**PhD Thesis Title:** Quantitative susceptibility weighted imaging (SWI) in grading of intracranial mass lesions and assessment of acute ischemic stroke penumbra

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## Abstract

This PhD thesis aims to explore the novel potentials of one of the advanced MRI methods known as Susceptibility Weighted Imaging (SWI), to develop quantitative biomarkers from SWI and to finally validate their implication in routine clinical setting particularly for specific disease conditions: glioma, primary cerebral nervous system lymphoma (PCNSL), and acute ischemic stroke. The scope of this thesis results in finding unmet benefits in terms of diagnostic accuracy, confidence as well as in reducing scan time and contrast dosage. It aims for better treatment prognosis, planning and management that can benefit the patients.

The second chapter of the thesis proposes a noninvasive segmentation based quantitative approach to analyze intra tumoral susceptibility signal (ITSS) from SWI and finally calculate ITSS vasculature volume (IVV) within grades of glioma. The proposed method scores over the existing semiquantitative method in terms of ITSS estimation and grading accuracy. The current study also evaluates the role of quantitative susceptibility mapping (QSM) for segmentation of ITSS into hemorrhage and vasculature; compute QSM based IVV and compare the results with $R_2^*$ based IVV for glioma grading. A high correlation between both these methods is found. Therefore, QSM can be used interchangeably with $R_2^*$ to calculate IVV for differentiation between grade II vs III and grade II vs IV. For grade III vs IV, $R_2^*$ based IVV scores better. True biological classification of ITSS is necessary to understand the tumor viability, aggressiveness, and angiogenesis. This study develops a novel quantitative approach that combines SWI, $R_2$* relaxivity and DCE MRI parameters for segmenting ITSS and its further classification into biological behaviour-based subcategories.

The third chapter of the thesis, our findings suggest SWI to be the most useful sequence in the glioma grading as it contributes to calculating the IVV metric, which can singlehandedly

improve the glioma grading much further when combined with radiomic analysis used in combination with PCA feature reduction and random forest ML classifier. In the case of patients where contrast injection is impossible due to renal impairments, non-contrast way of glioma grading based on radiomic analysis use of SWI alone can provide almost as good accuracy as using the combinational approach of FLAIR and SWI. This chapter explores the differences between hemorrhage and vasculature ITSS masks regions within the tumor, assessed by SWI images involving radiomic features extraction and machine learning-based classification. This chapter also focuses on evaluating the performance of texture-based features of SWI in improved differentiation of PCNSL from grade IV gliomas which proves to be a better standalone classification method.

Objectives of the fourth chapter of the thesis are to enhance the Prominent hypo-intense vein sign (PHVS) visibility in SWI, automatically segment and quantify stroke penumbra volume from it and calculate the mismatch ratio between PHVS(SWI) and DWI. The proposed approach demonstrates a high correlation with the gold standard ASL method, suggesting that PHVS and SWI based penumbra quantification has the potential to be used as an alternative for perfusion-based methods in stroke therapy setups. It could save the scan time, does not require any contrast dose to be injected and therefore should be beneficial for acute stroke therapy management.

The author believes that the work in the thesis can help the clinicians (radiologists, neurosurgeons, and neurologists) in improved diagnosis and overall treatment planning of the patients and will also benefit the patients suffering from neuro-diseases (glioma, PCNSL, acute ischemic stroke) to be benefited from no harmful contrast dosage, lesser scan time with expected outcomes. The author sincerely hopes her work will help humanity in general.