

Prediction of Outcome in Cerebellar Infarction by Diffusion MRI

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Background and Purpose—Early identification of patients at risk for neurological deterioration after stroke remains a challenge. MRI based volumetric assessments of infarct have been shown to predict poor outcome amongst patients with large middle cerebral artery infarcts.^{1,2} However, no such quantitative imaging measure exists to predict outcome following cerebellar stroke. In this study, we tested the hypothesis that the volume of cerebellar infarction and its associated apparent diffusion coefficient (ADC), as estimated from diffusion-weighted images (DWI), can provide reliable information for the prediction of neurological deterioration.

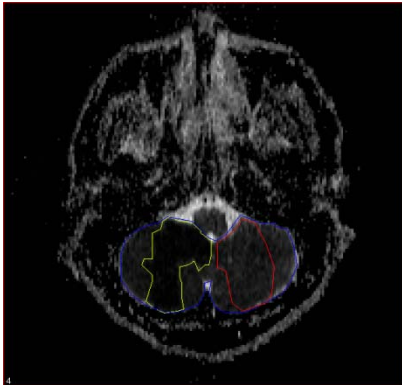


Figure 1: An apparent diffusion coefficient map demonstrates the manual trace of lesion (yellow), contralateral normal tissue (red), and the whole cerebellum (blue).

Methods—We retrospectively identified twenty-eight consecutive patients (age 58.2 ± 13) with cerebellar stroke who underwent MRI (median 40.8 hours) with DWI. Patients were divided into poor (N=7) and good (N=21) outcomes. Patients with poor outcome were defined as those who required posterior fossa decompression or died as a result of their cerebellar infarct. Areas contralateral to lesions were manually outlined to obtain the mean ADC value of normal cerebellar tissue (**Fig. 1**). Voxels with ADC values above $1 \times 10^{-3} \text{ mm}^2/\text{s}$ were excluded to reduce contamination from cerebrospinal fluid.³ The same procedure was used to obtain volumetric and mean ADC measurements of the whole cerebellum. Lesions were first manually outlined on the ADC map. A further threshold was used to include only voxels with ADC values that are at least one standard deviation from the mean ADC values of contralateral normal tissues. The ratio of the lesion volume to the whole cerebellum volume was calculated (rVolume) as well as the ratio of the lesion mean ADC to normal cerebellum mean ADC (rADC). The National Institutes of Health Stroke Scale (NIHSS) score, as well as age, sex and race were collected. Binary logistic regression was used to identify predictors of poor outcome. The sensitivity and specificity of rVolume and lesion volume were determined in predicting poor outcome using ROC analysis. The relative lesion volume was compared to NIHSS score.

Results—Logistic regression analysis revealed that rVolume ($p=0.018$), lesion volume ($p=0.034$), NIHSS score ($p=0.020$) and whole cerebellar ADC value ($p=0.043$) were significant predictors of poor outcome. The rADC ($p=0.073$) approached significance. **Fig. 2** shows the distribution of cerebellar ADC and rVolume amongst patients with poor outcome versus all others. The rVolume ($p=0.047$) remained a significant predictor of outcome even when controlling for age, NIHSS score, and hours to scan, while a trend towards significance for lesion volume ($p=0.072$), cerebellar ADC ($p=0.069$) and rADC ($p=0.061$) was also observed. There was no significant relationship between rVolume and NIHSS score ($p=0.343$). ROC analysis revealed that rVolume had a specificity of 95% and a sensitivity of 57% in predicting poor outcome. This implies that a lesion volume greater than 30% of the cerebellum (or ~41 cc of an average cerebellum) would more likely result in poor outcome.

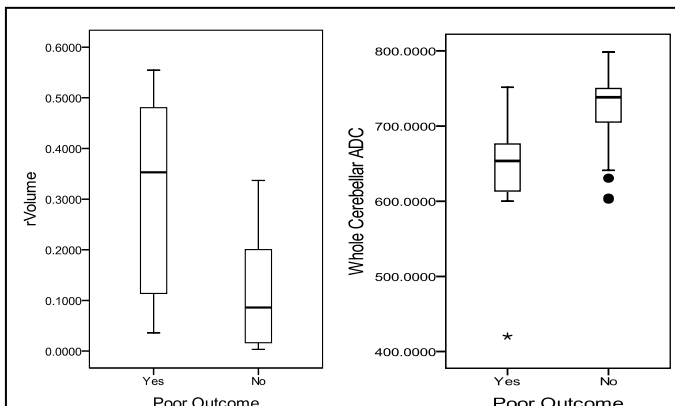


Figure 2: Box plots of whole cerebellar ADC (left) and rVolume (right) in outcome categories. Whole cerebellar ADC is lower ($p=0.043$), while rVolume is higher ($p=0.018$), in patients with poor outcome.

Conclusions—Quantitative measurement of rVolume, lesion volume, and cerebellar ADC values are significantly correlated with patient outcomes following cerebellar stroke. Although cerebellar ADC provided additional sensitivity, the rVolume appears to be a strong predictor of outcome when controlling for age, NIHSS score and time to scan. This suggests quantitative MRI analysis lends information to patient prognosis that traditional clinical observations do not. Quantitative analysis of diffusion MRI may assist in identification of patients with cerebellar stroke at highest risk of deterioration. Prospective validation is warranted.

References:

- [1]. Arenillas, J.F., et al., Stroke. 33:2197-2205. 2002. [2]. Thomalla, G. et al., Annals of Neuro. 68:435-45. 2010. [3]. Sener, R., Computerized Med. Imag. and Graphics. 25:299-326. 2001.