

Time course of ADC and FA in brainstem infarcts

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INTRODUCTION: The change of diffusion imaging in stroke shows a typical time course and is well described in hemispheric infarcts. Because lacunar brainstem infarcts have a good clinical prognosis, other pathophysiological mechanisms may play a role than in hemispheric ischemia.

MATERIAL AND METHODS: 20 patients with ischemic brainstem lesions were included into the study. Sequential MR scans were acquired at admission, in the first two weeks, and 3 to 6 month after onset of symptoms. MR scans included diffusion weighted imaging (DWI), where apparent diffusion coefficients (ADC) and fractional anisotropy (FA) have been derived from. In order to calculate a trend curve describing the change of diffusion parameters over time, a function was fitted to the single measurements (nonlinear least squares):

$$y(t) = \left(y(0) + \frac{t}{t_i} \cdot [y(t_i) - y(0)] \right) \cdot \frac{t_i}{t + t_i} + \left(y(t_i) + s \cdot \log\left(\frac{t}{t_i}\right) \right) \cdot \frac{t}{t + t_i} = y(0) + \left(2 \cdot [y(t_i) - y(0)] + s \cdot \log\left(\frac{t}{t_i}\right) \right) \cdot \frac{t}{t + t_i}$$

The independent variable t indicates the time after stroke onset. The fitted parameters have already been described by Copen et al. [1]. t_i is the time of transition between the linear and the logarithmic part of the function and s is the slope of the logarithmic part.

RESULTS: The patients got 111 MR scans at different time points after symptom onset. Mean ADC and FA maps were measured over time after onset of the brainstem infarcts. All measurements were compared to the intact contralateral side and quantified as relative values (rADC and rFA). A continuous decrease of rADC was shown in the first 50 hours (2 days) after brainstem infarct (minimum: 49±21 h). After transition (nadir) the rADC increased continuously with a pseudonormalization time around 348 hours (14.5 days) with a 68%-confidence interval of ±179 hours (7.5 days), at which the mean ADC was similar to the mean ADC contralateral to the lesion site. After that period the rADC further increased to higher values (Fig. 1a). In contrast, the relative fractional anisotropy (rFA) showed another time course: The rFA continuously decreased over the time and was found still decreasing after 3-5 months (Fig. 1b). In order to compare the ADC time course found in the studied brainstem infarcts with data from hemispheric infarcts the trend function was fitted to data published before in the studies by Schlaug et al. [2] and Copen et al. [1]. The data points were taken from the published scatter plots. The results are outlined in Table 1.

	Schlaug [2]	Copen [1]	this study
Pseudonorm.	191 ± 53 h	309 ± 106 h	348 ± 179 h
Minimum	22 ± 5 h	33 ± 9 h	49 ± 21 h

Table 1: Averages and 68%-confidence intervals of pseudonormalization and transition times after fit of the trend curve to the data shown in the published scatter plots. It can be seen that estimated pseudonormalization times in this study are longer than in the others. It has to be noted that the data published by Copen et al. [1] has been derived from a heterogeneous group of non-lacunar (hemispheric) and lacunar infarcts (lacunar hemispheric and brainstem).

CONCLUSION: Times of transition and pseudonormalization were longer than described for territorial hemispheric infarcts, which may be due to delayed cell death (apoptosis) in brainstem ischemia. In contrast, the continuous decline of FA over 3 to 6 months indicates a chronic process in brainstem ischemia. While ADC is a MR-marker of the acute phase, FA can be regarded to be a marker of the chronic phase.

REFERENCES: [1] Copen WA, Schwamm LH, Gonzales GR, et al. Ischemic stroke: Effects of etiology and patient age on time course of the core apparent diffusion coefficient. *Neuroradiology*. 2001;221:27-34. [2] Schlaug G, Siewert B, Benfield A, et al. Time course of the apparent diffusion coefficient (ADC) abnormality in human stroke. *Neurology* 1997;49:113-119.

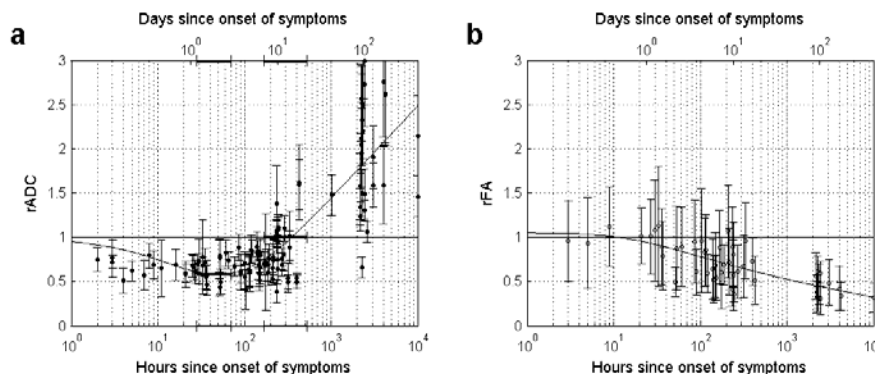


Figure 1: Plots of the relative values of ADC (a) and FA (b). The bars show the 68%-confidence intervals of the minimum and the baseline-crossing of the trend function.