# Automatic selection of arterial input function on dynamic contrast-enhanced MRI images: comparison of different methods

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**INTRODUCTION:** Cerebral blood flow (CBF), blood volume (CBV), and mean transit time (MTT) can be estimated from DSC-MRI with gadolinium images by deconvolution given the arterial input function, AIF(t), and tissue concentration, C(t),: $C(t)=CBF \cdot [AIF(t) \otimes R(t)]$, where R(t) is the tissue residue function. Often AIF is found by manually inspecting tracer concentration maps which is very time consuming and operator dependent. In our study we compare 5 methods of AIF automatic selection, including a novel one. The performance of the methods are tested on a stenosis data set. To analyze the impact of partial volume presence a simulation study was also performed.

**MATERIALS AND METHODS**

**Patient:** 12 patients with various degree of stenosis were studied. The data are obtained with a gradient echo EPI (TR=1560ms, TE=51ms, 30cm field of view, 5mm slice thickness), the bolus dose is 0.2mmol/Kg of Gd-DTPA, at a rate of 5 ml/s in an antecubital vein. For each patient we obtain twelve slice and every slice is composed by fifty images.

**Simulation:** the simulation follows Murase, *et al.,* [5]. The data set include voxels that represent AIF, gray and white matter, partial volume effect and also some trend that represent false AIF. Gray and white curves are obtained by convolution of AIF and an exponential R(t).

**Methods:** *Method A* is based on Rempp [1] and uses information regarding the peak value, the moment of maximum concentration and the full width at half maximum. *Method B* is a K-means clustering based on Ashburner [2]. *Method C* selects AIF voxels on the basis of the ratio between the peak and the time to peak [3]. *Method D* assumes that standard deviation (SD) maps of concentration data reliably emphasize vasculature over other tissue classes. By applying filters based on SD maps it is possible to select an adequate number of candidate voxels [4]. *Method E* selects AIF by manually inspection. *Method F* is novel and based on a hierarchical clustering applied dichotomously, i.e. at each step one of the two clusters is chosen to be reclusterized on the basis of the peak height or, if the difference is not significant, of the time to peak.

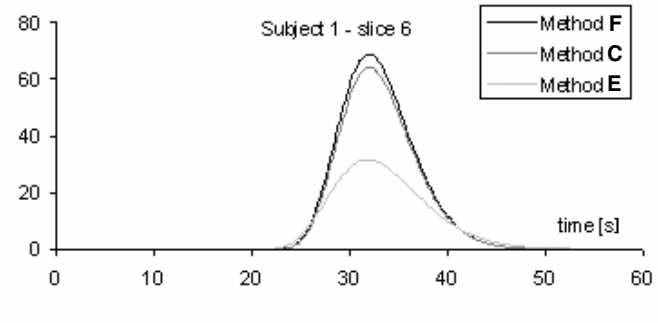


**Fig 1. AIF recovered with different methods in a single patient**.

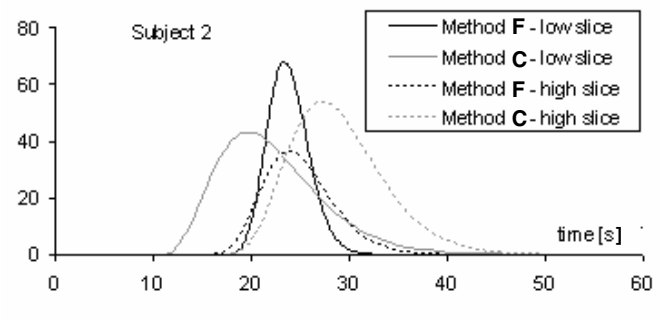


**Fig 2. AIF results with methods C and F in two different slices of a single patient** - "low slice": carotids presence; "high slice": anterior cingulated presence.

**RESULTS** **Patients** Methods A, B, D were discarded because of computational problems and subjectivity of required thresholds. In particular, method A needs additional refinements in order to reach a completely automatic AIF selection. Methods C and F were successful and AIF was calculated by averaging the voxels selected by each algorithm in each slide. AIF shape obtained with methods C and F are similar and both higher and narrower than that provided by the manual method (E) (Fig 1). Comparing the automatic algorithms we see that method C usually selects AIF higher (64.3% of the cases), but also delayed (79.8%) and wider (66.7%) than those selected by method F. With method F, AIF of each slice toward the top of the head becomes gradually lower and wider, while method C shows a variability with has no physiological explanation (Fig 2). However, method F is the worst in term of computational time: ~20s per slice vs ~2s per slice for method C. **Simulation** Method F is less influenced by partial volume artifacts. In fact, voxels selected by method F were for ~90% composed by "true" arterial voxels while method C selects ~85% of "true" arterial voxels.

**DISCUSSION** Both methods C and F perform better than the manual method E. Method F appears to be superior due slice-by-slice coherence and physiological behaviour of AIF. We are evaluating the possibility to improve the performance of method F by exploiting anatomical information.

[1] Rempp KA et al.; Radiology. 193, 637-641 (1994); [2] Ashburner J et al.; San Diego Academic Press. 301-306 (1996); [3] Ibaraki M et al.; JCBFM. 25, 378-390 (2005); [4] Butman JA et al.; ISMRM 13th Scientific Meeting & Exhibition, Miami. 1126 (2005); [5] Murase K et al.; MRI. 13, 797-806 (2001)