Quantitative susceptibility mapping for iron

Quantitative Susceptibility Mapping (QSM) provides a contrast mechanism in Magnetic Resonance Imaging (MRI) different from traditional Susceptibility Weighted Imaging.

The voxel intensity in QSM is linearly proportional to the underlying tissue apparent magnetic susceptibility, which is useful for chemical identification and quantification of specific biomarkers including iron, calcium, gadolinium, and super paramagnetic iron oxide (SPIO) nano-particles.

Quantitative susceptibility mapping (QSM) is used to differentiate between calcification and iron deposits. Few studies have examined the relationship between CT attenuation values and magnetic susceptibility in such materials. Purpose To assess the relationship among metal concentration, CT attenuation values, and magnetic susceptibility in paramagnetic and diamagnetic phantoms, and the relationship between CT attenuation values and susceptibility in brain structures that have paramagnetic or diamagnetic properties. Materials and Methods In this retrospective study, CT and MRI with QSM were performed in gadolinium and calcium phantoms, patients, and healthy volunteers between June 2016 and September 2017. In the phantom study, we evaluated correlations among metal concentration, CT attenuation values, and susceptibility. In the human study, Pearson and Spearman correlations were performed to assess the relationship between CT attenuation values and susceptibility in regions of interest placed in the globus pallidus (GP), putamen, caudate nucleus, substantia nigra, red nucleus, dentate nucleus, choroid plexus, and hemorrhagic and calcified lesions. Results Eighty-four patients (mean age, 64.8 years ± 19.6; 49 women) and 20 healthy volunteers (mean age, 72.0 years ± 7.6; 11 men) were evaluated. In the phantoms, strong linear correlations were identified between gadolinium concentration and CT and MRI QSM values ($R2 = 0.95$ and 0.99, respectively; $P < .001$ for both) and between calcium concentration and CT and MRI QSM values ($R2 = 0.89$ [$P = .005$] and $R2 = 0.98$ [$P < .001$], respectively). In human studies, positive correlations between CT attenuation values and susceptibility were observed in the GP ($R2 = 0.52$, $P < .001$) and in hemorrhagic lesions ($R2 = 0.38$, $P < .001$), and negative correlations were found in the choroid plexus ($R2 = 0.53$, $P < .001$) and in calcified lesions ($R2 = 0.38$, $P = .009$). Conclusion CT attenuation values showed a positive correlation with susceptibility in the globus pallidus and hemorrhagic lesions and negative correlation in the choroid plexus and calcified lesions [1].

Findings suggest that quantitative susceptibility mapping can characterize the composition of carotid plaques and quantify the degree of intraplaque hemorrhage and iron deposits [2].

Quantitative Susceptibility Mapping (QSM) MRI allows accurate assessment of iron content in cerebral cavernous malformations (CCM), and a threshold increase by 6% in QSM has been shown to reflect new symptomatic hemorrhage (SH) in previously stable lesions.

It is unclear how lesional QSM evolves in CCMs after recent SH, and whether this could serve as a monitoring biomarker in clinical trials aimed at preventing rebleeding in these lesions.

In 16 CCM patients who experienced a SH within the past year, whose lesion was not resected or irradiated.

The data acquisition was performed using QSM sequence implemented on a 3T MRI system ASSESSMENT: The lesional QSM assessments at baseline and yearly during 22 patient-years of follow-up were performed by a trained research staff including imaging scientists.

Biomarker changes were assessed in relation to clinical events. Clinical trial modeling was performed using two-tailed tests of time-averaged difference (assuming within-patient correlation of 0.8, power = 0.9 and alpha = 0.1) to detect 20%, 30% or 50% effects of intervention on clinical and biomarkers event rates during two years of follow-up.

The change in mean lesional QSM of index hemorrhagic lesions was +7.93% per patient-year in the whole cohort. There were 5 cases (31%) of recurrent SH or lesional growth, and twice as many instances (62%) with a threshold (6%) increase in QSM. There were no instances of SH hemorrhage or lesional growth without an associated threshold increase in QSM during the same epoch [3].

1)
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3)
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