

A Brain Death Dilemma: Apnea Testing While on High-Frequency Oscillatory Ventilation

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Apnea testing is an essential component of the evaluation to determine death by neurologic criteria (brain death).¹ Advancing life support technologies can, however, blur the distinction between irreversible coma and brain death, thus presenting challenges to the application of current brain death criteria. Herein we report on a child who met all components for the determination of brain death except for a positive apnea test. This element of the evaluation could not be performed because the child's oxygenation was achieved via high-frequency oscillatory ventilation (HFOV) and discontinuing such support would presumably lead to lung collapse, hypoxia, and sudden changes in pulmonary vascular resistance leading to cardiac compromise. This case highlights a dilemma that clinicians may face when following the guidelines to determine if a patient, on the basis of neurologic criteria, has died.

A 4-year-old girl was brought to our hospital after being found unconscious. On arrival, the girl's Glasgow Coma Scale score was 3, and mechanical ventilation was instituted. The clinical presentation and the computed tomographic scan of the head pointed to trauma as the cause for the child's obtundation. Because the child's condition continued to deteriorate, especially the ability to maintain adequate oxygenation, HFOV was initiated. Based on the clinical suspicion that the child's condition was compatible with the diagnosis of brain death, we were asked to assess her. The clinical examination revealed cessation of all functions of the entire brain, including the brainstem. An apnea test, however, could not be completed because discontinuing HFOV would likely cause lung collapse and hypoxia. Ultimately, the brain death evaluation was forgone because the family elected to allow for the child's natural death. We, however, were left with an enhanced awareness of the difficulties that can arise when adhering faithfully to current guidelines for brain death determination in pediatric patients whose tissue oxygenation is maintained through means other than conventional mechanical ventilation. As such, we sought to find potential solutions to this conundrum, recognizing that those could include modification to, or even abandoning, the apnea test.

Guidelines for the determination of brain death list the parameters for apnea testing.¹ A prerequisite is that the test be performed "safely." Such a requirement is important for at least 2 reasons: (1) in case the patient exhibits evidence of respiratory effort and mechanical ventilation needs

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to be reinstated and (2) if organ donation is considered, the need for the patient to remain stable until the second brain death examination is performed. Completing apnea testing in our patient posed significant challenges because discontinuing HFOV would likely lead to hypoxia, an indication to halt the test. In light of the challenges presented by apnea testing, we considered using ancillary tests to corroborate the neurologic examination's findings. According to existing pediatric guidelines, ancillary tests that aid in the diagnosis of brain death include the following: conventional cerebral angiography, cerebral perfusion scintigraphy, and EEG.¹ In the case of our patient, the use of standard ancillary tests was impractical. The HFOV equipment is not portable, rendering studies in the radiology department impossible. And performing an EEG to document electrocerebral silence would have been compromised by both motion and electrical artifacts. Additional ancillary tests approved for adults, including computed tomographic angiography and Doppler ultrasound, also would not have been viable options because of their nonstandard use in children, need for transportation of the patient, and movement artifact caused by the oscillating ventilation.

Alternatives to the traditional method of apnea testing have been published. Brain death was diagnosed in a patient receiving HFOV when the results of the neurologic examination were paired with those of somatosensory evoked potentials, even while alpha-like artifact was seen on the EEG.² In a different situation, an alternative method was used to complete the apnea test in 3 patients receiving extracorporeal membrane oxygenation.³ In these cases, hypercarbia was induced by altering the oxygen and carbon dioxide content in the extracorporeal membrane oxygenation circuit after which the patients were monitored for respiratory effort. Several authors

have shown that the duration of apnea testing can be significantly shortened by artificially augmenting the carbon dioxide content in the inspired air before assessing the patient for spontaneous respirations. This schema has been shown to be safe, from a cardiovascular standpoint, in patients receiving traditional ventilation.⁴ Despite these published alternatives, if one faithfully adheres to current guidelines, death by neurologic criteria cannot be diagnosed in patients who cannot tolerate conventional apnea testing or the approved alternative ancillary tests.

Arguments have been made to abandon cessation of brainstem function, and by extension the apnea test, as a requisite in the determination of death.⁵ Instead, Whetstone⁵ favors equating brain death to the irreversible loss of consciousness, a criterion that our patient undoubtedly met. The apnea test has specifically been criticized for its nonspecificity, variability in its application, and lack of solid philosophical rationale.⁶ In fact, some clinicians have abandoned the current apnea test guidelines. The authors of a recent retrospective chart review reported that in Canadian PICUs 18% of patients who were declared "brain dead" did not undergo an apnea test.⁷ Furthermore, 33% of patients who eventually became organ donors only underwent 1 apnea test.

In the case of our patient, all evidence pointed to her having met neurologic criteria for death, but under current guidelines we could not document that such was the case. Had the family requested the girl be an organ donor we would have been forced to discontinue HFOV and wait for cardiac death, which can be very prolonged, thereby compromising the organs and the family's last wishes for their child. This case highlights an inadequacy of current brain death guidelines. What is truly needed is

a validated standard measure that can be used in all cases and/or an exemption clause for selected cases in which apnea testing is not feasible.

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