Comparison of Diffusion-weighted imaging strategies in acute ischemic stroke

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Introduction

Restricted water diffusion associated with acute ischemic stroke (AIS) results in increased signal intensity on diffusion-weighted images.[1] Varying the diffusion sensitivity (or *b* value - a function of diffusion gradients) alters the image contrast between normal and ischemic tissue.[1] Higher *b*-value sequences increase normal-to-ischemic contrast on DWI;[1] although if *b* is greatly increased studies have shown a decreased signal difference between normal and ischemic tissue.[2] Fluid-inversion-prepared DWI (FLIPD) is a technique that produces cerebrospinal fluid (CSF)-nulled diffusion images, and thus attempts to minimize partial volume effects due to CSF.[3] The objective of this study was to evaluate at 3 T which DWI technique: (1) $b = 1000$ mm^{-2} s, (2) $b = 1500$ mm^{-2} s or (3) FLIPD-prepared with $b = 1500$ mm^{-2} s is most effective in detecting AIS in adults.

Methods

Seventy-seven consecutive AIS patients presenting within 24 hours of symptom onset were studied over a two-year interval. DWI were acquired on a 3 T scanner (Signa; General Electric Medical Systems, Waukesha, WI) as single-shot spin-echo echo-planar-imaging, TR = 7000 ms, TE = 96.5 ms, field-of-view = 32 cm x 19 cm, 192 x 116 acquisition matrix, and nineteen 5-mm slices with a 2-mm gap) with (1) $b = 1000$ mm^{-2} s, (2) $b = 1500$ mm^{-2} s, and (3) FLIPD-prepared (TR= 9500 ms and TI= 2200 ms) with $b = 1500$ mm^{-2} s. Four experienced raters reviewed the images independently. Images from the three DWI were reviewed separately and in a random order. Each rater indicated the presence or absence of AIS changes for each hemisphere on each slice. To examine intra-rater reliability a portion of the review was completed twice by each rater. In order to produce a gold-standard for the presence or absence of AIS changes, two neuroradioligists gave a consensus rating from simultaneous review of all three DWI sets with relevant patient history and other imaging findings (including follow-up MR and CT imaging).

Results

The average age was 64.1 years ± 14.7 years (mean ± standard deviation; range of 20 years – 90 years) with MR imaging occurring 6.4 h ± 6.4 h of onset. The median NIH stroke scale (NIHSS) score was 4 (range: 0 to 29) at MR imaging and 2 (range: 0 to 21) after 24 h. Table 1 summarizes the sensitivity, specificity, positive predicative value and negative predicative value (NPV). Only the sensitivity and NPV of the FLIPD-prepared data were significantly different and were found to be lower than the non-FLIPD techniques. The pooled intra- and inter-rater reliability (kappa statistic) are summarized in Table 2. Reliability was excellent in all three techniques although the intra-rater reliability for FLIPD was significantly lower, and the inter-rater reliability was lower for the $b = 1500$ mm^{-2} s compared to the other two techniques.

Table 1: Pooled sensitivity (Sens), specificity (Spec), positive predicative value (PPV), and negative predictive value (NPV). Shown are mean and 95% confidence intervals.

	b = 1000	**b = 1500**	**FLIPD + b = 1500**
Sens	82.7 % (77.5 – 87.2)	84.5 % (79.3 – 88.7)	62.0 % (55.7 – 68.0)
Spec	99.3 % (98.8 – 99.5)	98.6 % (98.1 – 99.0)	96.6 % (95.8 – 97.2)
PPV	91.2 % (86.7 – 94.5)	84.4 % (79.6 – 89.0)	90.6 % (85.3 – 94.6)
NPV	98.4 % (97.9 – 98.8)	98.6 % (98.1 – 99.0)	99.4 % (99.0 – 99.7)

Table 2: Pooled intra- and inter-rater reliability. Shown are kappa statistic (lower 95% confidence interval).

	b = 1000	**b = 1500**	**FLIPD + b = 1500**
Intra	0.86 (0.82)	0.85 (0.81)	0.78 (0.74)
Inter	0.85 (0.84)	0.81 (0.79)	0.83 (0.82)

Conclusions

Our results showed that while $b = 1000$ mm^{-2} s and $b = 1500$ mm^{-2} s DWI provide essentially similar diagnostic interpretations. FLIPD with $b = 1500$ mm^{-2} s was less sensitive and had a lower intra-rater reliability for detecting AIS lesions. The lower sensitivity exhibited by FLIPD is likely due to the lower signal-to-noise ratio of these images[4]. Differences in AIS detection were most prominent with FLIPD, probably because true changes were incorrectly discounted as artifact. The increase in intensity of AIS changes associated with a high *b* value of 1500 mm^{-2} s, did not significantly improve AIS detection and resulted in a slight yet significant decrease in inter-rater reliability. However, these results might be explained by an experience bias of our reviewers against the $b = 1500$ mm^{-2} s, which is not included in standard clinical imaging of AIS patients. This study demonstrates that FLIPD/b=1500 mm^{-2} s is not an optimal choice for AIS detection and suggests that the increased signal-to-noise ratio of $b = 1500$ mm^{-2} s does not necessarily translate to more effective detection of AIS.

References:

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