Evaluation of reconstruction algorithms and imaging acute stroke with multi-frequency electrical impedance tomography in a head-shaped tank with a real human skull

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Multi-frequency electrical impedance tomography (MFEIT) is one of the possible applications for imaging acute stroke. There is no pre-stroke baseline data available, therefore absolute or frequency difference imaging is needed.Simple frequency difference algorithms are ineffective with a complex background even in cylindrical 2D tank.This can be overcome with a background correction, using a weighted frequency difference algorithm with which correction is made for a frequency dependent background. Weighted frequency difference images in 3D head shaped tank without skull were shown in reasonable quality. The purpose of this study was to assess whether any available time or frequency difference algorithm could produce acceptable images in realistic head-shaped tank containing a skull. The phantom comprised a spherical, 2.5 cm diameter, potato test object, placed in four different positions in a saline or carrot-saline complex conductivity background. Data were collected with the UCLH Mk2.5 MFEIT serial system, with 269$\mu A_{p\text{-}p}$current injected consecutively through opposing electrode pairs in the EEG31 protocol at nine frequencies (80Hz- 164 kHz), with voltages recorded through 31 electrodes in a modified 10-20 electrode arrangement. Image reconstructions were performed with time difference (TD), frequency difference (FD), FD adjacent (FDA), weighted FD (WFD), and weighted FDA (WFDA) linear algorithms. Comparison of the image quality wasevaluated both qualitatively and quantitatively. Quantitative investigations showed that localisation error was <10% for all positions in the saline background except the anterior position. No reliable imaging was possible with the FD and FDA algorithms in the carrot-saline background, because signal to noise ratio (SNR) is around half of the saline background for all positions. With posterior and lateral placement of the test object TD, WFD and WFDA images were qualitatively acceptable, while for the other positions they were not.The total error is including localisation, shape and SNR error about 35-40% for posterior and lateral. This indicates that, in the presence of a highly resistive skull, no algorithm is successful for imaging of all perturbation locations because of thelow SNR level. Work is in progress to examine alternate excitation configurations, improved forward modelling and non-linear inverse reconstruction methods, prior to undertaking studies in clinical subjects.