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MR Diagnosis of Brain Death

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Summary: The authors describe their experience with MR in the determination of brain death.

Index terms: Brain, death; Cerebral blood, flow; Magnetic resonance, indications

With the advent of increasingly sophisticated life-support systems, the determination of brain death has in some cases become more difficult. Angiography, computed tomography (CT), ultrasound, and nuclear medicine perfusion imaging have all been advocated in the evaluation of cessation of cerebral blood flow. We present a case of unsuspected brain death diagnosed by magnetic resonance (MR) imaging.

Case Report

A 13-year-old girl with a nonresectable astrocytoma and resultant blindness presented to clinic with persistent frontal headache. Increasing lethargy developed, with bradycardia, Cheyne-Stokes respirations, and vomiting with aspiration. The patient was intubated following respiratory arrest. Initial examination revealed equal and sluggishly reactive pupils, with intact corneal, cough, and gag reflexes. The patient opened her eyes and withdrew extremities in response to pain. Reflexes were intact and the patient was intermittently able to breath spontaneously. CT showed a large hypothalamic mass and possible brainstem hemorrhage, and an electroencephalogram (EEG) was obtained that showed no seizure activity.

Over the next 4 days, a gradual decline was noted on physical examination, with loss of spontaneous respiration, corneal and gag reflexes, and extraocular movements. The patient became only minimally responsive to stimulation. An MR performed the following day to rule out brainstem hemorrhage demonstrated a large hypothalamic mass, with brainstem herniation caudally. MR also showed absent cerebral blood flow, confirmed on flow-sensitive gradient-echo sequences (Figs. 1A–1D). Following MR, further neurologic evaluation and an apnea test demonstrated findings compatible with brain death. An EEG was performed that demonstrated no electrical activity. Because of the findings on MR and on the subsequent tests, it was felt that no further studies were needed.

Discussion

With the increasing complexity of life-support systems, the clinical determination of brain death is not always a straightforward process. In 1981, criteria were established by the President's Commission based on the Uniform Determination of Death Act, defining death as "1) irreversible cessation of circulatory and respiratory functions, or 2) irreversible cessation of all functions of the entire brain, including the brain stem . . . . " (1). Criteria for brain death included 1) deep unresponsive coma, 2) no brainstem function (no pupillary light, corneal, oculocephalic, oculovestibular, oropharyngeal, and tracheal reflexes), and 3) no respiratory (apnea) reflex despite P_{CO_2} greater than 60 mm Hg. Multiple ancillary studies have been proposed to help in the determination of brain death. EEG, though not necessary for the diagnosis, has been widely used and may shorten the observation period. However, errors have been reported (2), and absent EEG activity with subsequent patient recovery has been reported in comatose children (3, 4) and in cases of barbiturate overdose (5). Evoked potential studies have been suggested for evaluation of brainstem activity (6).

Radiologic studies have also been widely used to help in the determination of brain death. Cerebral angiography has been used extensively (7), and as recently as 1989, intravenous digital subtraction angiography has been advocated for diagnosis of brain death (8). Nuclear medicine cerebral perfusion imaging, which can be performed

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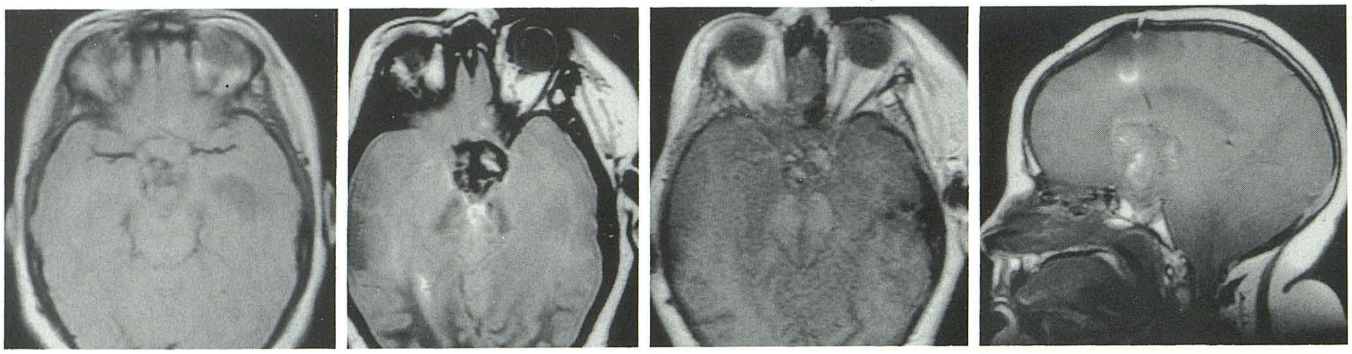

Fig. 1. *A*, Axial proton density 2000/30 (TR/TE) image prior to patient admission demonstrates a large suprasellar mass with normal vascular flow in the MCA distribution.

B, Repeat scan following admission at slightly different angle demonstrates no appreciable cerebral blood flow.

C, Flow-sensitive (24/5/50°) image confirms absence of cerebral blood flow.

D, Sagittal T1-weighted (600/15) image demonstrates tumor, with absent cerebral blood flow and inferior brainstem herniation.

portably, has been used extensively with reportedly good results (9). More recently, a Tc-99m HMPAO compound has been utilized for evaluation of brain parenchyma, as well as the usual radionuclide angiogram.

MR has been used extensively for evaluation of vascular flow, including intracerebral flow, and MR angiography promises additional application of this new technology. In our case report, the events leading to the patient's death were of a gradual nature, and the diagnosis of brain death was not suspected at the time of the scan. A routine brain scan was enough to establish the absence of intracranial flow, and additional tests were not deemed necessary in this case. Additional flow-sensitive gradient-echo sequences requiring only a few minutes, as in this case, provide additional confirmation of absent intracranial flow.

It seems reasonable to assert that, with the availability of nuclear medicine flow scans and MR, angiography is no longer routinely indicated for the diagnosis of brain death. Although MR is undoubtedly a powerful tool in the evaluation of intracranial blood flow, and flow-sensitive scans can be obtained in a few minutes, it is far from clear that this modality should be used routinely for the diagnosis of brain death. The examination is expensive and cannot be performed portably, as can the radionuclide scan. Furthermore, patients on extensive life support are difficult to transport and require MR-compatible equipment. Radiologists and other clinicians should also be aware that in certain situations, slow flow may have an MR appearance which mimics that of complete occlusion (11). Even flow-sensitive gradient-echo sequences may be misleading, and caution should be exercised when evaluating intracerebral blood flow. Given the power and rapidity of MR, however, its potential use in selected situations would certainly merit further study and debate.

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