

ADC-based prediction of MCA infarct growth: validation in 216 acute stroke patients

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Background:

The MRI prediction of the risk of infarct growth is of a considerable interest for decision making in acute stroke treatment. Therefore, it can be used as a surrogate biomarker of efficiency in phase II “proof-of-concept” trials¹. It relies so far on the perfusion-diffusion mismatch but this concept remains challenged yet². We recently develop a method³ that only requires DWI acquisition and apparent diffusion coefficient (ADC) map to predict the infarct growth volume (PIG). This method is based on an algorithm able to make the initial infarct lesion growing up to its final size, taking in account the slight ADC decrease which occurs in the at-risk tissue. The process is stopped when the mean ADC value of the growing region reached a predetermined ADC cut-off value, able to discriminate tissue-at-risk and not at-risk. We suggest that image analysis techniques applied only to DWI sequences and ADC maps could help predict the final infarct volume (FV) in the acute stage of ischemic stroke.

In this study, we have reported the validation of this method on 216 MCA acute stroke patients who have had an initial MRI in the first six hours of stroke onset and a follow-up MRI in the first week, without symptomatic hemorrhagic transformation

Material and Methods:

The global dataset was split at random by two-third and one third with balancing on the infarct growth status to obtain a training dataset (n=144) and a validation set (n=72). The *observed* infarct growth (OIG) was defined as the final *minus* initial DWI hypersignal volume and the *predicted* infarct growth as the *predicted minus* initial DWI hypersignal volume.

The training set was used to find the ADC cut-off value able to stop the algorithm growing process. We have explored 6 ones, and the final decision took in account the correlation between final DWI and predicted volumes and the quantitative assessment.

On the validation set, purposes were (1) to verify and valid the ADC cutoff value found on the training set by correlation analysis; (2) to determine the accuracy of our method in the infarct growth status prediction using ROC curves analysis.

We therefore investigate on the global dataset if ADC-defined tissue-at-risk was really a hallmark of true penumbra by studying the impact of recanalization in the relationship between observed and predicted infarct growths.

Results:

In the training set, the better ADC cut-off value was an ADC ratio of 0.93. In the validation set, the mean OIG volume was 33.9 cm³ (IQR: 9-45), and the mean PIG volume was 32.2 cm³ (IQR: 0-44). Predicted and observed final infarct sizes and infarct growths were significantly correlated (r: 0.82 and 0.48, p < 0.001).

The ROC curve for predicting the group “infarct in evolution” (defined as OIG ≥ 10 cm³) had an area under the curve of 0.756, indicating a fair predicting performance. The best threshold of predicted infarct growth to achieve a robust classification had given a sensitivity of 73% and a specificity of 75%, 76% of the patients were properly classified into their group. We then analyze the effect of MCA recanalization (n=144/210) on the relationship between observed vs. predicted infarct growths, assuming that recanalization should spare the at-risk tissue. In good line with this hypothesis, the slope of the regression line OIG vs PIG was significantly higher in persistent MCA occlusion than in patients with MCA recanalization (0.68 vs. 0.37, p=0.05).

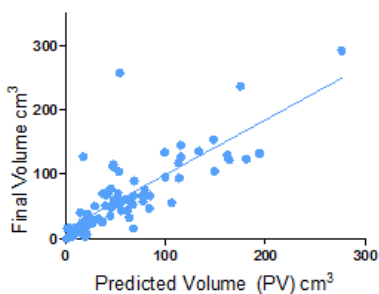


Figure 1: Scatter plots of Final vs. Predicted volume. The equation of the regression line is $FV=13.9+0.85PV$.

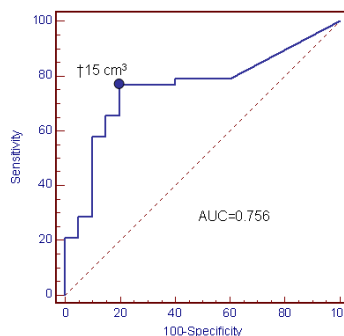


Figure 2: ROC curve of PIG for the prediction of infarct in evolution. AUC: Area under the curve.

Conclusion:

These results suggest the feasibility of ADC-based prediction of infarct growth with a new, automatic, and almost operator-independent algorithm. Our data show a significant correlation between *observed vs. predicted* infarct growth, and that the fate of ADC-DWI mismatch is affected by recanalization as expected in true penumbra. Sensitivity and specificity of this method are good, but there are not sufficient for individual clinical decision making. Because of its poor negative predictive value, it seems difficult to adjust thrombolytic therapy individually, by using it. Nevertheless, accuracy of our method and of PWI/DWI mismatch appears to be similar. ADC-based prediction of infarct growth is more appropriate for clinical trial enrolment, as PWI/DWI is.

References

- 1 Warach, Curr Controls Trial Cardiovasc Med, 2001
- 2 Kane, JNNP, 2007
- 3 Rosso, Radiology 2009