In order to understand the pathophysiology and to determine the optimal treatment of chronic occlusive cerebrovascular disease, it is vital to clarify the degree of hemodynamic compromise in each patient. Patients at a high risk of ischemic stroke generally exhibit abnormally high oxygen extraction fraction (OEF) and elevated cerebral blood volume, a combination of states described as misery perfusion or Grade 2 hemodynamic stress. The concurrent measurement of cerebral blood flow, metabolism, and blood volume on the same occasion by positron emission tomography (PET) serves as the optimal method for evaluating hemodynamics in patients. PET is usually unavailable in daily clinical practice, however, and it provides only poor information on the structural integrity of hypo-perfused tissue.

Perfusion-weighted magnetic resonance imaging (PWI) provides various parameters on cerebral hemodynamics non-invasively and in less time than PET. We have been extensively using PWI with dynamic susceptibility contrast magnetic resonance imaging technique (DSC-MRI) for the evaluation of hemodynamics in patients with moyamoya disease. We conducted a study to compare the parameters obtained with DSC-MRI and PET in moyamoya patients (Tanaka et al. 2006) and obtained interesting results. Recently, we have started to use another PWI technique, arterial spin labeling (ASL) on 3T MRI machine. We started a study to compare the cerebral blood flow (CBF) value obtained with ASL-MRI and that obtained with PET in moyamoya disease or with single photon emission tomography (SPECT) using N-isopropyl-^{123}I-p-iodopamphetamine (IMP) in atheroscrelotic cerebral arterial occlusion.

In the present lecture, I will summarize our comparative study among DSC-MRI, ASL-MRI, PET and SPECT in chronic cerebral ischemic disease especially from the point of neurosurgeon who conduct surgical revascularization against it.

Our comparative study revealed that CBF value obtained by DSC-MRI was not reliable in patients with moyamoya disease (Figure 1). Instead, CBF value obtained by ASL-MRI showed significant correlation with that obtained with PET or IMP-SPECT both in patients with atheroscrelotic cerebral arterial occlusion and moyamoya disease (Figure 2). Correlation co-efficient between ASL-CBF and PET- or SPECT-CBF was greater in atheroscrelotic patients than in moyamoya patients. The value of mean transit time (MTT) obtained by DSC-MRI, however, was a highly useful value to evaluate the degree of hemodynamic compromise in moyamoya disease. More than 2 seconds delay in MTT in comparison to control region corresponded well with the area of misery perfusion as detected with abnormally elevated OEF in PET study (Figure 3). We also showed that 2 seconds delay in MTT was a good indicator to predict natural stroke risk, surgical risk and also surgical benefit in the treatment of moyamoya disease. Degree of MTT delay was also used to detect misery perfusion in atheroscrelotic patients.

As these DSC-MRI study indicates, significant perfusion delay occurs in chronic cerebral occlusive disease especially in ones who need surgical revascularization. Such perfusion delay is a important factor to consider the reliability of CBF value obtained by ASL-MRI. As Figure 4 indicated, correction coefficient between ASL-CBF and SPECT-CBF was less in cerebral hemisphere with vascular occlusion than in control hemisphere using preset post-labelling delay (PLD). By using longer PLD, correction coefficient in lesion side increased. This indicated that optimum PLD may be different among patients in chronic occlusive disease from other type of patients or normal population.

Although we need further clarification study to confirm the reliability of ASL-CBF, there is no doubt that ASL-MRI is a useful method for clinical use in practical management of patients who receive surgical revascularization. As Figure 5 indicates, we can frequently examine the post-operative CBF non-invasively with ASL-MRI and the time course of CBF increase by indirect-bypass surgery can clearly be demonstrated. This technique could be used to monitor post-operative hyperemia in carotid-endoarterectomy patients.

In conclusion, MR-PWI with DSC and ASL technique can offer useful information for clinical decision making and for post-operative monitoring in patients with chronic cerebral arterial occlusive disease. Further study to validate the reliability of measured parameters and to determine the optimum image acquisition protocol for ASL technique may be the important study theme. .

Reference)

Tanaka Y, Nariai T, Nagaoka T, Akimoto H, Ishiwata K, Ishii K, Matsushima Y, Ohno K. Quantitative evaluation of cerebral hemodynamics in patients with moyamoya disease by dynamic susceptibility contrast magnetic resonance imaging--comparison with positron emission tomography. J Cereb Blood Flow Metab, 26:291-300, 2006.

Figure 1

Comparison between PET measured CBF value (y axis) and PWI measured CBF ratio against control region (x-axis) in moyamoya disease. In any type of analysis method, DSC measured CBF was not reliable.

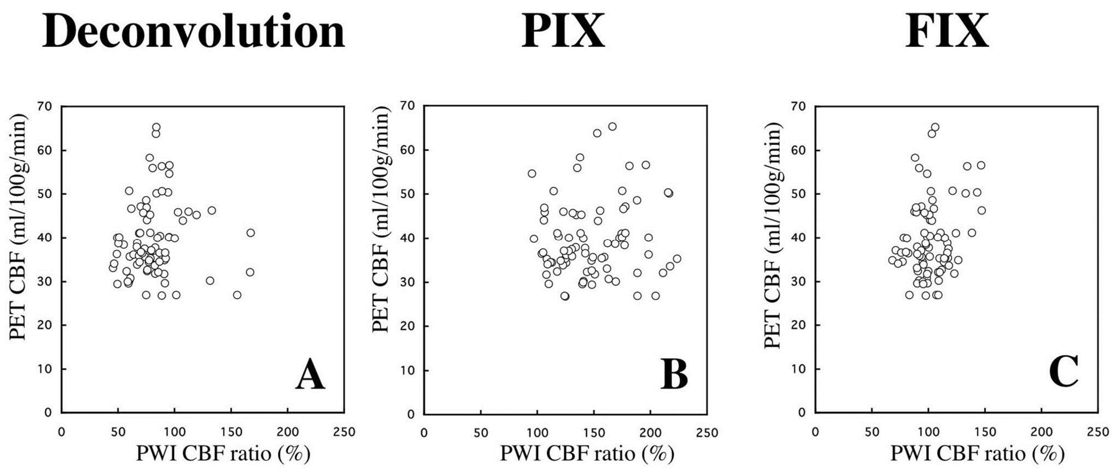

Figure 2

ASL measured CBF showed significant correlation with PET or SPECT measured CBF in moyamoya disease (left) and in atheroscrelotic arterial occlusion (right).

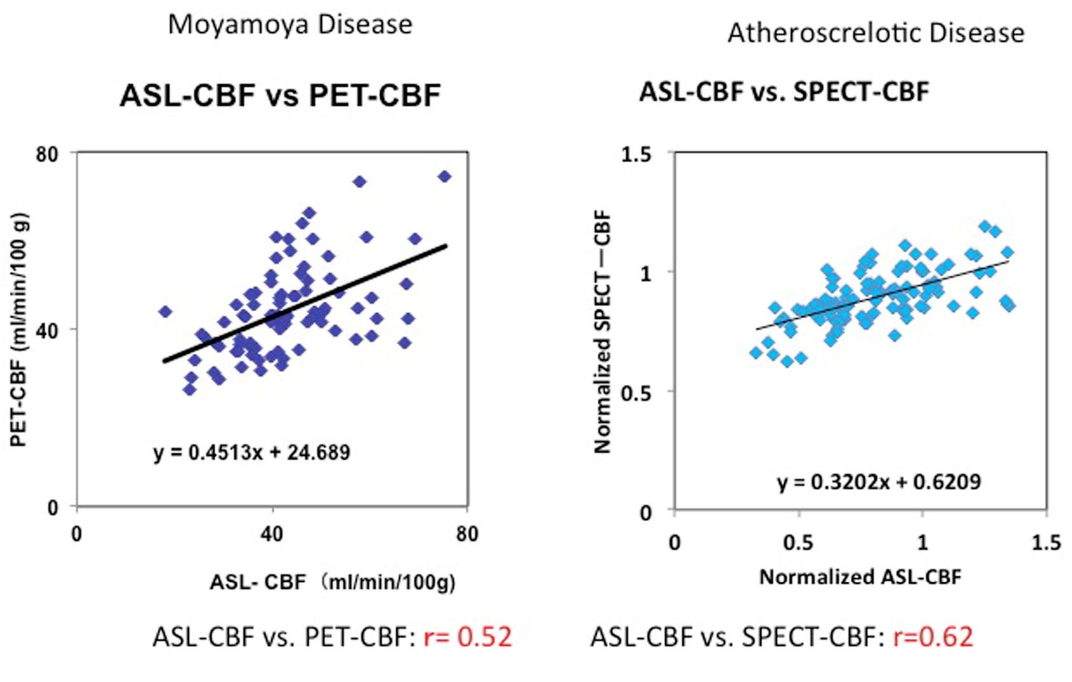

Figure 3

When mean transit time (MTT) exceeded 2 second threshold against control lesion, oxygen extraction fraction (OEF), a PET parameter to indicate misery perfusion, also significantly elevated.

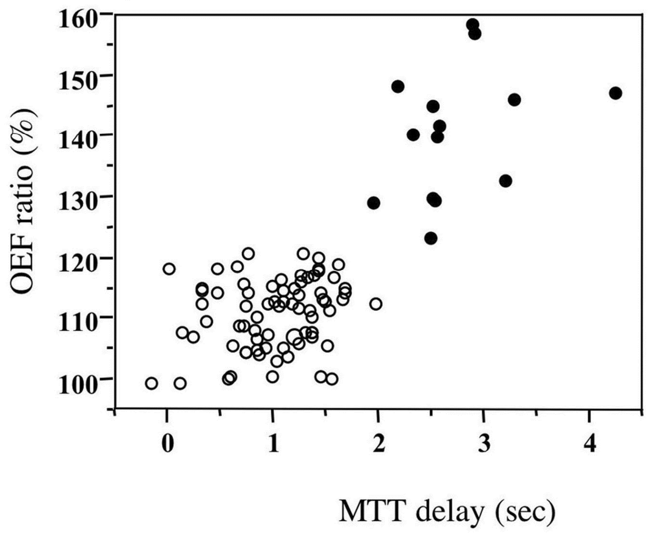

Figure 4

In atheroscrelotic cerebral occlusion, better correlation coefficient was obtained by using more prolonged post labeling delay (PLD) in occlusion side. Such difference was not noted in control side.

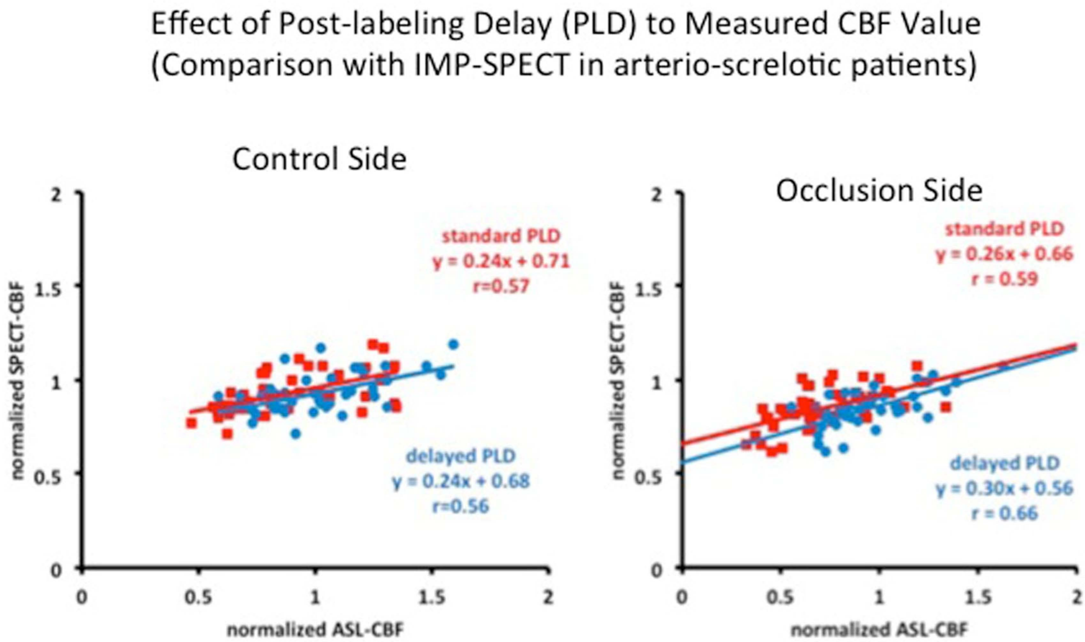

Figure 5

Pre- and post-operative CBF was monitored with ASL-MRI in a patient with moyamoya disease who received indirect bypass surgery in left side. Increase in CBF began on the very surface area of operated side in two weeks, and became apparent at 4 weeks after surgery (red arrows). Improvement further extended in 12 weeks. Such frequent measurements were available and were justifiable because of non-invasive nature of ASL (no pharmaceutical, no radioactivity).