Observation of the Lenticulostriate Arteries in the Human Brain In Vivo Using 7.0T MR Angiography

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Background and Purpose—We sought to examine the feasibility of observing the lenticulostriate arteries (LSAs) noninvasively by ultrahigh-field MRI with 7.0T.

Methods—We used 3-dimensional time-of-flight MR angiography with a radiofrequency coil optimized for 7.0T MRI. We examined the LSAs of 6 healthy subjects and compared 7.0T MR angiography images with 1.5T ones to examine the potentials of ultrahigh-field MRI for angiography.

Results—The results show clear details of LSAs and their distribution in the normal healthy subjects with large variations in the shapes, the number of branches and the sites of origin. We also observed substantial differences between the left and right sides within each subject. Although we studied only 6 subjects, we found no age- or gender-related differences in the LSAs.

Conclusions—The visualization of microvasculature of the brain, such as LSAs, using 7.0T MR angiography, is possible in in vivo human studies noninvasively. We, therefore, believe that it could play a major role in the study of small vascular abnormalities, such as the early stages of cerebral strokes. **(*Stroke*. 2008;39:1604-1606.)**

Key Words: lenticulostriate arteries ■ microangiography ■ MR angiography ■ 7.0T MRA

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Lenticulostriate arteries (LSAs) are one of the most important vascular structures in the human brain and the sites of many neurological diseases. Ischemic and hemorrhagic cerebral strokes often occur in the areas of the brain supplied by these perforating arteries.[1,2] Even though there is a great need for observation of microvasculature in the brain for the early detection of cerebrovascular strokes in routine clinical practice and for research purposes,[3,4] currently available angiographic techniques remain relatively inconvenient and often risky in practice because they require unusually large contrast materials, such as iodine. In this study, for the first time, we have visualized LSAs in the human brain in vivo using 7.0T MR angiography (MRA), in a totally noninvasive manner.

Materials and Methods

Six right-handed healthy volunteers (the mean age 34.3±10.8 years) were recruited and signed an informed consent form. We measured their blood pressure, heart rate and body temperature before and after scanning. The blood pressure of all subjects were within the normal range for the age group (mean arterial blood pressure 93.1±4.88 mm Hg). The experiments were approved by our institutional review board.

For the imaging of the LSAs, we have developed a birdcage type radiofrequency coil specifically designed for an angiographic application at 7.0T MRI (Magnetom, Siemens AG). A 3-dimensional gradient-echo sequence was used, and the total imaging time was 8 minutes 30 seconds. In this experiment, the measured transmission power and the specific absorption rate of the birdcage coil were 160 to 220 Volts and 4 to 7.9 W/kg for the total imaging time, which corresponds to 30% to 60% of the FDA limit. Targeted maximum intensity projection was made for the region of interest, which focused onto the main trunk of the middle cerebral artery (MCA) as well as the anterior cerebral artery (ACA).

Results

Figure 1a shows a sketch of typical LSAs in the area of basal ganglia. Figure 1b shows an angiogram of LSAs in the area of basal ganglia that can be obtained using digital subtraction angiography (DSA; Axion Artis, Siemens AG) with a contrast material. Figure 1c shows a typical LSA image obtained by MRA at 7.0T from a young subject. In addition to the clinical complexity in performing DSA imaging of the LSAs, it is normally poor in contrast. The MRA image, however, shows substantially clearer picture of all the branches of LSAs, suggesting that high field MRA could serve as a tool for noninvasive microvascular imaging of the human brain in vivo.

Figure 2 shows a set of typical images of the LSAs obtained by 7.0T MRA from healthy subjects in their 20s. As shown in Figure 2, five to six LSAs, which are branching out from the main trunk of the MCA, are clearly visible. These results show and also confirm that there is a great variety among LSAs in terms of their shapes and number of branches.[5] These images also clearly indicate left–right differences in vascular structures within subjects. For comparison, a corresponding image of LSAs obtained using 1.5T MRA is shown in Figure 2c. As is known, with lower field MRI (1.5T), none of the small perforators or vessels can be seen. In Figure 3, similar images obtained for the subjects in their 30s and 40s are shown. Although the number of subjects is small, it appears that the

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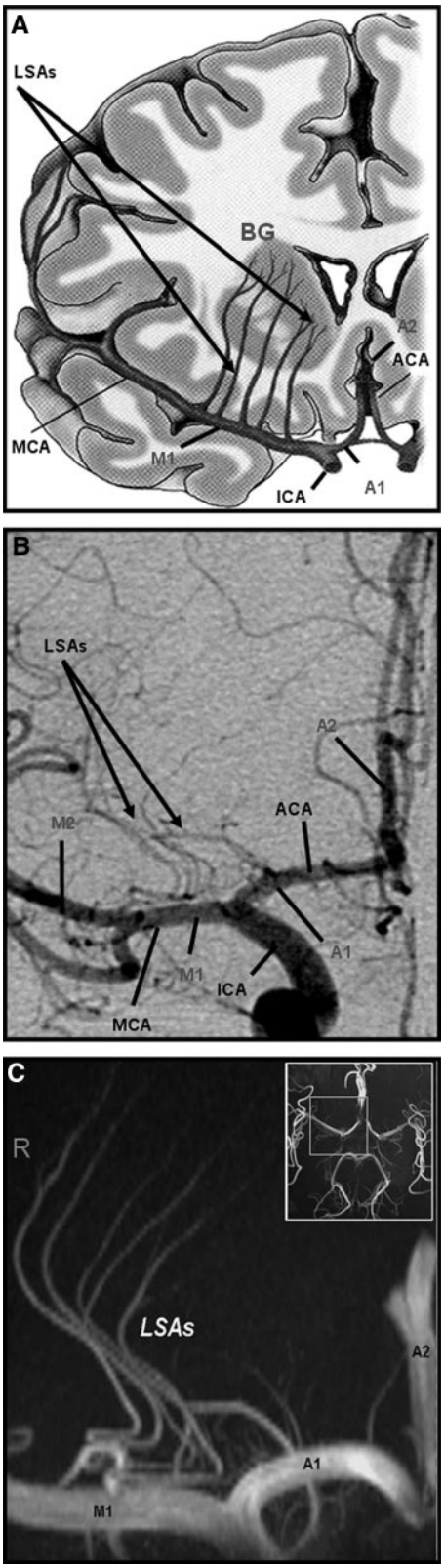

Figure 1. (a) Courtesy of "Neuroscience" (3rd ed). Dale Purves et al (eds), Sinauer Associates, Inc Publishers, Sunderland, MA, USA; 2004: 765. (b) This is DSA image obtained from a 36-year old patient. (c) This is an anteroposterior (AP) 2D maximum intensity projection view of LSAs obtained by 7.0T MRA. The inset at the upper right shows a superior maximum intensity projections view with indication of the selected region of interest for LSAs. BG indicates basal ganglia; ICA, internal carotid artery.

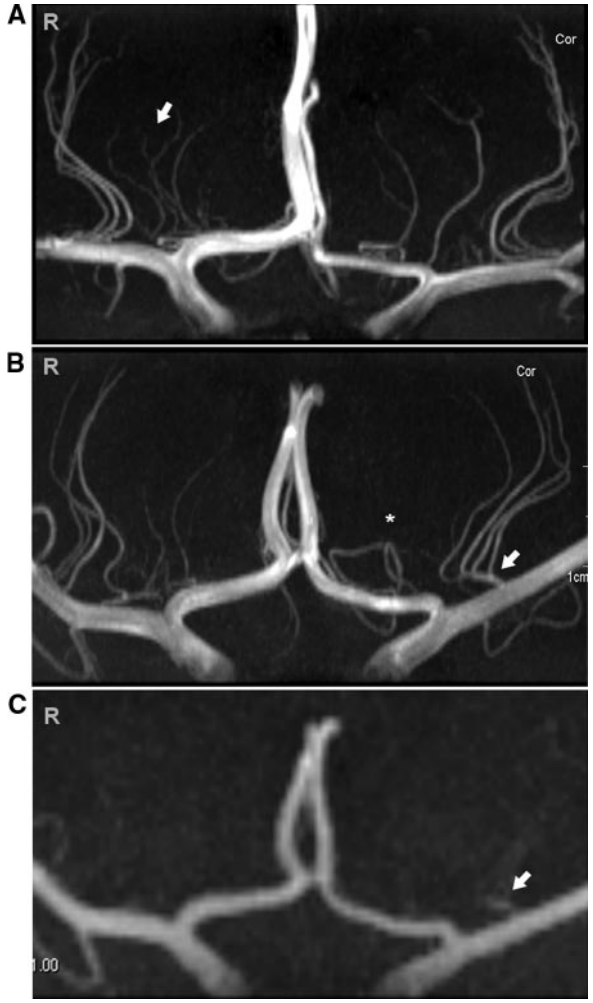

Figure 2. (a) A typical 7.0T MRA image of three large LSAs originating from the MCA on both the right and left. There are also several thin LSAs arising from ACA, especially on the right (arrow). (b) Another example of four LSAs branching from a single trunk on the left MCA obtained from 7.0T MRA (arrow). In this example, there are no further LSAs arising from the ACA on the left (*). (c) 1.5T MRA image obtained from the same subject as (b). A main branch originating from MCA is only shown faintly (arrow).

difference between the age groups, if any, is minor compared to the individual fluctuations within each group.

Discussion

The detection of small vascular structures or microvessels such as LSAs has been a major challenge for the elucidation of microvascular structures and their abnormalities in the living human brain.[6,7] Currently, DSA is considered the "gold standard" for angiography, but it is highly invasive. It requires not only the administration of a contrast agent but often requires a substantially complex imaging procedure. Therefore, it is usually limited to the examination of symptomatic patients only. Its drawback is the faint outlines of the LSAs, which is shown in Figure 1b. Hence, there is a need for a high resolution imaging technique, with which one can observe the microvasculature structures noninvasively deep in the brain. Clinicians and researchers have long searched for noninvasive tools for the visualization of abnormalities in the territories of LSAs, such as

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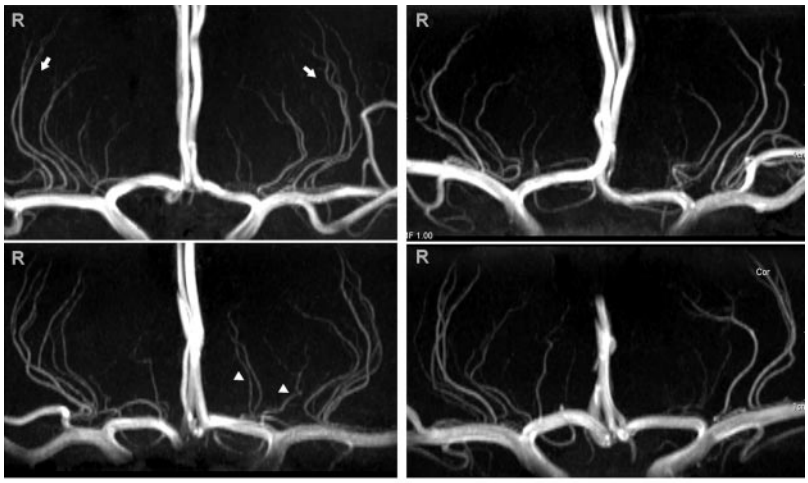

Figure 3. A few typical examples of LSAs obtained from healthy volunteers in their 30s (a) and 40s (b), respectively, by 7.0T MRA. Many branches arise both from the main MCA (thick arrows) as well as ACA (arrow heads).

lacunar infarcts, using MRI/MRA and CTA.[8,9] The results were, however, largely unsuccessful, especially in imaging of microvascular structures in vivo noninvasively. As has been demonstrated with the recently available ultrahigh-field MRI, especially 7.0T, we began to obtain many microvascular angiograms, hitherto unavailable with low field MRI, that is, noninvasive microvascular imaging and angiography without contrast agents.

Although we have studied only 6 healthy subjects, this preliminary study suggests strong evidence that a potential application of the technique in microvascular imaging in human for screening and early identification of vascular abnormalities of various kinds, such as strokes, is possible. A potential of noninvasive screening of microvascular abnormalities for asymptomatic subjects would be an important asset in preventive medicine that could be readily available in the near future, as we have proposed. This preliminary investigation, therefore, calls for a more in-depth study of any age- or gender-related and disease specific changes in the LSAs, as well as intraindividual left-right differences that might have implications in the risk factors in stroke, such as hypertension, diabetes, dyslipidemia and obesity.

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Disclosures

None.

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