Regional Cerebral Volume Flow Using Quantitative Magnetic Resonance Angiography

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Introduction: Quantitative magnetic resonance angiography (QMRA) can non-invasively and accurately determine volumetric flow rates (VFR) and flow directions in vessels with different sizes [1-2]. The range of blood flow for a healthy individual vessel in the brain, however, can be quite diverse due to inherent vascular anatomy and/or anatomic variations in the Circle of Willis [3]. A decreased volume flow in an individual vessel may not necessarily be caused by vascular disease. An effective decision-making paradigm based upon hemodynamic assessment requires an algorithm that accounts for both anatomic variations and assessment of volume flows in distal vessels (regional CBF) [1]. The purpose of this present study was to develop an algorithm to determine the volume flows to specific brain areas, i.e., regional cerebral volume flow, and to determine the distribution of cerebral volume flows within different regions of the brain circulation in healthy volunteers.

Methods: The study population consisted of eighty-three healthy volunteers (age range, 24-74 years; mean age, 42 years; 40 men, 43 women). All subjects underwent QMRA study with a standard NOVA head-and-neck protocol (VasSol, Inc., Chicago), which includes measuring VFRs of six vessels in the neck (two CCAs and two ICAs, and two VAs) and seven vessels in the head (BA, two MCAs, two ACAs, two PCAs), as well as PCOMs if present. The mean VFR values and flow directions for all the vessels were determined using the NOVA system [1-2]. Twelve regions were identified in a partition tree (see Fig.1). The cranial circulation (CC) was first partitioned into left extracranial circulation (LEC), right extracranial circulation (REC), and intracranial circulation (IC). The IC was then partitioned into anterior circulation (AC) and posterior circulation (PC). The AC was further partitioned into three sub-regions, right middle cerebral territory (RMC), left middle cerebral territory (LMC), and anterior cerebral territory (ACE). The PC was also further partitioned into three sub-regions, right posterior cerebral territory (RPC), left posterior cerebral territory (LPC), and cerebellar and basilar territory (CB). The rCVF value for each region was determined based on the mean VFR values and flow directions of the inlet/outlet arteries to/from the region. The relative contribution of volume flow in each region to its parent region was calculated as the percentage of the rCVF for the region over the rCVF of its parent region.

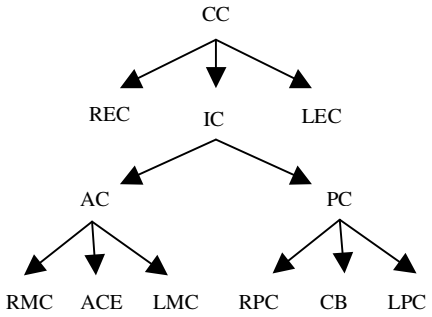

Fig. 1 Partition tree of cerebral circulation

Table 1 rCVF value and its relative contribution to its parent region in twelve regions of cerebral circulation

Region	CC	IC	LEC	REC	AC	PC	LMC	RMC	ACE	CB	LPC	RPC
rCVF (ml/min)	949 ± 158	695 ± 113	126 ± 61	129 ± 63	483 ± 87	212 ± 34	150 ± 31	145 ± 27	187 ± 50	82 ± 26	66 ± 14	63 ± 14
Relative Contribution of rCVF		74% ± 9	13% ± 5	13% ± 5	69% ± 3	31% ± 3	31% ± 4	30% ± 3	39% ± 6	38% ± 9	32% ± 5	30% ± 5

Results: The mean value and standard deviation for both rCVF and its relative contribution to its parent region for all twelve regions are shown in Table 1. The total blood volume flowing into the cranial circulation (CC) was 949 mL/min ± 158. Symmetrical volume flows were found in the left and right regions, i.e., LEC and REC, LMC and RMC, LPC and RPC. The relative contribution of volume flow in IC to the volume flow in CC is 74% ± 9. The relative contributions of volume flows in AC and PC to the volume flow in IC are 69% ± 3 and 31% ± 3 respectively. The relative contributions of volume flows in LMC, RMC, and ACE to the volume flow in AC are 31% ± 4, 30% ± 3, and 39% ± 6 respectively. The volume flowing into cerebellum and basilar territory and the relative contribution of volume flow in CB to the volume flow in the posterior circulation are 82mL/min ± 26 and 38% ± 9 respectively.

Conclusions: Twelve regions in the brain circulation were identified in a partition tree and the volume flow for each region was determined based on the QMRA study results. The rCVF values and rCVF indexes may be useful hemodynamic variables in the stratification of various cerebral vascular disorders.

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