Penumbra-Imaging in Patients with Acute Stroke Using Susceptibility Weighted MR-Imaging

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Target Audience: Physicians and scientists interested in the field of clinical application of SWI.

Introduction:

Although increasingly used for the clinical management of patients with acute ischemic stroke the mismatch-concept, based on MR perfusion and diffusion imaging, has become under debate, since it is reported that Time to peak (TTP) maps, generated from PWI, tend to overestimate the tissue at risk.[1] Susceptibility-weighted imaging (SWI) has been reported to enable the identification of the tissue at risk in patients with acute ischemic stroke due to the visualization of hypointense vessels within the hypoxic area.[2] The aim of this study was to assess size of the penumbra determined by either SWI or TTP-perfusion maps and calculate their intersection.

Methods:

70 patients with ischemic infarction proved by clinical symptoms (NIHSS>2) and a reduced perfusion on the time to peak perfusion (TTP) map determined by dynamic susceptibility contrast perfusion images (TE 35, TR 1920, FoV 240, slice thickness 5 mm, 75 dynamic scans, injection of 0,1 mmol/kg DOTAREM with bolus technique after the third frame followed by 20ml of NaCl solution) were included. Alterations of SWI were defined as a conglomeration of vessels presenting a higher diameter than vessels on the contralateral, non-ischemic hemisphere (Figure 1). Regions of altered SWI, restricted diffusion on diffusion-weighted images (DWI) and reduced perfusion on PWI were manually delineated on SWI, apparent diffusion coefficient (ADC)-DWI and TTP maps. Subsequently, the maps were automatically coregistered and intersections of the determined regions were calculated and visualized using in house developed software (Figure 2).

Results:

In all patients the area of SWI alterations could be delineated. Medium size of the delineated SWI region (2994.8 mm² ± 1097.3) was significantly smaller than size of the delineated TTP-maps (3626.6 mm² ± 1315.5) ($p<0.0001$) but significantly larger than areas on ADC diffusion maps (1396.6 mm² ± 1102.0) ($p<0.0001$). Median intersection of TTP and SWI was 73.6% of the delineated TTP area, SWI and ADC intersected on 34.0% of the size of SWI area (Table 1).

Discussion and Conclusions:

This study determines for the first time the size of the penumbra with susceptibility weighted imaging in a large patient collective. Since the identified region on SWI was significantly smaller than TTP map, that supposedly overestimates the tissue at risk, SWI may determine the size of the penumbra more accurately. Further studies are required to clarify the pathomechanism of SWI alterations and verify our findings considering follow up images and patient outcome. Until then SWI provides a valuable tool in addition to PWI for penumbra estimation and treatment decision. Since SWI does not require contrast agent injection, it can be used in patients with contraindications to contrast agents.

1. Kidwell CS, Alger JR, Saver JL. Beyond mismatch: Evolving paradigms in imaging the ischemic penumbra with multimodal magnetic resonance imaging. *Stroke*. 2003;34:2729-2735
2. Santhosh K, Kesavadas C, Thomas B, Gupta AK, Thamburaj K, Kapilamoorthy TR. Susceptibility weighted imaging: A new tool in magnetic resonance imaging of stroke. *Clin Radiol*. 2009;64:74-83

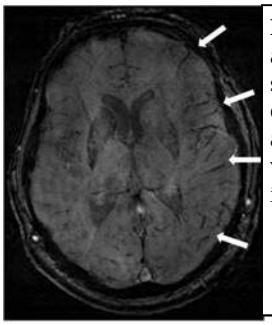

Figure 1 Patient with symptoms of acute left-hemispheric-stroke. SWI shows alterations in terms of a conglomeration of vessels presenting a higher diameter (arrows) than vessels on the contralateral, non-ischemic hemisphere.

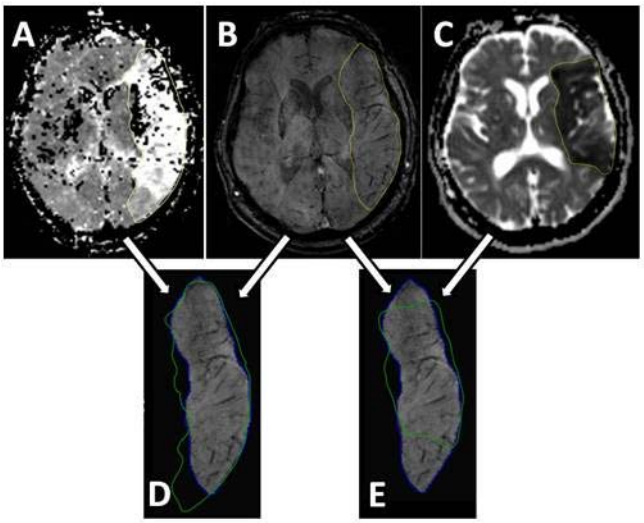

Figure 2 Workflow diagram. TTP perfusion map, SWI and ADC images were coregistered. Areas of reduced perfusion (A), altered SWI signal (B) and restricted diffusion (C) were delineated manually (yellow line) and size and intersection were calculated and visualized (D, E). **D** TTP-lesion outline in green, SWI alterations delineated in blue. **E** ADC-lesion outline green, SWI blue.

Table 1 Results

Sequences	Size (mm²)	
Mean lesion size		
TTP	3626.6 ± 1315.5	
SWI	2994.8 ± 1097.3	
ADC	1396.6 ± 1102.0	
Mean intersection		
TTP-SWI	2668.2 ± 1038.6	(73.6 % of TTP lesion)
TTP-ADC	1047.6 ± 1032.2	(28.9 % of TTP lesion)
SWI-ADC	1017.6 ± 960.2	(34.0 % of SWI lesion)
Mean penumbra size		
TTP-ADC	2542.7 ± 1385.8	
SWI-ADC	2049.7 ± 1222.8	