Metabolic Insights into Neurobehavioral Changes Utilizing Software-Based Regional Analysis Following Treatment of Brain Metastases

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Introduction

There is a need for presurgical planning and postsurgical tracking of brain metastases, which can cause significant neurological dysfunction varying based on lesion location. 18-Fluorodeoxyglucose (FDG) PET/CT imaging can identify regions of altered brain metabolism, but further region-specific analysis is desired to guide surgical treatment. This study pioneers the utilization of MIMneuro (MIM Software, Inc., Cleveland, OH, USA) for the regional characterization of metabolic changes identified by 18-FDG PET/CT in the setting of treated metastatic disease.

Methods

Our study participant is an 85-year-old male patient with a history of skin melanoma, basal cell carcinoma, and squamous cell carcinoma. The patient underwent an 18-FDG PET/CT imaging at baseline and 14 months after baseline. We utilized MIMneuro version 7.1.5 with an integrated anatomic atlas to conduct a comprehensive regional brain metabolism analysis in 70 distinct brain regions. Regions within or spatially adjacent to the site of the lesion were excluded.

References:
1. Rishi A, Yu HM. Current Treatment of Melanoma Brain Metastasis. Curr Treat Options Oncol. 2020 Apr 30;21(6):45.
2. Rolls ET. Emotion, motivation, decision-making, the orbitofrontal cortex, anterior cingulate cortex, and the amygdala. Brain Struct Funct. 2023 Jun;228(5):1201-1257.

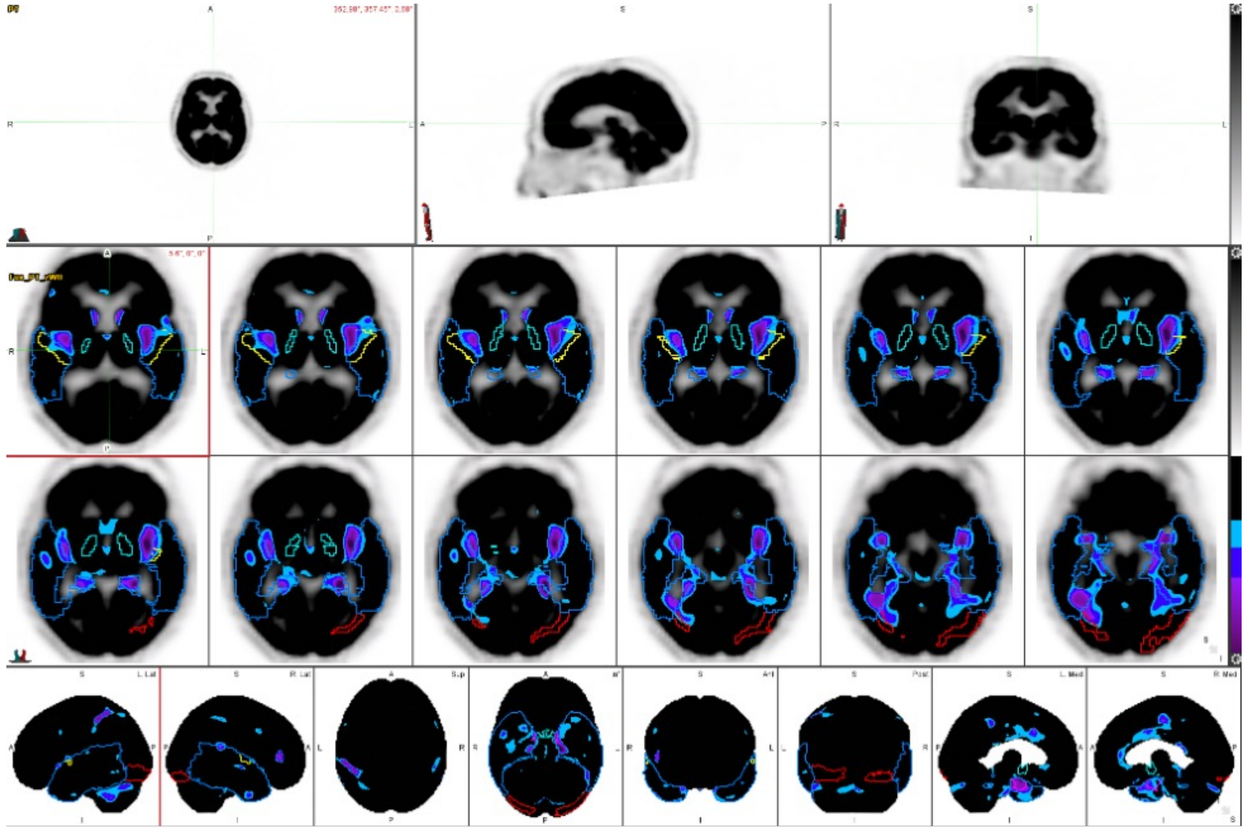

Figure 1 – Evaluation of 18-FDG-PET through quantitative analysis using MIMNeuro version 7.1.5 (MIM Software, Inc., Cleveland, OH, USA). Low 18-FDG uptake is represented by purple and blue contours. The globus pallidus (light blue), Heschl's gyrus (yellow), inferior occipital gyrus (red), amygdala (pink), and temporal lobe (dark blue) have been delineated as regions of interest in this patient.

Results

Baseline PET/CT showed no evidence of metastases in the central nervous system. 18-FDG PET/CT 14 months later revealed non-FDG avid lesions in the left centrum semiovale and left parietal region, likely representing treated metastatic disease. PET/CT demonstrated significant bilateral hypermetabolism across 8 regions in the orbitofrontal area ($z>1.65$), the globus pallidus ($z=2.53$) and the inferior occipital gyrus ($z=2.04$), and significant bilateral hypometabolism in the auditory cortex ($z< -1.65$) and the limbic system ($z<1.65$).

Conclusions

The orbitofrontal area is extensively connected with the limbic system to regulate emotional processing, personality, and behavior. These metabolic changes may reflect a shift in where these are predominantly processed after treatment of brain metastasis.

Our results demonstrate the potential of MIMneuro software imaging to characterize functional changes in regional brain metabolism using post-treatment 18-FDG PET/Ct imaging. Software-based quantitative regional analysis may further aid in presurgical planning of tumor resection and correlate with clinical findings of neurologic and sensory function before and after surgery.