Brain Death
Evaluation of Cerebral Blood Flow by Use of Arterial Spin Labeling

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A 48-year-old woman was admitted to the emergency department with a history of nuchal rigidity, tonic seizure, and loss of consciousness. Five hours after lumbar puncture for diagnostic purposes, no pupil reaction to light and apnea was detected. Immediate MRI revealed tonsillar impaction in the foramen magnum, loss of signal void in the bilateral internal carotid arteries suggesting arrest in flow, severe gyral swelling, and extensive intravenous thrombi filling vessel lumens (Figure 1). Clinical examinations for brain death were performed on hospital day 20, and were consistent with clinical brain death. On hospital day 22, electroencephalogram was performed, and the result of electrocerebral silence was recorded as being consistent with electroencephalogram criteria for brain death. For determining cerebral blood flow (CBF), conventional angiography or radionuclide angiography was requested by the neurologists. However, the patient’s family resolutely refused any additional invasive modality using contrast media or radioactive material. Therefore, on hospital day 23, unavoidable MR imaging using the arterial spin labeling (ASL) technique was performed, and revealed a severe perfusion defect in the whole brain. Mean value and standard deviation of CBF value measured in all pixels composing the gray matter were 7.9 and 3.4 mL · 100 g⁻¹ · min⁻¹ (Figure 2). By hospital day 25, her status had shown no improvement. After 1 month in the hospital, mechanical ventilation and other supports were withdrawn in the operating room and her organs were donated to 5 other patients.

Discussion
Brain death is a clinical diagnosis. Cardinal requirements for clinical determination of brain death include coma, absence of brain stem reflexes, and apnea.1 Although confirmatory tests, also mentioned as ancillary tests, are not mandatory in most situations, additional testing may be necessary for declaration of brain death in patients in whom the results of specific components of clinical testing cannot be reliably evaluated.1 Furthermore, in many countries, including Central and South American, European, and Asian countries, confirmatory testing is required by law.1

ASL is an emerging MRI technique for measurement of CBF. With ASL MR imaging, protons in arterial water are magnetically labeled in the feeding vasculature of the brain. Labeled arterial protons flow through the vascular tree and exchange water with unlabeled brain tissue. A perfusion-weighted image can be generated by subtraction of an image in which inflowing arterial spins have been labeled from an image in which spin labeling has not been performed.2 The
main advantages of ASL are that it is completely noninvasive and provides information on absolute CBF.

An important issue in the clinic is how well ASL performs in comparison with established gold-standard methods. Validation studies in humans have been performed comparing ASL and positron-emission tomography, and revealed the validity of ASL in the gray matter even though there is a tendency to underestimate the CBF in the white matter.3

According to a previous report, there is a lower limit of CBF that is required by the human brain, and this value is \( \approx 10 \text{ to } 15 \text{ mL} \cdot \text{g}^{-1} \cdot \text{min}^{-1} \) for regional CBF.4 In our patient, gray matter CBF of \( 7.9 \text{ mL} \cdot \text{g}^{-1} \cdot \text{min}^{-1} \) was far lower than the minimum limit required in the brain.

Because a noninvasive MRI technology can provide an absolute CBF value at the tissue level, ASL is particularly appropriate for suspected brain death. In the unique aspects of a clinical setting, under suspicion of brain death, in which a patient’s kin, in deep sorrow, frequently refuse any additional invasive modality, the ASL technique has the potential as a noninvasive imaging tool for determining CBF.

Disclosures

None.

References

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