Optimizing a 3D Double Inversion Recovery (DIR) Protocol to Obtain Optimal Grey/White Matter Contrast in the Pediatric Brain

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Purpose: The double inversion recovery (DIR) sequence allows both cerebrospinal fluid (CSF) and white matter signal to be suppressed [1, 2]. This may be of benefit to image the cortex alone to detect subtle malformations of cortical development (MCD). The T1 of CSF remains relatively constant through age ranges. However, using the TI parameters from our adult DIR protocol did not provide optimum white matter signal suppression to diagnose subtle MCDs in our pediatric patient population as the T1 of the white matter varies with the degree of myelination [3]. The purpose of this study was to determine appropriate TI values for suppression of white matter signal using a 3D fast spin echo (Cube) double inversion recovery (DIR) pulse sequence [4] to obtain optimal grey-white matter contrast for approximate age ranges of the pediatric brain.

Methods: A Cube DIR sequence employing two adiabatic inversion recovery RF pulses to null the signal from CSF and white matter was evaluated in a pediatric population. The TI values for nulling of the CSF (TI_{csf}) and WM (TI_{wm}) were automatically calculated based on an algorithm that included the user specification of approximate T1s of CSF and white matter. For our study, we scanned 35 patients between the ages of 2 days and 7.3 years (14 females, 21 males) on a 3T MR scanner (MR 750 GE Healthcare, Waukesha WI, USA). The protocol for the Cube sequence was: TE/TR 18/6000 msec, receiver bandwidth 31.2 kHz, FOV 24x21 cm, imaging matrix 256x256, section thickness 1.2 mm, 148 sections, NEX 0.5 with parallel imaging acceleration factor 2.9 using an 8 channel phase array head coil. We varied the user specified approximate T1 values of white matter to empirically determine optimal TI values to null the white matter and CSF. The images were reviewed by two board certified Radiologists with additional training in Neuro MRI.

Results: In 8 patients under 1 year of age, TI_{csf}/TI_{wm} values between 1777/472 and 1580/757ms did not provide sufficient white matter contrast suppression. For patients aged 1-2 years (n=7), TI_{csf}/TI_{wm} values ranged from 1777/472 to 1706/579ms with optimal white matter suppression and grey-white matter contrast around TI_{csf}/TI_{wm} = 1706/579ms. For patients aged 2-3 years (n=6), TI_{csf}/TI_{wm} values ranged from 1777/472 to 1714/568ms with optimal white matter suppression and grey-white matter contrast around TI_{csf}/TI_{wm} = 1714/568ms. For patients aged 3-5 years (n=6), TI_{csf}/TI_{wm} values ranged from 1777/472 to 1728/546 with optimal white matter suppression and grey-white matter contrast at TI_{csf}/TI_{wm} = 1728/546ms. For patients aged 5-7.5 years (n=4), TI_{csf}/TI_{wm} values ranged from 1744/522 to 1728/546ms with optimal white matter suppression and grey-white matter contrast at TI_{csf}/TI_{wm} = 1744/522ms. Table 1 summarizes these results.

AGE	TI_{csf}/TI_{wm} (ms)
1-2 years	1706/579
2-3 years	1714/568
3-5 years	1728/546
5-7.5 years	1744/522
16 years and higher*	1777/472

Table 1: TI values for optimal white matter .suppression by age from 1 year to 7.5 years. * from institution's adult protocol parameters

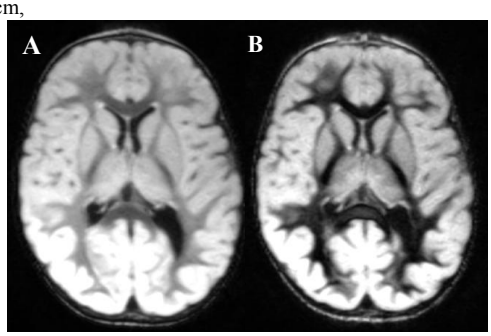

Figure 1: Axial reformats of Sagittal DIR sequences In a patient aged 1 year 6 months obtained with T1 values of 1777/472ms (A) and 1706/579ms (B). The images obtained with a T1 value of 1706/579ms demonstrate superior grey-white matter contrast.

Discussion: Malformations of cortical development are a common cause of drug-resistant epilepsy in patients under the age of 18 [5]. The double inversion recovery (DIR) sequence allows both cerebrospinal fluid (CSF) and white matter signal to be suppressed to image the cortex alone to detect subtle malformations of cortical development (MCD). Using standard TI_{wm} from our adult protocol did not provide optimum white matter signal suppression, grey-white matter contrast or image quality to diagnose subtle MCDs in our pediatric patient population. Previous studies have demonstrated a decrease in T1 with age from childhood through adolescence. We were able to determine approximate TI_{wm} values for use in 3D Cube DIR sequence to optimize the grey-white matter contrast in patients aged 1 year to 7.5 years. We were unable to optimize white matter suppression in children under 1 year of age. As there is significant variation of the T1 of white matter during this time period it may be difficult to define values appropriate for that age. Additional solutions for obtaining the appropriate TI_{csf}/TI_{wm} for that range will need to be investigated.

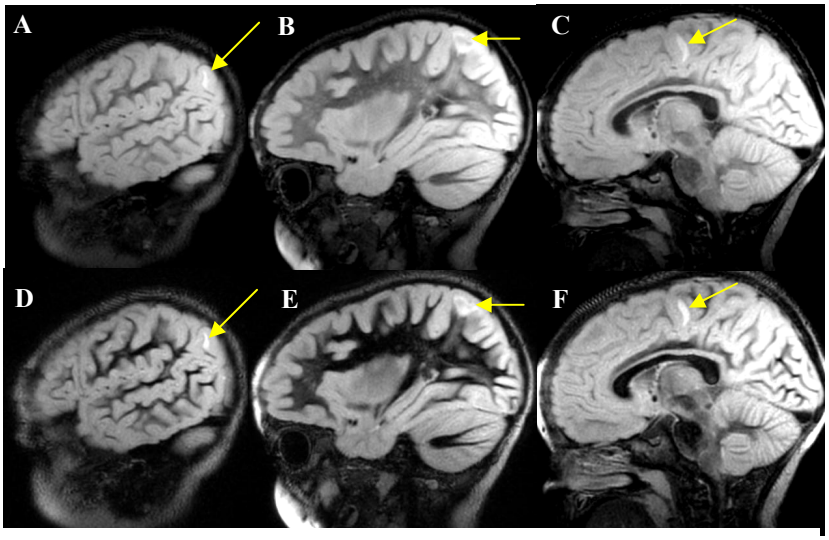

Figure 2: Sagittal DIR sequences in a patient aged 2 years 1 month obtained with TI values of 1777/472 (A, B, C) and 1714/568 (D, E, F). Images obtained with TI values of 1714/568ms demonstrate superior grey-white matter contrast and greater conspicuity of cortical tubers in a patient with tuberous sclerosis.

References:

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