Early Time Points Perfusion Imaging

K. K. Kwong[1], T. G. Reese[1], K. Nelissen[1], O. Wu[1], S-T. Chan[1], B. Thomas[1], J. B. Mandeville[1], M. Foley[1], W. Vanduffel[1], and D. A. Chesler[1]
[1]MGH/MIT/HMS Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Charlestown, MA, United States

Introduction

In susceptibility contrast-enhanced MRI of Gd-DTPA bolus injection, relative cerebral blood flow (rCBF) has commonly been analyzed using the deconvolution approach reported by Ostergaard et al. (1). Another strategy had been proposed (2) to calculate rCBF by measuring the initial rate of Gd-DTPA arriving within a time window smaller than the tissue mean transit time τ, a quantity known to be a few short seconds for gray matter in humans. We name this rCBF measurement technique which utilizes the early data points of the agent bolus the "early time points" method (ET). ET is based on the hypothesis that the quantity of Gd-DTPA present in the tissue is proportional to local CBF before the contrast agent has a chance to clear from the tissue. rCBF measured with ET inherently does not depend on the arterial input function and is potentially less sensitive to the *transit delays* of the bolus to the vascular bed. But what are ET's limitations? What conditions need to be tested before ET could be considered for perfusion analysis? We provided an initial analysis on those questions.

Given the short range of τ, we applied a TR of 300ms. With such a short TR, the limited number of slices reduces the clinical acceptance of ET. We used a recently developed fast sequence, the Simultaneous Image Refocusing (SIR) EPI technique (3,4) which acquired at least two slices in a single readout, to acquire 10 slices in the short TR of 300ms.

We imaged and measured the rCBF of a monkey using the initial slope of the Gd-DTPA bolus signal. We reanalyzed our data with the deconvolution method of Ostergaard et al (1), using standard deconvolution parameters employed in the clinical setting.

Materials and Methods

Experiments were performed in a 3 Tesla Siemens Trio scanner (Siemens Medical System, Erlangen, Germany) using a customized surface coil. For routine Gd-DTPA bolus imaging, we applied Gradient Echo (GE) EPI with TR=300ms and TE=31ms to acquire six slices with 600 data points and the Gd-DTPA injection taking place at around the 250th image. To obtain higher brain coverage at the same TR of 300ms, we applied Simultaneous Image Refocusing (SIR) EPI which acquired two slices simultaneously giving us 10 imaging slices. Spatial resolutions of both GE-EPI and SER-EPI were 3mm x 3mm x 3mm. We imaged the same healthy macaque (Macacca mulatta, 8 kg weight) with MRI in two different sessions. The monkey was anesthetized with ketamine/xylazin, held in place by a MR compatible head frame. The monkey was imaged by GE-EPI while being injected once with Gd-DTPA (0.2mmol/kg) flushed with 12ml of saline with an injection rate of 2ml/sec by a power injector. In the second imaging session, the animal received Gd-DTPA twice, about 30 minutes apart. The second injection was imaged by SIR-EPI.

ET requires the identification of the time of arrival (TOA) of the contrast agent and the compensation of TOA for each pixel. We defined TOA by the intersection of two lines, with one line fitted over the baseline and another line fitted over the rising part of the bolus. Due to the low contrast to noise ratio (CNR) in the neighbor of TOA, we applied a time shift from TOA, with the same amount of shift given to every pixel, to reach the higher CNR part of the early time points to make rCBF maps.

Results and Discussion

The average results of the gray-white flow contrast (between caudate gray and deep white) from two imaging sessions were 3.2±0.3 for ET, and 3.1±0.2 for deconvolution. For SIR-EPI results, the gray-white flow contrast was 3.2 for ET and 2.8 for convolution. ET's flow contrast numbers were within the range of reported literature values, giving support to the utility of ET for rCBF analysis.

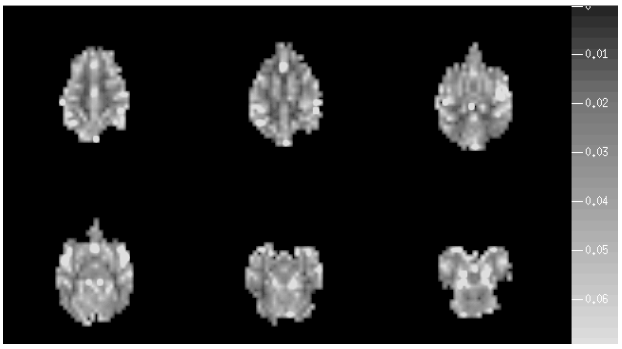

Fig.1. rCBF map made by ET showed good gray-white contrast

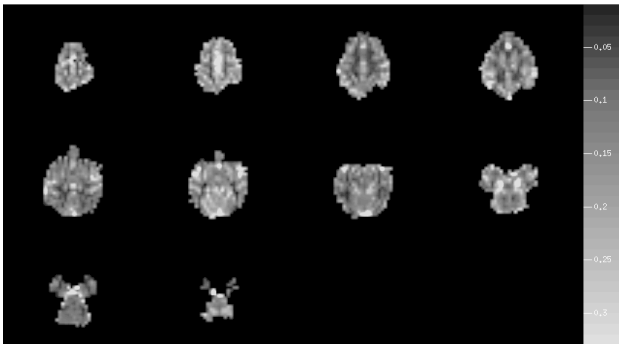

Fig 2. rCBF map made by ET using SIR EPI data.

References

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