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Current Practice in the Diagnosis of Brain Death is Not Consistent with Legal Statutes Requiring the Absence of All Brain Function

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Abstract. The legal standard for the determination of death by neurologic criteria in the United States is laid out in the Uniform Determination of Death Act (UDDA), which requires the irreversible cessation of all function of the entire brain. Most other nations endorse a "whole-brain" standard as well. However, current practice in the determination of death by neurologic criteria is not consistent with this legal standard, because some patients who are diagnosed as brain dead, in fact retain some brain function, or retain the capacity for the return of some brain function. In response, the American Academy of Neurology published updated guidelines, which assert that hypothalamic function is consistent with the neurological standard enshrined in the UDDA. Others have suggested that it is an open question whether the hypothalamus and pituitary are part of "the entire brain", as delineated in the UDDA. While we agree that determination of death practices are worthy of continued dialogue and refinement in practice, that dialogue must adhere to reasonable standards of logic and scientific accuracy.

Keywords: Uniform Determination of Death Act; brain death; specificity; misdiagnosis; hypothalamus; death determined by neurological criteria

The condition known as "brain death" was codified into state laws in the United States largely in the 1980's, based on the 1981 model law, the Uniform Determination of Death Act (UDDA). The UDDA states: "an individual who has sustained either (1) irreversible cessation of circulatory and respiratory functions or (2) irreversible cessation of all functions of the entire brain, including the brainstem, is dead".[1] While the second, neurological, basis for determining death continues to enjoy broad support from the medical and legal professions, it is also facing increased scrutiny and challenge, in courtrooms, academia, and public discourse.

One significant concern is imperfect diagnostic specificity. That is, some patients who are diagnosed as "brain dead" do not, in fact, meet the neurologic criteria enshrined in the UDDA and in similar "whole brain" laws in most nations around the world. For example, in this *Journal*, Dalle Ave and Bernat have reviewed multiple cases of inconsistencies between the standardly accepted tests[2,3] – which do not assess all brain functions – and the physiological criterion of irreversible cessation of all functions of the entire brain, which is alleged to be identified by these tests.[4; cf. 5] Dalle Ave and Bernat[4] document cases of patients diagnosed as brain dead who have preserved neurohormonal function, preserved oculocardiac reflex (a brainstem reflex), transient return of spontaneous breathing, persistence of electroencephalographic and evoked potential activity, and preserved intracranial blood flow. Furthermore, also in this *Journal*, Nair-Collins and colleagues reviewed studies encompassing over 1800 patients diagnosed as brain-dead, and found that approximately half demonstrated evidence of preserved brain function in the form of hypothalamic osmoregulation, manifested by the absence of central diabetes insipidus.[6]

The fact that false positives in the diagnosis of brain death are not merely a few isolated cases but are apparently widespread is concerning for several reasons. First, without taking a

stance here on the validity of neurological criteria for human death, presumably all can agree that for a determination as important as death, it is necessary to be assured, to the extent possible, that there are no false positives; that is, there should be as close to perfect specificity as possible. In the determination of death by neurological criteria, reasonable specificity is lacking; indeed if some brain function continues in roughly half of patients diagnosed as "brain-dead", then the positive predictive value of this diagnosis is 50%, which is quite poor. In contrast, near-certainty can be achieved with respect to the determination of death according to the irreversible cessation of circulatory and respiratory functioning, in the usual setting (that is, leaving aside debates surrounding autoresuscitation and organ procurement after death determined by circulatory criteria).

Second, leaders in the medical profession are obligated to disclose to clinicians and the general public such relevant facts regarding the validity and reliability of determination of death according to neurological criteria, and also to families or surrogates, so that they may make informed healthcare decisions; however, this information is not generally shared. Importantly, it appears that an increasing number of families are rejecting or questioning the diagnosis of brain death on behalf of their loved ones, and either requesting "reasonable accommodation" or turning to the legal system for adjudication.[7] In this context, disclosing relevant, accurate medical information is especially critical.

Third, since most vital organ donors are declared to be dead by neurological criteria, if some of those donors are in fact misdiagnosed then they are not dead at the time of organ procurement, thus rendering the procurement surgery lethal. This would seem to violate homicide laws, and it contravenes the so-called "dead donor rule", an ethical principle prohibiting causing death by organ procurement, and mandating vital organ procurement only

from those validly diagnosed as dead. While the dead donor rule is itself a source of debate,[8] it nonetheless stands as the currently accepted ethical and legal foundation for organ donation.[9] Thus, clearly the accuracy of neurological determination of death in light of the legal standards is an issue of significant concern.

These considerations have prompted several recent articles in prominent American medical and medicolegal journals, either calling for revisions to the UDDA, or, reaffirming the UDDA while arguing that current, standard practice is in fact consistent with the UDDA. Unfortunately, the claims made in these articles defy basic anatomical and physiological science, and even basic logic.

Lewis and colleagues, recommending revision of the UDDA, addressed the diagnostic problem of hypothalamic function after brain death has been diagnosed.[10] They wrote, "The second problem with the UDDA is the uncertainty about whether 'all functions of the entire brain, including the brainstem' includes hormonal functions [originating in the hypothalamus]".[10, p.1] Discussing recent lawsuits challenging the diagnosis of brain death partly on the grounds that hypothalamic function can continue, Lewis et al. (surprisingly) suggest that "this raised the question of whether the pituitary and hypothalamus are part of the 'entire brain'".[10, p.1]

Neurology recently published updated guidelines from the American Academy of Neurology (AAN) which explicitly endorse the UDDA while alleging that hypothalamic function is consistent with the diagnosis of whole brain death.[11] They wrote, "The AAN endorses the perspective of the UDDA that brain death has occurred when the irreversible loss of all functions of the entire brain including the brainstem has occurred. However, the AAN endorses the belief that preserved neuroendocrine function may be present … and is not

inconsistent with the whole brain standard of death".[11, p. 3] Further, "The AAN is unaware of any cases in which compliant application of the Brain Death Guidelines led to inaccurate determination of death with return of any brain function, including consciousness, brainstem reflexes, or ventilatory effort".[11, p. 2]

It is astonishing that these articles, authored by medical and legal experts, patently fly in the face of science and logic. It is an indisputable scientific fact that the hypothalamus is part of the brain, and that one of its vital functions is to regulate plasma osmolality. Moreover, if some functions of the brain are preserved in some individuals who satisfy the diagnostic tests for brain death, it is impossible for those individuals to fulfill the neurological standard of "irreversible cessation of all functions of the entire brain". This is a simple matter of logic: a determination of death that requires the absence of *all* functions of the entire brain precludes the presence of *some* function of any part of the brain. The assertion that the preservation of some brain function (e.g., hypothalamic osmoregulation) is consistent with no brain function (i.e., with the UDDA), is a patent logical contradiction and therefore it cannot possibly be a true statement.

Furthermore, for the AAN to allege that they are not aware of any cases in which compliant application of accepted brain death tests led to return (or preservation) of *any brain function*, is truly remarkable, and difficult to understand. Obviously, the preservation of hypothalamic function constitutes the preservation of a brain function. Apart from hypothalamic function, there are several well-documented cases of precisely what the AAN alleges not to exist: compliant application of the standard guidelines, followed by a return (transient or not), of spontaneous breathing, or brainstem reflexes.[4, cf. 5, cf.12] Indeed, Shewmon reported just such a case of return of spontaneous ventilatory effort, and even included a checklist demonstrating that the diagnosis was made in compliance with the accepted guidelines.[13] Making false, and even

logically impossible claims, does nothing to assist the AAN's members, nor the patients they serve; and indeed it deleteriously contributes to misinformation about brain death among clinicians and others.

One reason that Lewis and colleagues offer to justify questioning whether the preservation of hypothalamic functioning is inconsistent with the neurological determination of death appears in a longer article devoted to revising the UDDA, wherein they wrote, "However, the authors of the UDDA do not appear to have intended the phrase 'all functions of the entire brain' to encompass functions of the pituitary gland and hypothalamus; in their 188-page report, they mentioned 'coma' 120 times, 'brainstem' 22 times, and 'apnea' nine times. But not once did the Commission mention any terms to describe pituitary/hypothalamic/hormonal function".[7, p. 17] This is irrelevant. As a matter of science and logic, the preservation of hypothalamic functioning cannot be compatible with "the irreversible cessation of all functions of the entire brain." Besides, one could just as easily, and far more convincingly, argue that the authors of the UDDA surely did intend the phrase "all functions of the entire brain" to encompass all functions of the entire brain, since that is precisely what they in fact wrote in the UDDA.

Lewis and colleagues recommended the following language to revise the UDDA: "irreversible cessation of functions of the entire brain, including the brainstem, leading to unresponsive coma with loss of capacity for consciousness, brainstem areflexia and the inability to breathe spontaneously.'".[10, p.1] Specifying the medical consequences associated with severe brain injury that leads to a diagnosis of brain death does not obviate the inconsistency between the condition described in the UDDA, encompassing all functions of the entire brain, and preserved hypothalamic functioning. Furthermore, the three additional criteria added after the reaffirmation of the language of the UDDA are nothing but the cardinal features of the long-

accepted tests for brain death.[2,3] But those tests are precisely what is at issue, because they yield false positives, as described above. Therefore, patients who satisfy the second half of their proposed revision (with coma, brainstem areflexia, and apnea) would not necessarily satisfy the first half of their proposed revision (with irreversible cessation of all functions of the entire brain). That is precisely the problem of poor diagnostic specificity: a patient could satisfy those three features, yet have preserved hypothalamic (or other neurological) function.

Lewis and colleagues offer a second possible revision: "However, a more limited and less elegant revision to the UDDA to bring it in line with medical standards would add the phrase '. . . with the exception of hormonal function.'".[10, p.1] To add "with the exception of hormonal function" removes the inconsistency – but only for neurohormonal function. Recall that there are other cases involving preserved or transiently returned brain function, or signs indicating that neural tissue is still viable and hence, function may not be irretrievably lost. These include transient return of spontaneous breathing, preserved oculocardiac reflex, brain blood flow, and electroencephalographic and evoked potential activity.[4] Therefore, the second proposed revision would not remove the inconsistency between tests and physiological criterion. Furthermore, and more importantly, adding an exception for hypothalamic functioning, involving a homeostatic process of osmoregulation that promotes survival, is physiologically arbitrary.

A natural response to the fact of preserved hypothalamic functioning in some individuals who satisfy the current tests for diagnosing brain death would be to include assessment of such functioning as a standard component of the neurological determination of death, and to require the absence of hypothalamic functioning (e.g., central diabetes insipidus must be present to make the diagnosis). But this has not been the stance of the medical profession.

Modern determination of death practices are certainly worthy of continued dialogue and refinement in practice. But that dialogue must adhere to reasonable standards of logic and scientific accuracy. In view of the statements by medical and legal experts regarding the determination of death that we have critically examined, it is necessary to affirm what is obviously true: the hypothalamus is a part of the brain; and the preservation of some brain function is not consistent with the absence of all brain function.

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