Ischemic penumbra in acute MCA stroke: comparison of the PWI-DWI mismatch and the ADC-based NEURINFARCT methods

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Background: The prediction of the risk of infarct growth (IG) is essential to decision making in acute stroke treatment and to estimate stroke outcome. The Perfusion (PWI) / diffusion-weighted imaging (DWI) mismatch is the most used index of the ischemic penumbra in clinical practice and remains the gold standard. However, this method has no clearly defined standardized haemodynamic parameters and cut-off values for PWI-based calculations. A method of prediction of IG only based on PWI acquisition and apparent diffusion coefficient (ADC) map has recently been developed and validated in 98 stroke patients. This method called Neurinfarct is based on an algorithm able to predict the initial infarct lesion growth. This region growing algorithm takes into account the mild ADC decrease which occurs in the at-risk tissue. The process is stopped when the mean ADC value of the growing region reaches a predetermined ADC cut-off value, which discriminates tissue at-risk and not at-risk. In this study, we compared Neurinfarct with the gold standard PWI/DWI mismatch for identifying ischemic penumbra in patients with acute middle cerebral artery (MCA) stroke. Figure 1: Description of the algorithm

Materials and Methods: Eighty patients were included with PWI/DWI performed within the first 12 h following stroke onset and a control DWI in the first 5 days (VIRAGE cohort). Quantitative ADC maps were generated using SPM8. Initial (V1) and final infarct volume (V2) were defined as the abnormal hyperintense area seen on DWI and were measured by manual outlining using Anatomist. The observed IG was defined as the final minus initial DWI hypersignal volume. PWI volume (PIVPWI) was defined on the time to peak map (TTP>4s). Neurinfarct ADC-based prediction (Fig 1) was recalibrated with a range of ADC cut-off values using 5000 bootstrap resampled datasets. The recalibrated ADC cutoff value was 720x10^-6 mm²/s for the absolute and 0.85 for the ratio. The predicted IG (PIG) was defined as the predicted volumes (PIVPWI or PIV702 and PIV0.85 for absolute and ratio ADC cut-off values respectively) minus initial DWI hypersignal volume. Predicted infarct volumes (PIV) and PIG for both methods were correlated with final observed data for all patients and subsequently for two groups of patients: patients with MRI performed within the first 4h30 after stroke onset (n = 29, group 1) and patients with MRI performed between 4h30 and 12 h after stroke onset (n = 51, group 2).

Results: Median V1 was 12.8 cm³ and V2 was 26.5 cm³. V2 was significantly correlated to PIV for both methods: ρ = 0.853 for PIV0.85, ρ = 0.855 for PIV702 and ρ = 0.673 for PIVPWI (p<0.0001). The ρ value was significantly higher for the PIV0.85 and PIV702-V2 correlations than for the PIVPWI-V2 correlation (p<0.01). The slope of the regression line between V2 versus PIV702 or PIV0.85 (Fig2A) was steeper for PIV0.85 (0.78 vs. 0.56, p=0.01). IG and mismatches were significantly (p<0.001) and similarly correlated for PIV0.85 (0.438), PIV702 (0.545) and PIVPWI (0.470) (p=0.71). The slopes of the regressions lines (Fig 2B) between IG and the mismatches did not differ (0.43, 0.30 and 0.49, p=0.29). There was a significant decrease in ρ values for the PIVPWI between groups 1 and 2 (p = 0.029) whereas ρ values between the 2 groups using Neurinfarct were not significantly different (p = 0.5 for PIV0.85 and p = 0.7 for PIV702).

Conclusion: Neurinfarct ADC-based method was as efficient for predicting infarct growth and more efficient for predicting infarct volume than the PWI/DWI mismatch. The ADC ratio cut-off seemed to better estimate the final volume than the absolute cut-off. Neurinfarct’s performances were similar during and after the therapeutic window whereas results with PWI/DWI mismatch were significantly lower after 4h30 after stroke onset.

Figure 2 A and B: Slope of the regression lines.