Phase-contrast MR hemodynamic evaluation in basilar artery for posterior circulation ischemia: Preliminary reproducibility assessment using a three-point localization technique

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Introduction

Posterior circulation ischemia (PCI), a transient ischemic attack of the vertebrobasilar circulation [1], is commonly found in elderly people. Angioplasty or stenting are clinical procedures used to improve the symptoms of PCI. Phase-contrast MRI (PCMRI) has been used to evaluate the hemodynamic response of the basilar artery after angioplasty or stenting [1,2]. Due to small vessel size, flow measurement in the basilar artery is prone to physiologically unrelated imprecisions mixed with flow changes from the treatment. In this study, therefore, we evaluated a 3-point localization method with the aim to improve the reprodicubility of flow measurement in the basilar artery.

Materials and Methods

Our study population consisted of 9 healthy subjects without history of PCI (female: 5; male: 4; age: 56±8.3 years). Each subject received the same PCMRI examinations on two different days (inter-scan variations). In each single day, PCMRI with localization of the basilar artery was determined by two methods: One with and the other without the 3-point localization method (methodological dependency), each method scanned twice consecutively to assess intra-scan reproducibility using the same localizer. Thus 8 data sets were obtained for each of the 9 subjects (total 72 scans). PCMRI was performed on a 3T scanner (Siemens Trio, Erlangen, Germany) using the CP head coil with ECG gating. A 2D FLASH sequence (TR/TE=34/3.9 ms, flip angle=30^0, NEX=4) with 80 or 120cm/sec velocity-encoding gradient was applied, sampling 90% of the cardiac cycle. The slice was selected at middle basilar artery and perpendicular to its long axis. The long axis of basilar artery was determined by a 3-point localization method on 3D time-of-flight images (Fig.1). Flow volume was derived from integration on the PCMRI over the entire vessel cross-sectional area for all cardiac phases, and normalized to the cardiac cycle. Results of one-day intra-scan and two-day inter-scan reproducibility were expressed as percentage disagreements with respect to mean values, and reported separately for values obtained with (position 1) and without (position 2) using the 3-point localization method. Intuitively, the intra-scan variations with the same localizer scan reflected short-term systemic changes, whereas the inter-scan variations included localization errors.

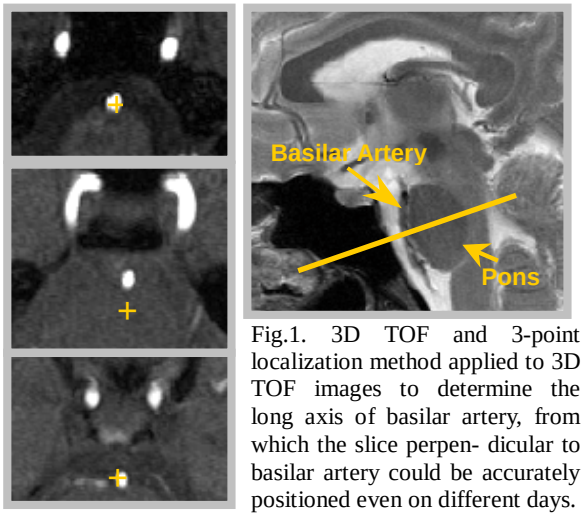

Fig.1. 3D TOF and 3-point localization method applied to 3D TOF images to determine the long axis of basilar artery, from which the slice perpen- dicular to basilar artery could be accurately positioned even on different days.

Results

Bland-Altman analysis showed that two-day inter-scan differences were reduced using the 3-point localization method for both vessel area (0.47±1.32 vs. 1.32±3.55 cm^2 (mean±2SD), Fig.2a) and flow volume (0.21±0.55 vs. 0.44±0.83 cm^2 (mean±2SD), Fig.2b). The 3-point localization improved inter-scan flow volume reproducibility by showing significantly lower percentage error of 10.6±11.6% as compared with 18.1±15.3% using manual localization (paired Student's t-test, $p < 0.02$, Fig.3). Intra-scan disagreements were less than 3.5% and hence negligible compared with localization errors.

Conclusion

Results from this study suggest that localization could itself be an important source of errors for flow measurements in the basilar artery. The 3-point localization method provides an objective means to determine the proper slice positions even on different days, which significantly reduced the inter-scan variability. Hemodynamic response of basilar artery after intervention could therefore be reliably assessed by PCMRI within 10% imprecision.

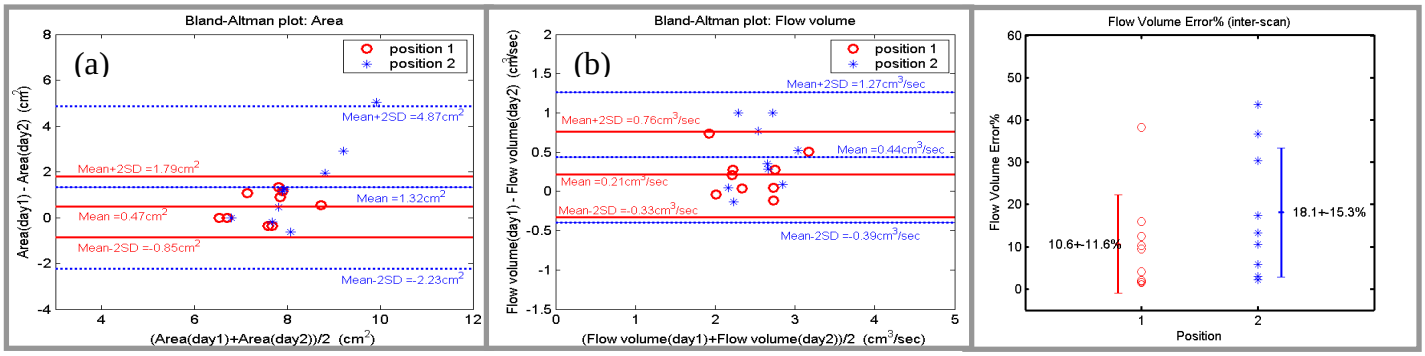

Fig.2. The Bland-Altman plots for inter-scan vessel cross-sectional area (a) and flow volume (b). The 3-point localization method (red solid lines) substantially improved the measurement precision as compared with manual localization (blue dotted lines).

Fig.3. Inter-scan percentage errors in flow volume of 9 subjects with (left) and without (right) using the 3-point localization method. The 3-point localization significantly improved the reproducibility of measurement.

References : 1. Kato T et al. AJNR 2002; 23:1346. 2. Guppy KH et al. Neurosurgery 2002; 51:327.