

Acute Stroke Follow-Up Study: Assessing infarct volume change

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Introduction: Rapid prediction of infarct volume and location is a key requirement in the diagnostic and prognostic workflow for stroke. The established method to identify and quantify infarct in the clinic is based on Diffusion Weighted Imaging (DWI). Accurate calculation of the infarct volume is possible using manual marking of the region on each image or by deploying emerging automated image segmentation techniques [1-6]. Our team has developed methods to automatically segment the infarct region using the DWI images taking into account the ADC feedback as well as anatomical information.[6]. The objective of this work was to assess the capability of this automated method to compute volume change between DWI image taken in the acute (Day-0) phase and the follow-up (Day-1). We correlate the qualitative assessment of infarct volume change to the change computed by automated methods to assess the potential use of this measure in a clinical workflow to monitor chronic stroke.

Methods: *Image Acquisition:* We applied our approach on 56 acute-stroke patients with varied lesion sizes in DWI images. All patients were imaged on a 1.5T (Signa HDx, GE Healthcare, Chalfont St Giles, UK) with an 8-channel head coil. Axial DWI images were acquired using a SE-EPI sequence (TE/TR = 81-102/6600, FA = 90°, NEX = 2, Acquisition matrix = 256 x 256, FOV = 240x 240 mm², slice thickness of 6 mm, b = 0 s/mm² and 1000 s/mm², diffusion encoding along axial, sagittal and coronal directions). All 56 cases were imaged using the very similar parameters on the day following the stroke event (Day-1). *Infarct Segmentation:* DWI data was retrospectively processed using our algorithm [6]. For each series (Day-0 and Day-1) of each patient, the algorithm reported an estimate of the infarct volume. *Qualitative Assessment:* A senior radiologist reviewed all the slices of each DWI series (Day-0 and Day-1) and indicated the relative change in the infarct volumes. This information was recorded in 7 levels (Large Shrinkage[LS], Medium Shrinkage[MS], Small Shrinkage[SS], No Change[NC], Small Growth[SG], Medium Growth[MG], Large Growth[LG]) for ward of the 56 patient cases. *Comparison of Change Estimation:* The volume estimates reported by our algorithm were plotted against the qualitative measures to visualize and quantify the degree of correlation in the estimates.

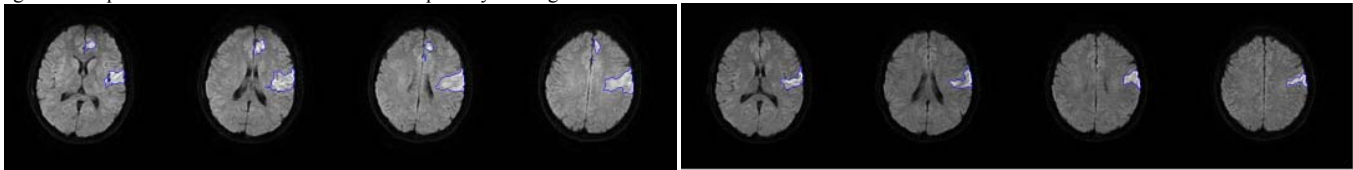


Figure 1. Case 1003: Slices 12-15 Acute Day-0 (left) & Day-1 (right) – Moderate Shrinkage (35-90%)

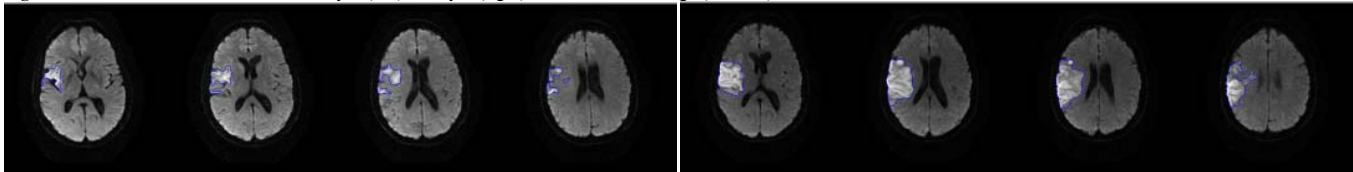
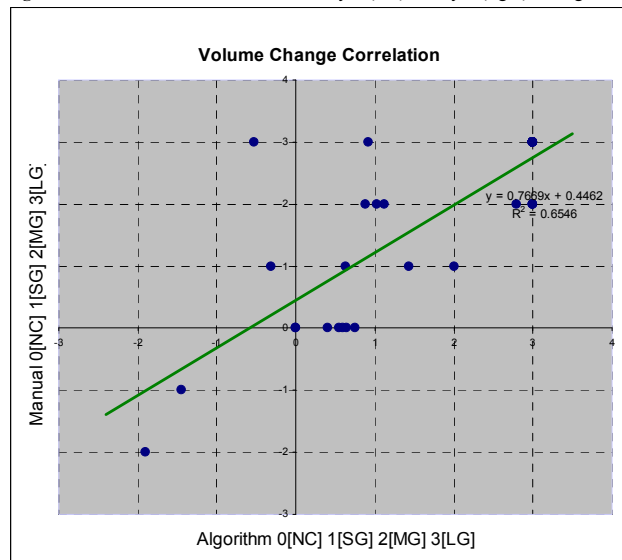


Figure 2. Case 1022: Slices 12-15 Acute Day-0 (left) & Day-1 (right) - Large Growth (> 100%)



Results and Discussion: Of the 56 cases analyzed at 2 time points; 38 cases were deemed satisfactory by the radiologist, based on the automated segmentation. The volume change for each of the 38 cases was compared between the algorithm and manual assessment in a binned manner. Representative results of the processing are shown in *Figure 1* & *Figure 2*. *Figure 1* shows a case where there was moderate shrinkage in the volume of the infarct and *Figure 2* is a case where large growth of the infarct was observed. The bins were defined as ($\pm 5\%$: No Change; $\pm(5-35\%)$: Small Change; $\pm(35-90\%)$: Moderate Change; $\pm(>90\%$: Large Change) for both growth and shrinkage of the infarct. Five percent of the cases (2/38) were indicative of infarct volume drop, while 95% showed a growth in the volume of the infarct. The algorithm was in agreement for 95% of the cases (36/38) in terms of the trend correlation (growth & shrinkage); kappa = 0.63 (linear weights). In the absence of accurate hand segmentation of the infarcts, comparing the quantitative volume change against the qualitative (Small, Moderate, Large) is prone to some variation and therefore the correlation between the two was done using binned data. Based on the ranges used by the radiologists, the volume change percentage derived from the algorithm was accordingly binned. The scatter plot shows this comparison as a correlation. The x-axis is the volume change percentage mapped to the SML bins, the y-axis is the radiologist's rating. R^2 was calculated to be 0.65, slope = 0.76 with small bias. Given the relatively few cases with volume reduction, quadrant 3 has limited data-points causing the trend line to have non-zero offset. In 11 of the 18 rejected cases, 1 of the 2 time points were incorrectly segmented. Most of these cases had either over-segmented the infarct region, due to either susceptibility/image artifacts or under-segmented the defect due to presence of decreased signal intensity in the infarct region due to hemorrhage. In a few cases lacunar infarcts with subtle restricted diffusion were missed or part of cerebellum was segmented due to higher inherent ADC of the tissue.

Conclusions: Automated infarct segmentation algorithms using DWI imaging for estimating infarct volume change correlate well with visual inspection of the longitudinal scan data and could help accelerate the prognostic clinical workflow for chronic stroke care. This would be especially useful in emergency situations in facilities where expert neuroradiology interpretation is not available round the clock.

References: [1] Wittsack et al, Radiology. 2002 Feb;222(2):397-403. [2] M.Luby et al., Stroke;v(37), p.2951-2956, 2006; [3] M.Straka et al., ISMRM, v17, p.728, 2009; [4] S. Nath et al., ISMRM, v17, p.4675, 2009; [5] S. Saraswathy et al., ISMRM v17, p. 2887, 2009 [6]. S. Nath et al., ISMRM, v18, p.678, 2010