Utilization of Quantitative MRA in Assessing Leptomeningeal Collateralization in Adult Patients with Unilateral Moyamoya Disease

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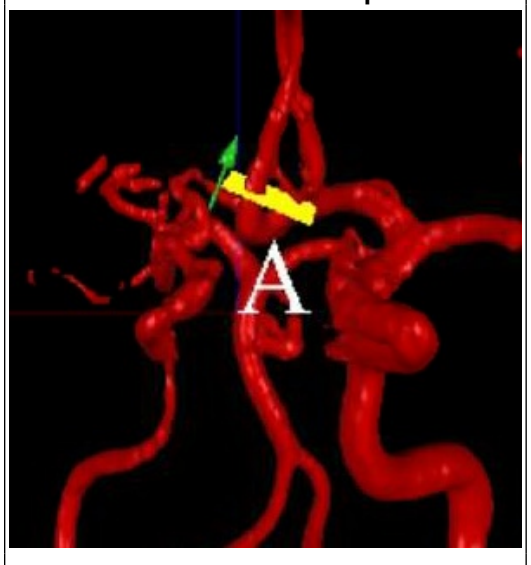
Introduction

- Arterio-occlusive disease of the cerebrovasculature
- Presents as ischemic events and/or intracranial hemorrhage
- Pathognomonic pial collateral networks
- Collateral networks have only been measured qualitatively via angiographic interpretation
- Neurosurgical management is designed to augment these collaterals, therefore it is paramount to quantitatively measure their flow noninvasively
- Purpose: To demonstrate QMRA can be used to measure the flow of Moyamoya collaterals and compare it to contralateral MCA flow
- Hypothesis: QMRA can measure hemispheric and collateral blood flow prior to, and following, cerebral revascularization

3D TOF Road Map



Patient #1

Methods

Twelve patients with Moyamoya disease underwent QMRA using a 1.5T MR imager (GE Healthcare, Milwaukee, WI). The noninvasive optimal vessel analysis (NOVA) software (VasSol, Chicago, IL) is used to compute the product of the velocity obtained from the gated 2D fast phase contrast sequence and a determined surface area on the TOF image. This results in a volumetric flow value for each vessel selected by the neuroradiologist.

Patient Data

Patient #	Presentation	Revascularization	6 month follow up angiogram
1	36 yo M Left sided weakness/ numbness; focal seizure	STA-MCA; EDAS	Pial collaterals: Decreased Bypass: limited increased filling of RMCA
2	45 yo F Left sided weakness/ facial; TIA	STA-MCA; EDAS	Pial collaterals: Decreased Bypass: significant RMCA filling
3	27 yo M p/w HA w/ SAH	EDAS	Pial collaterals: No change EDAS: Low flow
4	68 yo F p/w HA's	None	N/A
5	53 yo F p/w tinnitus	None	N/A

Five patients met the criteria

- **Collateral Flow =**
  (Ipsilateral ACA2 + Ipsilateral PCA) – (Contralateral ACA2 + Contralateral PCA)
- **Patient 1**
  - **Collateral Flow = 108 ml/min**
  - **Contralateral MCA = 156 ml/min**
  - **Computed C-M Ratio = 0.69**

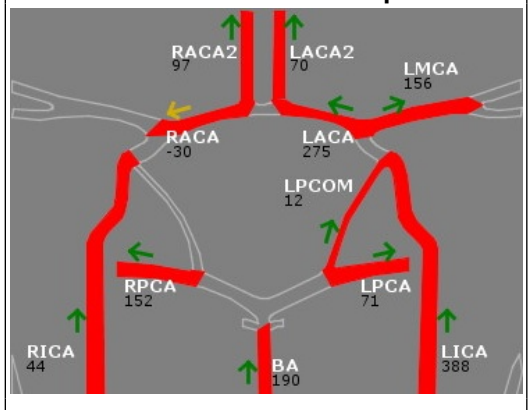
Patient Data

#	Collateral Flow	Contralateral MCA Flow	Preop C-M Ratio
1	108	156	0.69
2	100	150	0.67
3	67	164	0.41
4	54	97	0.55
5	26	130	0.20

Results

Patient collateral flow was measured using the formula presented. This measurement was then compared to contralateral (the non-diseased hemisphere) MCA flow to establish a ratio called the *C-M Ratio.* Here we use Patient #1 as a case illustration.

Volumetric Flow Map



Patient #1

Changes in C-M Ratio after Revascularization

Patient #	Pre-op C-M	6 month Post-op C-M	Reduction of C-M
1 (Direct + EDAS)	0.69	0.32	0.37
2 (Direct + EDAS)	0.67	0.55	0.12
3 (EDAS)	0.41	0.36	0.05

Conclusions

To our knowledge QMRA has not been previously used to describe pial collateral flows in a population of only moyamoya disease patients. We suggest that QMRA accurately measures Moyamoya collateral flow. Using this data, we derived a formula that may represent the flow demand placed on these collaterals. This ratio may be used to quantitatively measure the success of revascularization by demonstrating decreased flow burden on collateral flow. QMRA then could be used to evaluate the efficacy of direct bypass with EDAS versus EDAS alone. However, this will require further investigation.

Learning Objectives

QMRA's utility in:

- Measuring pial collateral blood flow
- Deriving a ratio that our initial data suggests may be useful in evaluating revascularization surgery