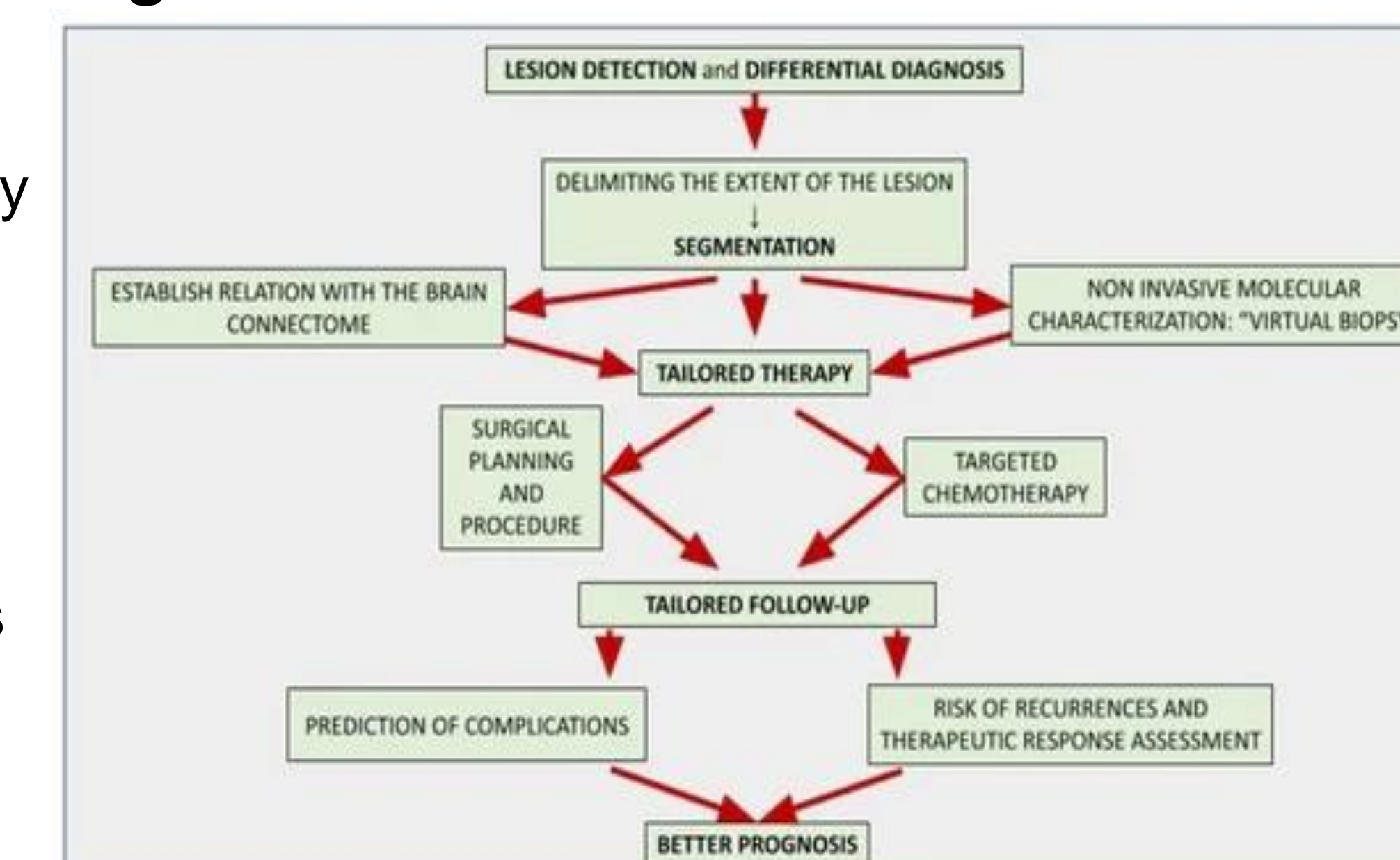
Case 1



A Pre-RT imaging: T1 post-contrast MRI, Pre-treatment 68Ga-DOTATATE PET, SUV Max=6.3, image from ROVER adaptive thresholding software. B Three month post-RT PET-MR imaging: T1 post-contrast MRI, 68Ga-DOTATATE PET/CT, SUV Max=3.8, image from ROVER adaptive thresholding software

- Kowalski et al.
- 22-year-old female presenting with 8-month history of progressive vision loss in right eye
- Initial CT without contrast did not demonstrate optic nerve calcification, further imaging with combination 68Ga-DOTATATE PET/CT confirmed diagnosis of optic nerve sheath meningioma
- New visualization promoted tailored treatment and 68Ga-DOTATATE PET/CT SUVmax decreased from 6.8 pre-therapy to 3.8 post-therapy
- Patient experienced improved right-sided vision at three-month check-up

Figure 1



- The flowchart in Figure 1 represents the current AI tools for brain tumor imaging and highlights their shared purpose of providing patient-specific therapy in order to achieve a better prognosis. (Cè et al.)

CONCLUSION

- The advancement of molecular imaging modalities and procedures is key to attaining **optimal patient outcomes** in the setting of various brain tumors
- Current imaging standards produce valuable information but can be **limited by lack of differentiation** between active tumor, tumor recurrence, and therapy-related change
- Utilizing the metabolic characteristics of brain tumors allows the production of radiotracers that **better visualize tumors** and assist in **overcoming previous imaging limitations**
- The development of artificial intelligence and other CAD models is not meant to replace physicians but rather **promote efficiency and accuracy**
- MI and AI advancements have shown enough **efficacy in limited studies** to continue being examined, but their usage continues to **highlight limitations that also must be analyzed**

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