Phase-Contrast MR Angiography for the Quantification of Blood Flow after Carotid Endarterectomy: Predictor for Cerebral Hyperperfusion Syndrome?

Lukas Andereggen MD; Sepideh Amin-Hanjani MD, FAANS, FACS, FAHA; Marwan El-Koussy MD, PhD; Andreas Raabe MD; Marcel Arnold; Robert H. Andres MD; Michael Reinert

Departments of Neurosurgery, Bern University Hospital, Boston Children's Hospital, and the University of Illinois at

Introduction

Cerebral hyperperfusion syndrome (CHS) is a substantial complication of carotid endarterectomy (CEA). We sought to determine whether quantitative hemodynamic assessment can stratify CHS risk and guide the need for intervention.

Methods

In this prospective trial, patients with ICA-stenosis were randomly selected for quantitative phase contrast MR Angiography (QMRA, MR-NOVA) before and after carotid endarterectomy. Assessment was standardized by a protocol including duplex sonography, CTA, QMRA of intra- and extracranial supplying arteries of the brain. Physiological and clinical parameters were documented. Blood pressure and end- tidal partial pressure of carbon dioxide (EtCO2) during QMRA studies were recorded.

Results

25 out of 153 patients that underwent CEA for ICA stenosis were selected for QMRA between November 2011 and December 2013. Clinical-, lesional characteristics and vascular risk factors were not significantly different between CHS- and non-CHS groups. Data showed a significant post-operative increase of blood flow in the operated internal carotid artery (ICA) by 174 ± 31 ml/min (mean difference ±SEM; $p<0.001$; Fig. 1A) and the middle cerebral artery (MCA) by 37 ± 13 ml/min ($p=0.01$; Fig. 1B). Four patients suffered from clinically manifest CHS. Postoperative ICA and MCA flow was significantly higher in patients with CHS compared to patients without CHS (546 ± 89 ml/min vs. 280 ± 20 ml/min; $p<0.001$ and 264 ± 38 ml/min vs. 152± 11 ml/min; $p=0.001$, respectively; Fig. 1A, B). ICA blood flow in CHS increased by >400% and MCA blood flow increased by >200% over preoperative values.

Conclusions

Carotid endarterectomy increases blood flow in the operated ICA significantly, by 174 ± 31 ml/min on average, as measured by quantitative MR flow technique. No clinical risk factor for CHS besides high baseline diastolic blood pressure could be otherwise identified. An increase in blood flow of more than 413 ± 99 ml/min measured by QMRA in the ICA might indicate risk for CHS and these patients may warrant closer monitoring in the perioperative setting.

Learning Objectives

By the conclusion of this session, participants should be aware of the potential role for QMRA in the assessment of CHS.

Fig. 1: QMRA data before and after CEA

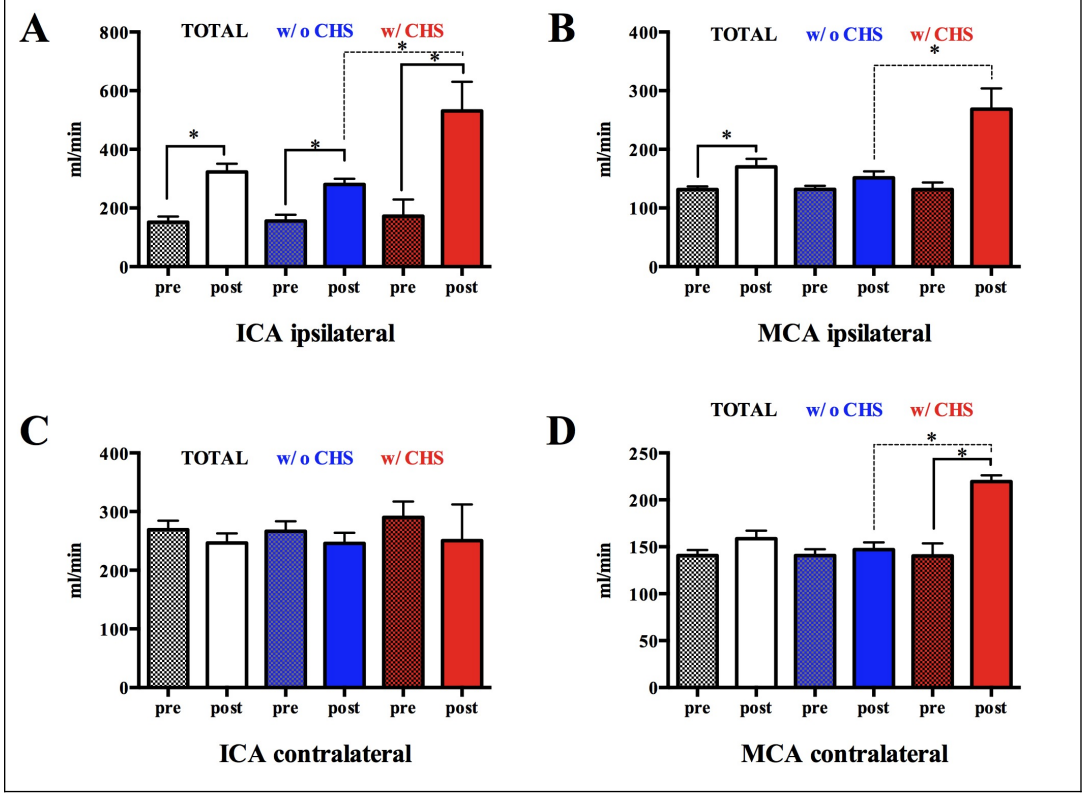

Fig. 1: (A) QMRA data show a significant increase in blood flow in the operated ICA in comparison to pre-operative values in all patients after CEA using a non-patch technique. This significant difference in blood flow was evident in the ipsilateral ICA in patients both with and without CHS. There is a further significant increase in post-operative flow velocities in patients with CHS in comparison to non-CHS patients. (B) Data on MCA flow velocities showed that patients with CHS presented with a significant flow increase in comparison to post-operative values in patients without CHS. (C) There were no significant differences in blood flow values for the non-operated ICA in comparison to perioperative values after CEA. (D) However, in the CHS group, contralateral MCA vessels showed significantly increase in blood flow in comparison to pre-operative values and to post-operative values in non-CHS patients. Data are reported as mean + S.E.M.