PROJECT

Supervisor:	Antonella Castellano
Title:	Explainable AI for Preoperative Characterization and Risk Stratification of Intracranial Meningiomas Using Multiparametric MRI
Curriculum:	Clinical and Experimental Medicine
Link to the personal page of the University or relevant hospital site website:	www.unisr.it/docenti/c/castellano-antonella

Description of the Project (max 3,000 characters including spaces)

Background/gap of knowledge

Meningiomas are the most common primary tumors of the central nervous system and are characterized by marked biological heterogeneity, resulting in highly variable clinical behavior and treatment outcomes. Despite advances in neuroimaging, preoperative assessment still relies largely on qualitative and subjective interpretation of MRI, which limits reproducibility and hampers accurate risk stratification. Furthermore, although recent deep learning approaches have shown promising classification performance, they often operate as "black-box" systems, providing limited insight into the biological features driving their predictions and thus restricting their clinical applicability.

In this context, there is a clear gap in the development of robust, interpretable, and clinically integrated AI tools capable of linking imaging phenotypes with underlying tumor biology. Radiomics and explainable artificial intelligence (XAI) offer a promising framework to extract quantitative imaging biomarkers and to provide transparent, clinically meaningful interpretations of model outputs.

Rationale and hypothesis

The rationale of this project is that combining multiparametric MRI-derived radiomic features with interpretable machine learning approaches can overcome the limitations of both traditional radiology and black-box AI systems. The central hypothesis is that such integrated models can accurately predict meningioma WHO grade and biological aggressiveness from preoperative imaging while simultaneously identifying the key imaging features driving these predictions, thereby enhancing clinical trust and usability.

Objectives and specific aims

To test this hypothesis, the project aims to develop and validate interpretable AI models for the characterization of meningiomas using a large multicentric dataset of preoperative MRI and histopathological ground truth. Specifically, the study will (i) develop robust semi-automatic segmentation methods for lesion delineation, (ii) extract and harmonize radiomic features from multiparametric MRI, (iii) build predictive models for WHO classification integrating imaging and clinical descriptors, and (iv) implement XAI techniques to identify and quantify the most relevant imaging biomarkers associated with tumor grade. The models will be validated on independent prospective data to assess generalizability and clinical utility.

Expected outcomes

The expected outcomes of this project include the development of a validated, interpretable AI-based decision-support tool for preoperative meningioma characterization, the identification of novel radiomic biomarkers associated with tumor aggressiveness, and an improved understanding of the relationship between imaging features and histopathological findings. Ultimately, this work aims to enhance diagnostic accuracy, support personalized treatment planning, and facilitate the integration of AI into clinical workflows, contributing to improved patient management and outcomes.

Skills that the student should acquire (max. 600 characters including spaces):

Medical image analysis, radiomics, machine learning and deep learning, explainable AI (XAI), Python programming, statistical modeling, clinical data integration, interdisciplinary collaboration, scientific writing, grant writing, and research dissemination.

References (max. 15)

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10. Zhou M, Scott J, Chaudhury B, et al. Radiomics in Brain Tumor: Image Assessment, Quantitative Feature Descriptors, and Machine-Learning Approaches. AJNR Am J Neuroradiol. 2018;39(2):208–16. doi: 10.3174/ajnr.A5391