# Early Experience with New Arterial Spin Labeling Techniques in the Assessment of Acute Stroke

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***Introduction:*** It was shown recently, that arterial spin labeling (ASL) techniques can be useful in the assessment of hemodynamical impairment of patients with acute stroke [1]. The different contrast mechanism compared to perfusion measurements using contrast agents (dynamic susceptibility contrast, DSC) might enable ASL to provide additional information for prediction of patient outcome. By varying the time between labeling the blood and actual readout of this information (inflow time TI) the presence of labeled blood can be captured in arteries (short TI) or microvasculature (long TI). Hemodynamical information of both parts of the vascular tree might be of value to characterize local ischemia. However, usually, it is difficult to acquire ASL at multiple different TI in a clinically acceptable time because of the low signal-to-noise ratio (SNR) of ASL. Recently, we presented a new acquisition technique for ASL [2], which improves SNR compared to standard EPI tremendously by using a single-shot 3D readout. This allows the acquisition of micro-vascular perfusion even at multiple TI in under 5 min. Macro-vascular flow can be captured more efficiently due to the higher velocities and higher SNR in large vessels [3-5]. Therefore, a Look-Locker approach is used to sample more than one TI after labeling [4], called dynamic angiography (DynAngio) in the following.

Here, we present our first experiences applying those two techniques to patients with acute ischemic stroke.

***Material and Methods:*** A clinical 1.5T scanner (Magnetom Sonata, Siemens, Erlangen, Germany) was used for imaging. Maximum gradient strength was 40 mT/m with a slew rate of 200 mT/m/ms.

Twelve patients with acute hemispheric stroke were examined (mean age 65.3 y). Informed consent was obtained from all patients. Patients underwent a standard imaging protocol including time-of-flight (TOF) angiography, diffusion and DSC perfusion imaging.

Micro-vascular perfusion (CBF) measurement was performed in two different ways, both employing single shot 3D-GRASE as readout module [2]. CBF was measured by either using a modified Q2TIPS scheme [6] with 18 slices at a spatial resolution of $2.5 \times 3.6 \times 5$ mm$^3$ or by acquiring a time series with isotropic resolution of 4 mm. For Q2TIPS TR, TI1 and TI2 were 2500 ms, 1000 ms and 1800 ms, respectively, and the total measurement time was 2 min. The time series were acquired with ten different TI ranging from 250 ms to 2500 ms. TR was 3000 ms. Overall measurement time was 5 min for all 10 time steps (5 averages per TI). CBF and bolus arrival time (BAT) were extracted from time series using nonlinear least-square optimization.

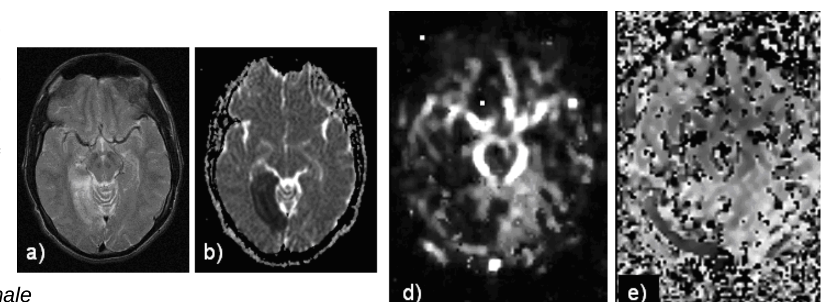
The DynAngio sequence [5] combines a FAIR inversion scheme with a segmented FLASH Look-Locker sampling strategy [4]. This results in time resolved images of the inflow of blood into the arterial tree comparable to digital subtraction angiography (DSA). 40 different phases of inflow with a temporal resolution of 36 ms were acquired within 2 min 20 s. Measurement parameters were as follows: TR = 12 s / TE = 3.7 ms / 3 segments per phase per magnetization recovery / spatial resolution = 0.9x0.9 mm$^2$ / slab thickness = 60 mm / no ecg-triggering. BAT was estimated pixelwise by determining the time, when the maximum signal was achieved.

***Results:*** CBF was measured in eight patients with the Q2TIPS sequence and in four patient time series were acquired. In general, the CBF measurement using ASL was feasible in all patients. Hemodynamical information could be gained in all four patients using the time series. Ischemic areas as seen in DSC and diffusion imaging could be identified in ASL-CBF as well. In some patients a mismatch in size and form was apparent for affected areas.

In eleven patients the DynAngio technique showed the inflow of the labeled blood bolus in acceptable quality (8 very good, 3 minor motion artifacts). In one patient the hemodynamical information could not be extracted due to severe motion. Small changes in BAT (down to 60 ms) could be identified.

Figure 1 shows an example of a 21 year old male patient with acute stroke in the right posterior cerebral artery territory. 6 out of 40 phases of the DynAngio sequence as well as the colored overlay of BAT and flow reveal a delay of the inflow of the labeled blood in the affected artery of about 90 ms. The 3D GRASE sequence shows a large area of reduced perfusion in the corresponding vascular territory. However, the increased noise in the estimated BAT indicates low signal in this area. Therefore, interpretation of CBF and BAT in some areas is difficult due to the vanishing flow.

***Discussion and Conclusion***: Dynamic angiography techniques are useful to estimate and confirm proximal vessel obstruction when analyzing the major intracranial arteries. It provides additional information to TOF angiography by introducing hemodynamical aspects. This information is comparable to DSA but does not use ionizing radiation and provides a better temporal resolution. ASL perfusion analysis demonstrates areas of reduced CBF matching the results of DSC in this respect. CBF can be underestimated by ASL in areas with severely delayed (longer than latest TI sampled) blood arrival. The DynAngio technique as well as the ASL time series provides higher sensitivity for hemodynamical changes as compared to DSC. Furthermore, ASL can be repeated since no contrast agent has to be used. The combined use of these techniques allows assessment of both, macro- as well as micro-vascular hemodynamics with high temporal resolution. In particular critical perfusion states in not yet infarcted areas may be more accurately characterized with ASL using this additional information.



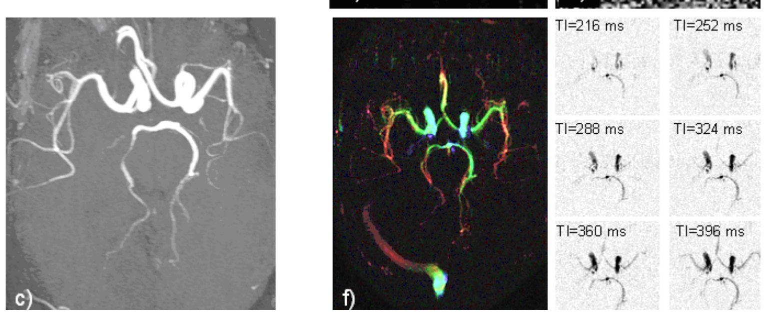




**Fig.1** *Example of 21y old male patient with acute stroke in the right posterior cerebral artery territory: a) anatomic picture b) ADC c) TOF d) CBF e) BAT, d) and e) were calculated by using ten different inflow times TI ranging from 250 ms to 2500 ms. Total measurement time 5 min. f) results of DynAngio sequence. Left image is a colored overlay of BAT and the average signal of all inflow phases. Right images are six out of 40 phases showing the delayed inflow of the right posterior artery.*

***References:***

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