Multiecho complex total field inversion

Typical quantitative susceptibility mapping (QSM) reconstruction steps consist of first estimating the magnetization field from the gradient-echo images, and then reconstructing the susceptibility map from the estimated field. The errors from the field-estimation steps may propagate into the final QSM map, and the noise in the estimated field map may no longer be zero-mean Gaussian noise, thus, causing streaking artifacts in the resulting QSM. A multiecho complex total field inversion (mcTFI) method was developed to compute the susceptibility map directly from the multiecho gradient echo images using an improved signal model that retains the Gaussian noise property in the complex domain. It showed improvements in QSM reconstruction over the conventional field-to-source inversion [1)].

Using improved susceptibility quantification, novel postprocessing QSM method from multiecho complex total field inversion (mcTFI) may better discriminate between acute and subacute ICH, compared to MEDI.

Study type: Retrospective cohort study.

Subjects: A total of 121 subjects enrolled following positive computerized tomography (CT) findings for ICH. Subjects were grouped based on time between admission and MR imaging: hyperacute (<24 hours), acute (1-3 days), early subacute (3-7 days), and late subacute (7-18 days).

Field strength/sequence: A multiecho gradient echo sequence at 3.0 T was paired with clinical noncontrast CT imaging.

Assessment: A quantitative index (CTindex) was derived based on relative intensities of blood on noncontrast CT. All images were co-registered, from which QSM parameters within the ICH area were assessed across groups, as well as the correlation with CTindex .

Statistical tests: Group differences were assessed using ANOVAs. Linear regressions between the CTindex , MEDI, and mcTFI measurements were used to assess their relationships. Statistical significance was set at $P < 0.05$.

Results: A total of 21 hyperacute, 72 acute, 21 early subacute, and 7 late-subacute patients were included in this analysis. Significant changes in blood susceptibility were found over time for the MEDI and mcTFI, although mcTFI better differentiated the hyperacute/acute from subacute stages. CTindex values within the ICH were more strongly correlated with mcTFI QSM ($r = 0.727$) than MEDI ($r = 0.412$) QSM.

Data conclusion: McTFI susceptibility estimation demonstrated better correlation with ICH acuity as suggested by CT, providing an improved method to assess acuity of intracranial blood products in clinical settings to identify cases that may require acute intervention [2)].

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Wen Y, Spincemaille P, Nguyen T, Cho J, Kovanlikaya I, Anderson J, Wu G, Yang B, Fung M, Li K, Kelley D, Benhamo N, Wang Y. Multiecho complex total field inversion method (mcTFI) for improved signal modeling in quantitative susceptibility mapping. Magn Reson Med. 2021 May 24. doi: 10.1002/mrm.28814. Epub ahead of print. PMID: 34028868.
2)

Champagne AA, Wen Y, Selim M, Filippidis A, Thomas A, Spincemaille P, Wang Y, Soman S. Quantitative Susceptibility Mapping for Staging Acute Cerebral Hemorrhages: Comparing the Conventional and Multiecho Complex Total Field Inversion magnetic resonance imaging MR Methods. J Magn Reson Imaging. 2021 Jun 11. doi: 10.1002/jmri.27763. Epub ahead of print. PMID: 34117811.