Selection of Arterial Input Function for Postprocessing of Cerebral CT Perfusion in Chronic Unilateral High-grade Stenosis or Occlusion of the Carotid or Middle Cerebral Artery

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Rationale and Objectives: We evaluated the effect of the arterial input function (AIF) on computed tomography perfusion (CTP) in patients with unilateral high-grade stenosis or occlusion in the carotid artery or middle cerebral artery without acute stroke.

Materials and Methods: CTP datasets were retrospectively postprocessed using the same venous output function and different AIF selections: the second segment of the anterior cerebral artery (A2 AIF), the second segment of the middle cerebral artery (MCA) on the lesion side (affected M2 AIF), and M2 on the contralateral side (nonaffected M2 AIF). We measured CTP values in the region of interest (ROI) in the bilateral MCA territory and evaluated the lesion-to-contralateral ratios.

Results: The mean and standard deviations of cerebral blood flow (CBF) on the normal side were similar to previously reported data only when using "non-affected M2 AIF." Selecting an "affected M2 AIF" overestimated the CBF and shortened the mean transit time (MTT) in normal and lesion areas. Selecting an "A2 AIF" may cause overestimation of CBF in the normal side in patients with nonaffected-side A1 hypoplasia or occlusion. The sensitivity of the CBF ratio or MTT ratio to detect these unilateral cerebrovascular diseases was 100% using "nonaffected M2 AIF for bilateral MCA ROIs" and 70% (CBF ratio) and 90% (MTT ratio) using "respective AIF."

Conclusion: The use of "nonaffected AIF for the bilateral MCA ROIs" was found to be the best of these AIF-ROI combinations in patients with chronic unilateral carotid or M1 severe stenosis or occlusion.

Key Words: Arterial input function; cerebral blood flow; cerebral blood volume; computed tomography perfusion; mean transit time.

Computed tomography perfusion (CTP) has been used successfully as a functional imaging technique for patients with cerebrovascular disease. It allows rapid qualitative and quantitative evaluation of cerebral perfusion by generating maps of parameters such as cerebral blood flow (CBF), cerebral blood volume (CBV), mean transit time (MTT), and time to peak (TTP). In CTP, the first passage of a bolus of contrast agent through brain tissue is monitored. Often, quantification of CBF and MTT requires measurement of the arterial input function (AIF) (1,2). One may obtain different quantitative results when different arteries are chosen for the AIF. The AIF is optimally selected in one unaffected vessel that is perpendicular to the acquisition plane, which may be one of the anterior cerebral arteries (ACAs) or the contralateral middle cerebral artery (MCA) (3). Wintermark et al (4) found that AIF selection had no significant influence on MTT and CBF values in ischemic territories in patients with a hemispheric stroke of less than 48 hours' duration and that the ACA is an appropriate AIF for CTP processing in patients with acute stroke. Kamath et al (5) found that the CBF value obtained with each vascular territory's own AIF (respective AIF) on CTP correlated best with positron emission tomography (PET) CBF in patients with chronic cervical carotid artery occlusion.

The aim of this study was to evaluate the effect of different AIFs in the postprocessing of perfusion in patients with

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TABLE 1. Patient Demographics

No.	Age	Sex	Disease Characteristics	Site of Proper AIF
1	40	F	Right ICA occlusion	Left M2
2	84	M	Left CCA occlusion	Right A2
3	55	F	Right proximal M1 occlusion	Left M2
4	74	M	Right ICA occlusion	Left M2
5	77	M	Left ICA occlusion	Right A2
6	46	M	Left M1 occlusion	Right M2
7	66	M	Right ICA occlusion	Left M2
8	94	M	Right ICA occlusion	Left M2
9	63	M	Right ICA 95% stenosis	Left M2
10	80	M	Right ICA occlusion	Left M2
11	69	F	Left ICA occlusion	Right M2
12	88	M	Left ICA 95% stenosis	Right M2
13	80	M	Right ICA 90% stenosis	Left M2
14	54	M	Right ICA occlusion	Left M2
15	88	M	Left ICA 94% stenosis	Right M2
16	61	M	Left ICA occlusion, right M1 <50% stenosis	Right A2
17	68	F	Left ICA 95% stenosis	Right M2
18	84	M	Left CCA occlusion, right ICA <50% stenosis	Right A2
19	46	F	Left ICA occlusion	Right M2
20	78	M	Right ICA 95% stenosis	Left M2

CCA, common carotid artery; ICA, internal carotid artery; M1, first segment of the middle cerebral artery.

chronic high-grade unilateral arterial stenosis or occlusion without acute infarction. In addition, we examined whether the ACA and respective AIF would be appropriate for the postprocessing of perfusion data in these patients.

MATERIALS AND METHODS

Patients

We retrospectively reviewed all CTP studies performed between October 2007 and December 2010 at our institution and selected 20 patients (15 males, 5 females) for postprocessing in this study (Table 1). Only patients with unilateral stenosis more than 90% in degree or occlusion in the carotid artery or first segment of the middle cerebral artery (M1) were included in this study. The contralateral-side carotid artery and MCA could be normal or with stenosis less than 50% in degree. These arterial conditions were confirmed by digital subtraction angiography in 18 patients, computed tomography (CT) angiography in one patient, and MRA in one patient. Institutional Review Board approval was obtained for this study. Written informed consent was obtained from each patient for the CTP study, in accordance with our clinical routine.

Patients ranged in age from 40 to 94 years (mean ± standard deviation, 69.8 ± 15.6 years). The patients underwent CTP study as part of the preoperative evaluation before extracranial-intracranial bypass or carotid stenting. All patients had chronic arterial disease without any symptoms of acute or hyperacute infarct. The CT of all patients and magnetic resonance imaging diffusion-weighted images of two patients confirmed there was no acute or hyperacute infarction at the time of the CTP study.

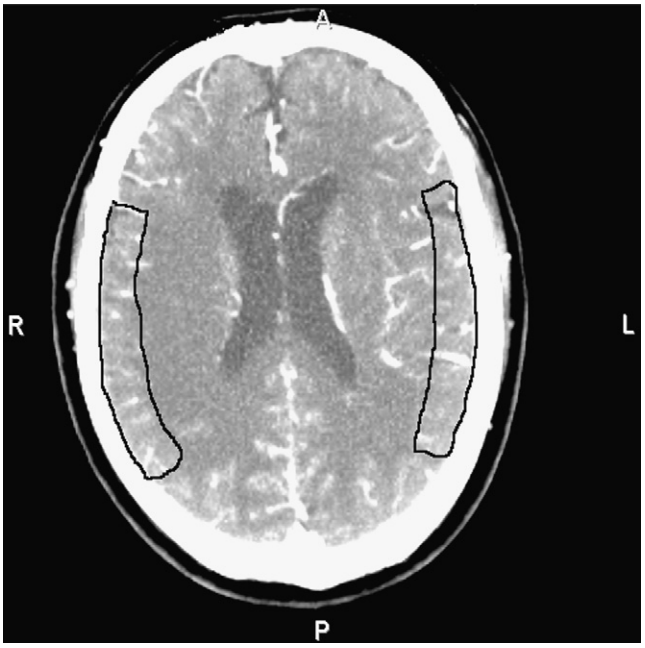

Figure 1. Region of interest drawing on the high ventricular plane (the same case as Figure 3).

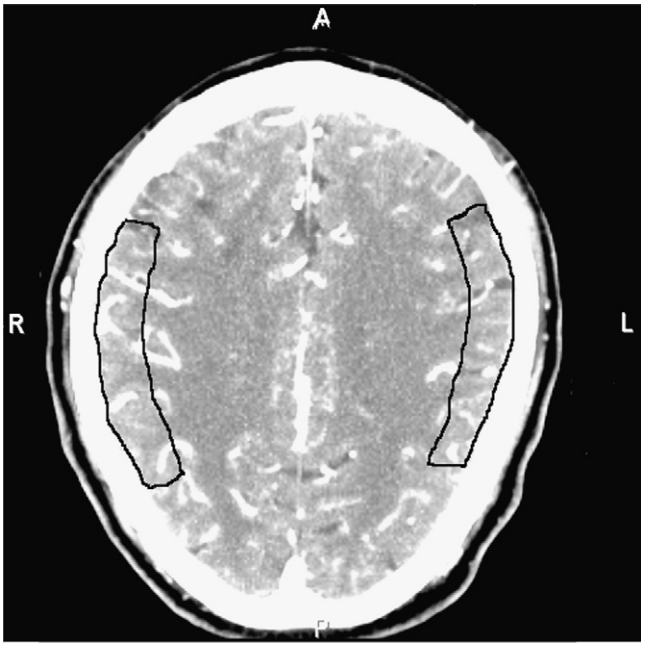

Figure 2. Region of interest drawing on the supraventricular plane (the same case as Figure 4).

CTP Scanning Protocol

All CTP studies were performed using a spiral multidetector CT (MDCT) scanner (Brilliance 40, Philips Medical Systems,