EVALUATING SEVERITY OF WHITE MATTER CHANGES FROM CT WITH MACHINE LEARNING (CONVOLUTIONAL NEURAL NETWORK)

Johanna Pitkänen¹, Juha Koikkalainen², Tuomas Nieminen², Ivan Marinkovic¹, Sami Curtze¹, Gerli Sibolt¹, Jyrki Lötjönen², Timo Erkinjuntti¹, Susanna Melkas¹

¹ Clinical Neuroscience, University of Helsinki and Department of Neurology, Helsinki University Hospital, Finland

² Combinostics Ltd., Tampere, Finland

BACKGROUND

White matter changes are a surrogate for cerebral small vessel disease (CSVD), which is the major reason behind accumulating vascular burden in aging populations.

A radiologist evaluates the severity of white matter changes (WMC) in magnetic resonance image (MRI) with a visual scale called Fazekas scale (range 0-3). The interpretation of WMC varies between different radiologists and often needs radiologists experience to be reliable. There are several studies aiming to specify the MRI findings in WMC. Yet the most common, cheap, easy and less time consuming imaging method globally is computed tomography (CT).

PURPOSE

The purpose of this study was to evaluate if the severity of WMC can be reliably estimated from CT images using fully automatic image analysis methods.

The benefits of quantifying the WMC volume automatically from CT are:

- Provides clinicians means for enhanced WMC research, for evaluation of medical decisions and the consideration of proper treatment.
- Can be foreseen to be an excellent tool for the inexperienced radiologists as it leaves time to focus on developing their working methods.
- Decreases the workload of radiologists.
- Provides savings for the society as CT can be used instead of MRI.

METHODS

The brain images (2014-2016) in the Helsinki University Hospital, Finland, were screened. Selection criteria for the study was that both CT- and MRI-images were taken and the time interval between CT and MRI was from 1 day to 6 weeks. Images with tumors, cortical infarcts, bleedings (except microbleedings in Fazekas 2-3 were included) and multiple sclerosis and obvious contusions were excluded. In total, 147 patients were included in the study. The images were divided into three Fazekas groups by a radiologist: Fazekas 0-1, Fazekas 2 and Fazekas 3.

Convolutional neural network (CNN) was used to segment WMC. To produce comparison data and ground truth segmentation for CT, the WMC was first segmented from MRI data. Here, the ground truth data for the training of CNN was from the LADIS-study (Leukoaraiosis and Disability in the Elderly study). Then the WMC was segmented from CT images using the MRI segmentations as the ground truth. The training and testing of CNN for CT was performed using 10-fold cross-validation. The Fazekas score was estimated from the WMC volumes by searching for the optimal thresholds that maximize the share of correct scores as compared to the visual score.

RESULTS

There was a high correlation of 0.91 obtained between the automatic WMC volumes of MRI and CT segmentations. When estimating the Fazekas score from WMC volumes, the CT segmentation classified correctly 76% of images.

CONCLUSION

CNN-based segmentation of CT images provides means to evaluate the severity of WMC for research and to support clinicians in treatment decisions.

Figure 1. An example of WMC segmentations from the MRI and CT images of one patient.

Figure 2. The correlation between WMC volumes segmented from FLAIR and CT images.

Table 1. Confusion matrix between the visual and automatically from CT derived Fazekas scores.

	Automatic		
	Fazekas 0-1	Fazekas 2	Fazekas 3
Visual Fazekas 0-1	37	13	0
Fazekas 2	8	36	4
Fazekas 3	0	11	38