

Relation of 4D Flow MRI of ophthalmic artery to cerebral vascular reactivity estimated with SPECT in patients with internal carotid artery occlusion

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Purpose

Collateral arteries develop in the patients with internal carotid artery occlusion (ICO). One of these collateral arteries is ipsilateral ophthalmic artery (OphA) with retrograde flow. This retrograde flow represents the reversal of the pressure gradient between the external carotid artery and the internal carotid artery (ICA): higher pressure of the external carotid artery. This reversal is related to severity of neurological deficits induced by decrease in cerebral vascular function¹. The aim of this study was to assess the flow direction of OphA in patients with ICO using time-resolved 3-dimensional (4D Flow) MRI and to investigate correlation between the flow direction and the cerebral vascular reactivity (CVR). Decreased CVR measured by SPECT can predict the risk for stroke in patients with ICO².

Methods and Materials

We enrolled 16 patients (14 men; mean, 70 years) with ICO. We confirmed the patency of bilateral OphA by CT angiography (CTA). The 4D Flow MRI was performed using a 3.0 T with the following parameters: TR / TE = 8.4 / 5.4ms, FA = 13 degree, voxel size = 0.82 x 0.82 x 1.4mm³, 15 cardiac phases, and acquisition time = 5-7 min. VENC was set to 70 cm/s because the 4D Flow MRI for ICO was performed to analyze the contralateral ICA and basilar artery. The flow vector map was generated using GTFlow software (GyroTools) (Fig. 1). The flow directions of OphA were classified as anterograde, retrograde, and undetermined.

Iodine 123 N-isopropyl-p-iodoamphetamine (¹²³I-IMP) SPECT was performed at rest and after intravenous acetazolamide administration. CVR was defined as (cerebral blood flow after acetazolamide administration – cerebral blood flow at rest) / cerebral blood flow at rest.

We analyzed the correlation between the flow direction of OphA and CVR at the 6 vascular territories, including ipsilateral and contralateral anterior cerebral artery (ACA) territories, ipsilateral and contralateral middle cerebral artery (MCA) territories, and ipsilateral and contralateral posterior cerebral artery (PCA) territories.

Result

4D Flow MRI identified the anterograde flow in the contralateral, normal OphA in all 16 cases. The flow directions of the ipsilateral OphA were anterograde in 2, undetermined in 6, and retrograde in 8 cases by 4D Flow MRI. The 8 patients with the retrograde flow of ipsilateral OphA had significantly lower CVR at ipsilateral MCA territory (43.0 ± 20.2 vs. 23.3 ± 15.0 %, $p < 0.05$), at ipsilateral PCA territory (43.6 ± 16.9 vs. 30.5 ± 14.0 %, $p < 0.05$), and at contralateral PCA territory (49.4 ± 18.1 vs. 39.8 ± 12.9 %, $p < 0.05$) than the other 8 patients without the retrograde flow (i.e., anterograde or undetermined).

Discussion

4D Flow MRI was able to assess the flow direction of OphA. The retrograde flow of ipsilateral OphA visualized by 4D Flow MRI was significantly related to decreased CVR. The flow directions of the contralateral, normal OphA was depicted by 4D Flow in all cases. On the other hand, the flow direction of the ipsilateral OphA was undetermined in 6 of the 16 cases, indicating its stagnant flow. When compared with SPECT, the retrograde flow of the ipsilateral OphA was significantly related to decreased CVR at the ipsilateral MCA and PCA territories. The decreased CVR of the contralateral PCA was also observed in these cases. It may indicate steal phenomenon from contralateral PCA to ipsilateral PCA.

Conclusion

4D Flow MRI is able to identify the retrograde flow of ipsilateral OphA, which is related to decrease in CVR, in cases of ICO.

Reference

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2. Ogasawara K, Ito H, Sasoh M, et al. Quantitative measurement of regional cerebrovascular reactivity to acetazolamide using ¹²³I-N-isopropyl-p-iodoamphetamine autoradiography with SPECT: validation study using H₂ 15O with PET. *J Nucl Med* 2003;44:520-525.

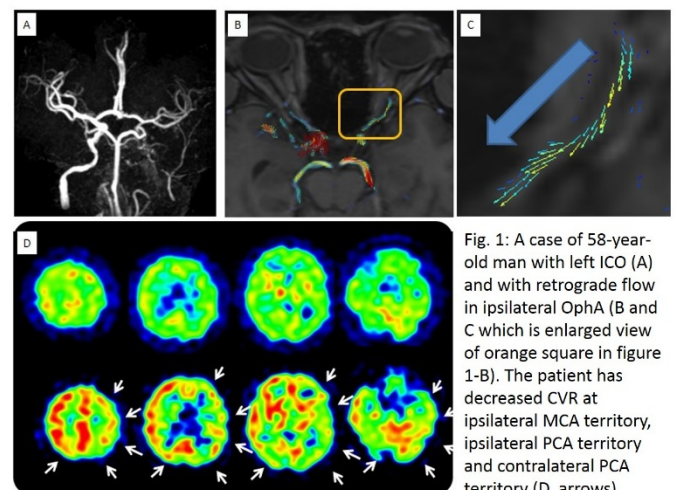


Fig. 1: A case of 58-year-old man with left ICO (A) and with retrograde flow in ipsilateral OphA (B and C which is enlarged view of orange square in figure 1-B). The patient has decreased CVR at ipsilateral MCA territory, ipsilateral PCA territory and contralateral PCA territory (D, arrows).

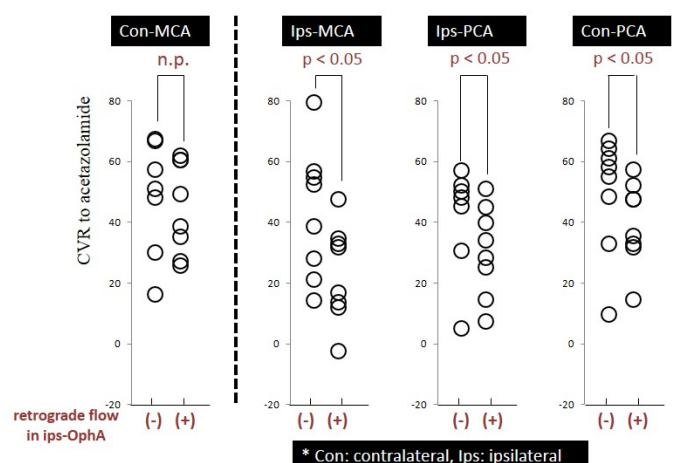


Fig. 2: Patients with the retrograde flow in ipsilateral OphA shows decreased CVR in ipsilateral MCA, ipsilateral PCA and contralateral PCA.