Reproducibility of Dynamic Susceptibility Contrast MR with Standard and Block-Circulant Deconvolution Matrix

W-T. Zhang[1], C. Mainero[1], O. Wu[1], A. G. Sorensen[1]
[1]Massachusetts General Hospital, Charlestown, MA, United States

BACKGROUND

Repetitive dynamic susceptibility contrast magnetic resonance (DSC-MR) perfusion weighted imaging (PWI) within several hours is potentially useful to detect fast hemodynamic changes such as those during migraine aura [1] and early stroke. However, the number of repetition is limited by the allowed maximal dose of the contrast agent. The application of high field magnet (>3 T) greatly reduced the optimal dose of the contrast agent, which means 3 or even more DSC-MR scans could be performed within hours if necessary.

However, any temporal changes detected in the repetitive DSC-MR have to be based on the assumption that serial PWI maps in the normal state are stable and reproducible. The primary aim of this study is therefore to determine the test-retest reproducibility of relative cerebral blood volume (rCBV) and flow (rCBF) acquired with the interval of half an hour. The secondary aim is to investigate the effect of different algorithms for rCBF calculation, namely the singular-value decomposition (SVD) with a single measured arterial input function (AIF) [2] or SVD with a block-circulant matrix of AIF [3], on the reproducibility of rCBF.

SUBJECTS AND METHODS

This reproducibility study is part of the migraine study ongoing in our center. All data used for reproducibility analysis were acquired during patients' interictal phase, i.e. without migraine for at least one week. Six migraine patients (5 females, age range 24~53 years old) were enrolled in the study. Each subject had two T2*-weighted DSC-MR scans (gradient echo; TR/TE=1500/43 ms; 17 tilted axial slices; in-plane resolution: 1.7*1.7 mm^2; slice thickness/gap: 4/0.8 mm) with the inter-scan interval of half an hour. On-line automatic slice positioning technique [4] was used to minimize the effect of head movement between two scans. The single dose of the gadolinium-based contrast agent was 0.1 mmol/kg (i.v.).

Each raw image was motion-corrected and aligned to the first image of the first scan. rCBV was calculated as the area under the curve when the contrast passed through the brain. rCBF was calculated by deconvolution with a single AIF measured from the left middle cerebral artery (MCA) using either singular value decomposition (SVD) with a standard matrix and threshold of 20% (sSVD) or with a block-circulant matrix and using a minimization of oscillation index of .095 (oSVD). Each map was normalized using the histogram equalization method. Regions of interest (ROIs) were manually delineated in the frontal lobe, occipital lobe, and cerebellum. There might be a delay of tracer arrival time between these ROIs' feeding artery and MCA. While sSVD is sensitive to this delay, oSVD has been proved not [3]. In each ROI, the first and second rCBV and rCBF were compared with two sided paired t-test and the repeatability was evaluated by intra-class correlation (ICC). ICC >75% generally implies good repeatability.

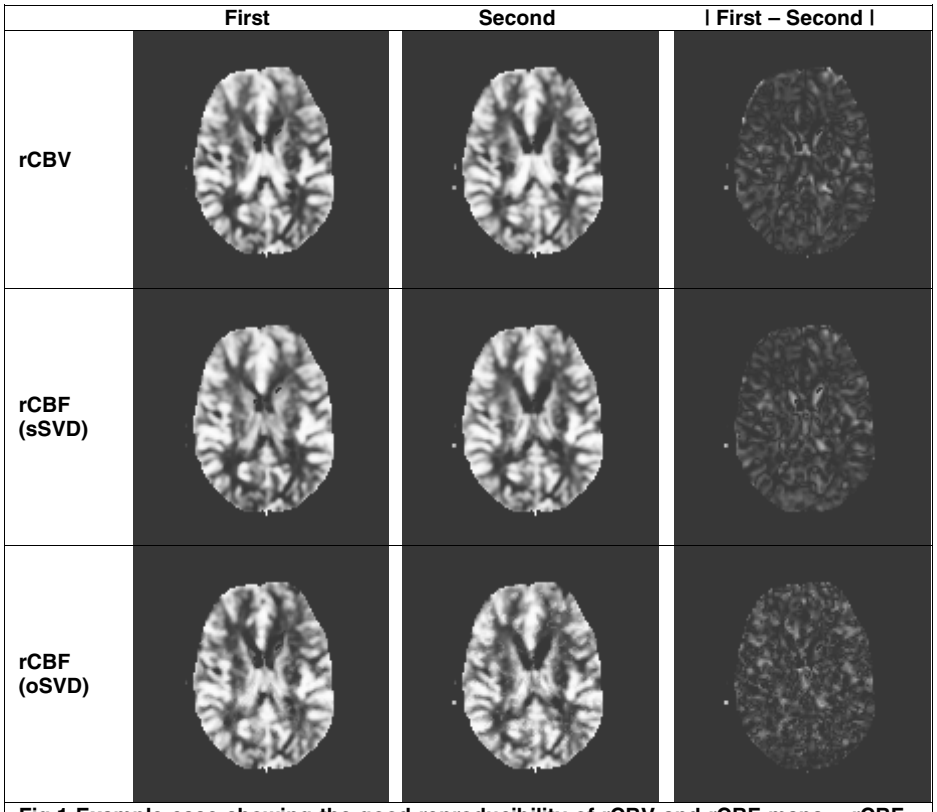

Fig.1 Example case showing the good reproducibility of rCBV and rCBF maps. rCBF maps calculated with oSVD showed improved reproducibility in the occipital lobe compared to that with sSVD.

RESULTS

PWI maps from a representative subject are shown in Fig.1. Compared to oSVD, sSVD tended to underestimate the rCBF in the occipital lobe. However, the contrast of rCBF from oSVD was a little lower compared to that from sSVD. rCBV maps demonstrated an excellent reproducibility and the ICCs in all three ROIs are over 90% (Table 1). There was no significant difference between the first and second rCBV maps (paired t-test, p>0.05). rCBF in all ROIs appeared well reproducible, too, except that rCBF calculated from sSVD in the occipital lobe was not consistent between two measurements (ICC=67%). In addition, there was a marginal significant difference (p=0.06) between the first and second rCBF from sSVD in the frontal lobe. rCBF from oSVD showed superb repeatability in respect to all indices in all ROIs.

Table 1. Intra-class correlation (ICC) and paired t-test between the first and second measurements of rCBV and rCBF. Poor reproducibility is highlighted in bold. N=6.

		frontal	occipital	cerebellum
rCBV	ICC	94%	93%	91%
	Paired t-test	p=0.58	p=0.13	p=0.27
rCBF (sSVD)	ICC	99%	**67%**	90%
	Paired t-test	**p=0.06**	p=0.40	p=0.40
rCBF (oSVD)	ICC	93%	96%	91%
	Paired t-test	p=0.46	p=0.45	p=0.76

CONCLUSIONS

Repetitive DSC-MR within a short period of time showed good reproducibility in rCBV maps. The reproducibility of rCBF maps from oSVD in the frontal and occipital lobe was better than those from sSVD. SVD with block-circulant matrix seems promising in the future.

References

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