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Introduction

Stump pressure (SP) has been used as an indication for selective shunting during carotid endarterectomy (CEA) and permanent occlusion of the internal carotid artery (ICA) [1]. The goal of this work is to develop a new patient specific, regional cerebral blood flow model to predict SP noninvasively.

Existing cerebral circulation models (0D, 1D, 2D, and 3D) have historically been too computationally convoluted to be practical and few are patient specific [2]. More recent developments focus on image-based techniques, namely quantitative MR Angiography (qMRA), that allow for patient-specific modeling and clinical utility [3].

The proposed model offers both improved accuracy and simplicity by utilizing patient specific data qMRA. This zero-dimensional, regional flow model is instituted at patient baseline and with internal carotid artery (ICA) occlusion. SPs were predicted for 4 patients that had undergone balloon test occlusion (BTO).

Methods

The cerebral circulation of four patients was modeled.The baseline model involves calculating the regional blood flows by vessel flow measurements (from qMRA) and peripheral regional resistances. The regional flow model based on ICA occlusion computes the new blood flows and pressures using the simulated occlusion of the ICA while keeping all peripheral regional resistances the same as the baseline's.

SPs calculated using the regional flow model with ICA occlusion were compared against the actual SP measurements during BTO to validate the proposed model.

Results

The proposed model was applied to four patients with ICA aneurysms, two of whom passed BTO and two of whom failed BTO.

The predicted SP using aortic pressure measurement resulted in -5%, -11%, 3% and 7% error when compared to clinical measurements.

The predicted SP using brachial artery cuff pressure resulted in -6%, -14%, 2% and 6% error when compared to clinical measurements.

Conclusions

The proposed model using qMRA data and cuff pressure can be used to predict SP with acceptable error for patients who have undergone BTO.

Learning Objectives

We hope the audience develops a deeper appreciation of quantitative MR Angiography in cerebral blood flow modeling, in particular predicting stump pressures to guide clinical decision making.

References

[1] AbuRahma AF, Mousa AY, Stone PA. Shunting during carotid endarterectomy. Journal of Vascular Surgery 2011;54:1502-1510
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[3] Zhao M, Kufahl R, Clark ME, et al. An Enhanced Patient-Specific Computer Model Using an Iterative Multi-Staged Algorithm. Neurol Res 2017;7:25-38

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Patient	Clinical (mmHg)	Model (mmHg) with aortic pressure	%change	Model (mmHg) with cuff pressure	%change
#2	70	62	-11	60	-14
#3	92	95	3	94	2
#4	69	74	7	73	6



