Reports of "Recovery" from Death by Neurologic Criteria

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1 Some cases of "recovery" from death by neurologic criteria

Death is irreversible, so there can be no recovery from death. The title of this chapter thus needs further explication. By "reports of recovery," we mean cases in which further observation and subsequent testing following a determination of death by neurologic criteria demonstrate that the determination that there was irreversible loss of function of the brain was in fact a false-positive (positive in the sense of being consistent with death by neurologic criteria). Several pediatric and adult case reports describing this type of "recovery" have been reported [1].

One unique example is the recent case of Jahi McMath; in her case, both her family and Dr. Alan Shewmon claimed she recovered to a minimally conscious state (MCS) after determination of death by neurologic criteria [2]. To our knowledge, this is the only case of purported recovery of consciousness after appropriate formal determination of death by neurologic criteria.

In this chapter, we offer brief summaries followed by a commentary of 4 cases of "recovery" from death by neurologic criteria, including the McMath case; these are selected examples and do not represent the findings of an exhaustive systematic review of all published reports. Our purpose in summarizing these cases is not to reproduce published details, but rather to provide our own commentary on these cases. It is outside our scope to discuss the accuracy of different clinical and ancillary tests used in these, or any, determinations of death by neurologic criteria.

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However, it must be recognized that considerations related to the accuracy of different tests should take into account the fact that determination of death by neurologic criteria is generally followed by withdrawal of artificial support inevitably leading to circulatory-respiratory arrest. After discussing these cases, we conclude by reviewing the implications of false-positive determinations of death by neurologic criteria.

1.1 Roberts et al. 2010

Roberts et al. presented two patients who regained spontaneous respiration following determination of death by neurologic criteria [3]. In both cases, the patients did not have absence of brain circulation.

The first patient, a 26-year-old man, was found to be comatose in the setting of a temporal lobe abscess with surrounding vasogenic edema and 1.3 cm midline shift. He was given antibiotics, mannitol and dexamethasone. Seven hours after he became comatose, he was determined to be dead by neurologic criteria based on a clinical evaluation, including apnea testing (in which $PaCO_2$ increased from 42 mm Hg to 69 mm Hg over 10 min). Clinical management became focused on organ preservation for the purposes of transplantation. To further delineate the anatomy of the temporal lobe abscess and to exclude involvement of extracranial vascular structures (which could present a contraindication to donation), brain magnetic resonance imaging (MRI) was performed 2 h after he was declared dead by neurologic criteria. The MRI revealed a flow void in the middle cerebral artery (MCA) and MCA enhancement in the axial T1-weighted post-gadolinium images, indicating the presence of flow. Twenty-eight hours after the declaration of death by neurologic criteria, he began triggering the ventilator and was found to have a spontaneous respiratory rate of 10 breaths/min. The rest of the neurologic examination remained unchanged with absence of brainstem reflexes. Spontaneous respirations persisted for 5 days before determination of death by circulatory-respiratory criteria.

In the second case, a 50-year-old woman suffered a severe traumatic brain injury with a basal skull fracture, subdural hematoma, subarachnoid hemorrhage, generalized cerebral edema, and effacement of the basal cisterns, followed by circulatory-respiratory arrest with return of spontaneous circulation after 5 min. Six hours after admission, she was determined to be dead by neurologic criteria based on her clinical evaluation, including apnea testing (in which $PaCO_2$ increased from 56 mm Hg to 80 mm Hg over 8 min). Nevertheless, a cerebral radionuclide scan was performed because of the authors' experience in the prior case which showed evidence of brain circulation. During subsequent donor management, 11 h after coma onset, she began triggering the ventilator and was found to have spontaneous respirations, though no other brainstem reflexes. Her family decided to proceed with withdrawal of artificial support and she was declared dead by circulatory-respiratory criteria.

The authors concluded that for both patients, several unrecognized confounding factors could have contributed to false-positive determinations. In the first case, ongoing treatment with glucocorticoids and antibiotics may have promoted some

resolution of cerebral edema or limited further abscess expansion resulting in restoration of brain circulation. It is also possible that cold caloric testing was not reliable due to otitis media and mastoiditis. In the second case, one could question the short observation period between return of spontaneous circulation after cardiac arrest and the determination of death by neurologic criteria. These cases may suggest that more routine use of studies to evaluate brain circulation should be recommended.

1.2 Webb et al. 2011

Webb et al. described a 55-year-old man with a 20-min period of circulatory-respiratory arrest [4]. He was initially hypothermic (35.2 °C) on arrival to the intensive care unit, but then rapidly became febrile. Therapeutic hypothermia was initiated, and he eventually reached a nadir of 33 °C at 48 h, then rewarming began at 50 h, and his temperature was 36.5 °C at 56 h after presentation. He was treated with propofol and fentanyl from 14 h to 50 h. 72 after return of spontaneous circulation, he had absent brainstem reflexes, then 6 h later, he was determined to be dead by neurologic criteria based on apnea testing and a repeat clinical evaluation. His family consented to organ donation. Twenty-four hours after declaration of death by neurologic criteria (98 h after admission), and on arrival to the operating room for organ procurement, the patient regained corneal reflexes and the cough reflex, and began having spontaneous respirations. 145 hours after admission, his clinical evaluation was again consistent with death by neurologic criteria. A nuclear study showed absence of brain circulation 200 h after admission, after which treatment was withdrawn and death was declared by circulatory-respiratory criteria.

In discussing this case, the authors considered three etiologies that could account for the false-positive determination: (1) fluctuating functional loss of lower brainstem function, which the authors named "brainstem ischemic shock"; (2) the application of therapeutic hypothermia as a confounder; and (3) the administration of glucocorticoids. The case generated controversy. Critics raised concern with the authors' conclusions highlighting the potential confounding effects of hypothermia in conjunction with administration of high dose infusions of fentanyl and propofol [5].

1.3 Latorre et al. 2020

Latorre et al. presented a 59-year-old man with a right basal ganglia and temporal lobe intracerebral hemorrhage causing 1.1 cm midline shift, who lost all brainstem reflexes over 48 h. Apnea testing was not performed due to hemodynamic instability [6]. Instead, a brain SPECT scan was obtained to complete the evaluation for death by neurologic criteria. The results showed absence of Tc-99 m Bicisate uptake in both supra- and infratentorial compartments that was interpreted as consistent with death by neurologic criteria. The family subsequently consented to organ donation. However, the following day, he was noted to have a cough reflex, intermittent

spontaneous respirations, and extensor posturing of the right arm and leg to noxious stimulation. Shortly thereafter, he had a generalized seizure and a circulatory-respiratory arrest and was declared dead by circulatory-respiratory criteria.

The authors noted that this was the first report of a false-positive determination of death by neurologic criteria using a brain SPECT scan with diffusible radiopharmaceutical tracers. The authors concluded that death by neurologic criteria should remain a clinical determination, and that an apnea test should be performed unless contraindicated due to severe shock or hypoxemia. They also suggested that if the clinical evaluation cannot be completed, a longer observation period may be necessary prior to ancillary testing unless demonstration of negative or zero cerebral perfusion pressure can be shown for an extended period of time.

1.4 Jahi McMath

The case of Jahi McMath has generated large interest and controversy in the medical literature as well in public media. A PubMed search for "Jahi McMath" in February 2022 yielded over 30 publications; a similar search in Google Scholar found 576 results. This case is particularly contentious and interesting because the patient's family and Dr. Alan Shewmon (the only neurologist permitted by the family to examine Jahi in the post-acute phase) claim that after determination of death by neurologic criteria, Jahi subsequently emerged into an MCS [2].

Jahi McMath was a 13-year-old girl who was declared dead by neurologic criteria on December 12, 2013, after a hemorrhagic complication of oropharyngeal surgery. Despite the issuance of a death certificate in California, Jahi's family objected to the declaration of death, and eventually transferred her to New Jersey where the law allows rejection of death by neurologic criteria on religious grounds.[1] Four and a half years later, she was issued a second death certificate after being declared dead by circulatory-respiratory criteria.

Determination of death by neurologic criteria was made and confirmed by capable examiners including a court-appointed independent child neurologist. She underwent several apnea tests, four electroencephalograms that were isoelectric, and a radionuclide SPECT scan with Tc 99 m bicisate, which showed no brain circulation on the dynamic sequence and no supratentorial or infratentorial parenchymal uptake. Interestingly, her brain MRI 9.5 months after declaration of death by neurologic criteria showed gross integrity of the cortex, basal ganglia, thalamus, and upper brainstem. Extensive demyelinating and cystic changes were noted in the subcortical white matter and lower brainstem.

Shewmon and Salamon, plausibly in our view, argue that despite this devastating degree of brain injury, persistence of gross structural integrity speaks against sustained absence of brain circulation, and suggests the potential for persistence of flow at levels not detectable by SPECT (at least at the time it was performed) [7].

[1] New Jersey is the only state with an exemption clause to determination of death by neurologic criteria.

2 Implications

There are two ways to conceptualize and draw implications from the above cases. The first approach is to consider them to be false-positive determinations of death by neurologic criteria made because of the failure to ensure that prerequisites are met or mimics are excluded before conducting an evaluation, or by inaccurate examination technique [5, 8]. The second approach is to take these reports at face value by accepting that the prerequisites were properly met, no known confounders were present, and that testing and determination were competently performed.

By the first approach, there is not much more to learn beyond unequivocally endorsing the recommendation that determinations of death by neurologic criteria should strictly adhere to published standards and clinicians performing these determinations must have adequate training and experience with determination of death by neurologic criteria.

However, we think that the second approach could generate fruitful discussion, even if one rejected the validity of the aforementioned case reports. In what follows, we provide support for the following two propositions: (1) Absence of brain circulation should be required to determine death by neurologic criteria, and, ideally, this finding should be demonstrated before apnea testing; (2) Death by neurologic criteria is a state, along the spectrum of devastating brain injury, sufficient for a person to be assigned the legal status of death.

2.1 Absence of Brain Circulation

The current neurologic standard in the Uniform Determination of Death Act (UDDA) explicitly calls for "irreversible" cessation of functions of the "entire brain" [9]. It follows that the only pathophysiologic avenue to meet the required burden of proof is via the complete and sustained cessation of brain circulation [10]. This understanding is supported in the recently published World Brain Death Project (WBDP) where it was suggested to ensure neuroimaging evidence of intracranial hypertension or measurement of intracranial pressure equal to or exceeding mean arterial pressure [11]. Nevertheless, it is important to note that the WBDP reiterates the guidance in most national medical standards that death by neurologic criteria is a clinical determination, and any further radiographic or brain circulation testing is merely ancillary, and is warranted if (1) part of the clinical evaluation or apnea testing cannot be completed; (2) uncertainty exists about the interpretation of findings; (3) to reduce the inter-examination observation period (if more than one evaluation is performed); (4) there is that concern medication effect may be present; (5) it is felt that this would be helpful for family members to accept death by neurologic criteria; or (6) there is isolated brainstem pathology (if the whole-brain formulation is being followed). These multiple reasons seem to us to justify requiring testing to assess for brain circulation, rather than considering it optional and ancillary, as discussed in detail elsewhere in this book.

The following modalities are available to assess brain circulation: four-vessel catheter angiography, radionuclide cerebral perfusion scan, transcranial Doppler, computed tomographic angiography, and magnetic resonance angiography. All these tests have pitfalls [12]. Nevertheless, as the aforementioned case reports show, the clinical evaluation is not immune from pitfalls, and does not have perfect sensitivity and specificity. Furthermore, the biases of self-fulfilling and self-reinforcing prophecies, in our opinion, call for epistemic humility in regard to claims about sensitivity and specificity of any of the available tests, clinical or not. We support the current American Academy of Neurology standards for determination of death by neurologic criteria and the WBDP in considering four-vessel catheter angiography, radionuclide cerebral perfusion scan, and transcranial Doppler (in adults) to be acceptable tests to evaluate brain circulation, and we further argue that at least one of these tests ought to be performed as part of all determinations of death by neurologic criteria. Furthermore, we recommend that a study to evaluate brain circulation be performed prior to apnea testing as, at least theoretically, the induction of hypercapnia could contribute to, rather than confirm, the absence of brain circulation [11 p. 1083; supp.4, p. 14].

2.2 Legal Status

A legal status is a category conferring rights and duties on those who fall within it [13, 14]. Just as legal blindness is recognized to be on a spectrum of visual impairment, death by neurologic criteria should be understood to be a threshold state along the spectrum of devastating brain injury, which sufficiently ascertains the permanent loss of consciousness and makes death behaviors appropriate.[2] There are arguments for and against such a proposal, and this concept is discussed in detail elsewhere in this book. The first supporting argument is that it addresses the false notion that death of the brain is sufficient for the irreversible loss of organismal homeostatic integration. Adhering to this position simply ignores contemporary understanding of homeostatic integration as an emergent property of biologic organisms not dependent on any single organ system [15]. By thinking of the medical determination of death as a legal status, one recognizes that by necessity, there must be some degree of "line drawing" in how we identify the transition from living to dead. Line drawing is relevant to the second supporting argument in changing the discussion from irreversibility to permanence. Irreversibility is an implausibly high, and even impossibly high, requirement to meet within the current state of scientific and medical knowledge. Permanence is, in fact, the standard employed in current clinical practice of determination of death by circulatory-respiratory criteria, and there is no justification for why it should be different for death by neurologic criteria [16]. This move is relevant in the case of Jahi McMath; if she indeed transitioned

[2] Death behaviors are behaviors and activities that are appropriate after the declaration of death such as discontinuation of artificial support, initiation of organ donation, burial or cremation, grieving, change of a survivor's marital status, and transfer of property.

from death by neurologic criteria to an MCS, then the current edifice of death by neurologic criteria based on irreversibility is mistaken and would require temporary cessation and full review from its foundation. Death by neurologic criteria as a legal status which requires permanent, not irreversible, loss of the capacity of consciousness is less vulnerable when considering the case of Jahi McMath. It also denotes that since it is a legal stipulation and a medical and social convention, it should be open to revision and update in concordance with increased knowledge or technological enhancements [17].

There are counterarguments to a legal status approach. Although it is a more palatable term than "legal fiction," it still implies that the patient is not really dead but can be treated as such under the law. This argument leads to the issue of transparency or acknowledged vs. unacknowledged fictions [18]. Legal blindness is a transparent legal status, while treating a corporation as a person is an acknowledged one. For death by neurologic criteria to be considered a legitimate legal status, must it be acknowledged as such and publicly deliberated? There are two responses to this question. The first is to grant that indeed transparency is essential and engage in public deliberation. Such deliberation could take the form of allowing personal choice or setting a default and permitting opt-out in the determination of death, as discussed elsewhere in this book. The second response is to reject the requirement for explicit acknowledgement. Despite occasional challenges, death by neurologic criteria has withstood the test of time and is widely considered to be sensible and socially beneficent [19, 20].

Without intending too wide of a digression, this last point can be put in more technical terms, and made stronger, as it pertains to public reason and justification. The recognition of citizens as free and equal moral persons requires that laws applying to them should be justified with reasons that they could recognize as valid [21]. This explains why it would be problematic for death by neurologic criteria to be a non-transparent legal status. Non-transparent reasons, policies and laws may not allow citizens to evaluate them and recognize them as valid by their own lights. However, there are different conceptions on the nature of justification that is in play, and one of them that may be relevant in our discussion about death by neurologic criteria is *evolutionary* justification [22]. According to evolutionists, a law or a policy is justified for members of the public when that law or policy is a stable and evolved equilibrium for the public (even if it is a legal fiction or status). This line of thought may conclude with the (controversial) claim that indeed death by neurologic criteria, by having withstood the test of time, is a stable and evolved equilibrium for societies that have accepted death by neurologic criteria for several decades. It follows that death by neurologic criteria as legal status may not require further justification.

3 Conclusion

There are several published reports of alleged "recovery" from death by neurologic criteria. Recovery from death is not possible, and so the more precise interpretation of these cases is that they are false-positive determinations. A common response to

such cases is to explain them away by identifying possible confounders or technical problems with the process of determination. Here, without necessarily committing to the validity of these reports, we discuss the implications of taking them at face value. Two potentially important implications follow. The first is the need to demonstrate absence of brain circulation to make a determination of death by neurologic criteria. Absence of circulation is a necessary pathophysiologic requirement for the cessation of function of any organ, and the brain is no exclusion. Although current knowledge about how long circulation needs to be lost before there is complete, irreversible loss of function of the brain is insufficient, and there are pitfalls of all techniques to evaluate brain circulation, we believe it is necessary to incorporate a study to evaluate brain circulation into all determinations of death by neurologic criteria. The second implication is that the declaration of death by neurologic criteria should be considered a legal status which relies on best available medical technology, with the understanding that the process of death declaration requires both societal acceptance and a focus on beneficence.

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