logical examination may have shown no cerebral uptake and therefore expedited the declaration of death by brain criteria.

In other cases where there was an early ^{99m}Tc-HMPAO study showing cerebral uptake of radiotracer, repeat scans were not consistently performed (*8–10*). When scans were repeated, the motivation was more than just because the previous scan had demonstrated cerebral perfusion; all patients either had interfering factors associated with the first clinical examination (e.g., hypothermia, barbiturate coma or high dose of a paralytic agent), or the patient was simply found not to be clinically brain dead.

Our case is notable for the fact that the patient was unequivocally brain dead in the absence of interfering factors and had failed an apnea test. If no flow was present, the clinical diagnosis of brain death would have been confirmed. Laurin et al. (*8*) recognized a tendency not to perform apnea tests given a flow study and clinical examination consistent with brain death. This was viewed as a bias introduced by the scan results. Our experience suggests the clinician appears unduly biased by the neurological examination; when a patient is found to be convincingly brain dead, the flow study can then only serve to expedite the declaration process.

Because clinically brain dead trauma patients with cerebral uptake of ^{99m}Tc-HMPAO may survive (*9*), the judgement of imminence of brain death can be dangerous. Consideration should be given to repeat scintigraphy. An alternative approach that we suggest is to study the patient as late as possible in the brain death declaration protocol. At our institution, this means just before the repeat neurological examination and apnea test at 6 hr. Absent intracranial uptake would obviate the need for repeated study of those patients for whom brain death was truly imminent, and who may have had cerebral perfusion 4–6 hr earlier. Injection of radiopharmaceutical in the ICU followed by imaging at a later time (*11*) is not recommended since only the state of cerebral perfusion at the earlier point in time will be assessed.

Since certain situations, including persistent perfusion, may still necessitate a repeat study, we also recommend administration of a smaller initial dose of ^{99m}Tc-HMPAO (<10 mCi). This would allow subsequent study at a shorter time interval with a higher dose (20 mCi) of the same agent, or with an intravascular agent for radionuclide angiographic images.

In conclusion, we have presented a case that illustrates how the persistence of cerebral activity following ^{99m}Tc-HMPAO uptake—one attribute responsible for the popularity of this radiopharmaceutical—may potentially impede the timely declaration of brain death. To best utilize this cerebral perfusion agent, we suggest that it only be used: (1) after unequivocal brain death has been established clinically, (2) with the minimum dosage for adequate imaging (<10 mCi) and (3) as late as possible in the sequence of clinical events prior to declaration of death by brain criteria in order to increase the likelihood of demonstrating absent cerebral uptake.

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EDITORIAL

Brain Death: A Diagnostic Dilemma

The diagnosis of death has generated extensive multicultural debate. The results of this debate necessarily influence medical concepts about death and also our efforts to develop and choose between appropriate diagnostic methods. The discussion by Larar and Nagel (this volume) represents one step in a much needed effort to clarify the use of a relatively new diagnostic approach to brain death. These data, and more, are imperative for the medical credibility and social acceptance of the diagnostic technique.

The accurate and timely determination of the death of an individual

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has taken on new significance and complexity over the last 30 yr. The major reason for this trend is technological. We have been increasingly successful in replacing the function of specific organs either artificially or by organ transplantation. Thus, a heart may die, but the individual may live with a transplanted heart. A similar situation exists for other organs but does not apply to the brain. The equivalency of the death of the brain with the death of the individual was given formal expression in the report of the Ad Hoc Committee of the Harvard Medical School to Examine the Definition of Brain Death in 1968 (*1*). Although there is now wide societal acceptance of the equivalence of death and brain death, it is not universal. In Japan, the debate continues (*2*), and in Denmark brain death is not an acceptable criterion for death according to the Danish Council of Ethics (*3*). This fundamental issue has been reviewed extensively (*4–6*).

One major reason for the reluctance of the Japanese to equate brain death with death is doubt about the technical aspects, reliability and objectivity of its determination. Even in societies that accept the death of the brain as final, diagnosis is the major point of debate. A search of the literature from 1983 through 1990 reveals that studies of the diagnosis of brain death increased about threefold. The central issue to the debate over diagnosis is manifest in the difference between the initial United States and United Kingdom guidelines. In the former, death is the "irreversible cessation of all functions of the entire brain, including the brain stem" (*7*). In the latter, "permanent functional death of the brain stem constitutes brain death" (*8*). This difference has led to significant repercussion and confusion in both countries. In the U.K., a British Broadcasting Corporation show titled "Transplants: Are the Donors Really Dead?" (October, 1980) is said to have suggested that the British Guidelines were inadequate in part because an EEG was not included in brain death criteria (*9,10*). The alarm incited by the program resulted in a significant decrease in the rate of kidney donations (*11*). In this country, a recent survey of 195 physicians and nurses showed that only 35% of these professionals, all likely to be involved in the process of organ procurement could correctly identify the legal and medical criteria for determining death (*12*). With regard to specific questions about the whole-brain criterion, 63% of those tested correctly identified this requirement.

The debate over the need for whole-brain criterion for death will continue. In the meantime, it remains an accepted part of the guidelines for the determination of brain death in the United States (*7*) and it is this requirement that presents the most difficult problem for diagnosis. The diagnosis of brain stem death is, by comparison, straightforward. The brain stem is dead when there is cranial nerve areflexia and the patient fails an apnea test. Clinical prerequisites include a negative toxicological screen, hemodynamic stability, normothermia and a period of observation that can vary depending on the cause of suspected death. The obstacle to the diagnosis of whole-brain death is therefore largely a problem with the determination of forebrain death. The majority of ancillary or confirmatory studies advocated by hospital guidelines for brain death in the United States have been selected for this purpose. It should be noted that such studies are almost always ancillary and "may not be necessary in every case", to quote the guidelines of the critical care committee at our institution. The problems of determining forebrain death have been well stated by the proponents of the brain stem criteria of death. Since the principle study of cerebral integrity has been the electroencephalogram (EEG), this study has received the brunt of the criticism. Further, this criticism is quite relevant to the discussion of and choice of any ancillary test.

Guidelines for the minimum technical standards for EEG recording in suspected cerebral death were set forward by the American EEG Society most recently in 1986 (*13*). The basic arguments regarding the use of the EEG in brain death were articulated by Pallis (*14*) almost 10 yr ago and are applicable to these guidelines. Among the arguments that he puts forth, the most relevant for this discussion are the conceptual, cultural and technical arguments.

The conceptual problem that is described is whether we should be testing "the brain as a whole" or "the whole brain" when an EEG or any other ancillary test is performed in the setting of brain death. This is simply a reformulation of the debate over whether brain stem death alone is a sufficient condition to declare someone dead. The U.S. guidelines for brain death are quite specific and specify "the entire brain, including the brain stem." Therefore, a supportive study should be one that gives the greatest information about whole brain vitality. The EEG samples a limited area but directly reflects neuronal function. Blood flow studies, while surveying a larger portion of brain, do not directly assess functional integrity.

The cultural argument implies that the EEG is used to supplement the determination of brain death in the United States because we are a technologically dependent, litigious culture. It has even been argued that personal gain may partly influence the physician ordering a study to supplement the clinical diagnosis of death. The latter seems particularly unlikely since most physicians make the diagnosis of brain death infrequently and would realize little profit. Still, the cultural influence is significant. Highly technological, diagnostic methods are a hallmark of American medicine and no one would deny the influence of malpractice litigation on the number and complexity of tests ordered. While the EEG is clearly technology, it can hardly be considered "high technology" at a time when digital subtraction angiography, positron emission tomography, magnetic resonance imaging, perfusion scintigraphy and other methods are applied

to the diagnosis of brain death. To a great extent, our societal view is simply a reflection of the medical profession's obsession with and confusion about the role of these tests. As a new technology is tested, a consensus is required as to its merits. This is frequently the role of specialty societies, such as the American EEG Society (AEEGS).

The technical arguments against the EEG in brain death are in some ways the most damaging but also the most useful for a discussion of ancillary testing. The problems are related to the sensitivity and specificity of the test. There is no doubt that a brain death recording is difficult to perform. Qualified technologists are not present at all hospitals and, when on the staff, often not available on a 24-hr basis. The same can be said about EEG readers. In one study of inter-rater reliability, 20% of all EEGs obtained for the determination of brain death were not readily interpreted (*15*). The major factor contributing to this problem is that of artifact. At the high sensitivity specified and in the electrically hostile environment of the intensive care unit, artifact cannot be eliminated. Electrocerebral inactivity is operationally that point at which the cortical activity does not exceed the electrical noise. The noise level must be clearly demarcated and quite low. If the degree of noise is great enough to raise any question as to the presence of cerebral activity, then the recording should be repeated. In some instances, the question cannot be answered.

The analysis presented above can be used to specify the requirements of a hypothetical ancillary test to convincingly diagnose brain death. It should reflect whole brain or at least forebrain function. A relatively uncomplicated or "low tech" approach would be best so as to be conceptually simple, reflecting some measurement of brain function that can be thought of as either present or absent. It should be of low cost. Most importantly, it should be technically easy to perform and yield no false-positive findings. The EEG is the most commonly used ancillary study for the diagnosis of brain death in spite of the issues discussed. There is extensive clinical experience with EEG and it is portable and inexpensive. The role that the EEG plays is in part due to its early introduction but also due to the efforts of the AEEGS to rigorously standardize its use, especially in brain death. Similar guidelines for the use of other promising diagnostic tools such as doppler ultrasonography or perfusion scintigraphy would be tremendously helpful. Suggestions regarding the timing of the study and data about false-negative findings, such as those made by Larar and Nagel (this volume), should be systematically organized and published. In general, the emphasis should be placed on methods that equal the EEG's portability and cost but are technically less difficult to do and interpret.

In summary, the diagnosis of death in the United States relies on clinical evidence of brain death, and confirmatory or ancillary testing especially directed at determining the degree of forebrain function. The reluctance to use brain stem death as sole criterion of death in the United States has been vigorously assailed and the ongoing debate has proven useful in examining our diagnostic studies. The EEG has been the test of choice for supporting the diagnosis and advocates of alternative diagnostic tools must develop equal conceptual and technical standards.

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