

**GUIDELINES FOR
DETERMINING DEATH BASED
ON
NEUROLOGICAL CRITERIA**

New Jersey

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These guidelines have been drafted by the New Jersey Ad Hoc Committee on Declaration of Death by Neurologic Criteria, under the leadership of Dr. John Halperin, M.D. and William Reitsma, RN. We are grateful for the hard work and knowledgeable input of each of the following medical, legal and health care professionals.

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BACKGROUND

This document provides guidance for determining death by neurological criteria (commonly referred to as “brain death”), aims to increase knowledge amongst health care practitioners about the clinical evaluation of death determined by neurological criteria and reduce the potential for variation in brain death determination policies and practices amongst facilities and practitioners within the State of New Jersey. The aim of these guidelines is both to help educate health care providers regarding such determinations, and to increase the public’s confidence that such determinations are made after a thorough and careful evaluation performed in accordance with accepted medical standards.

This document represents a broad consensus on the criteria for determining death by neurological criteria, as of June 2014, and has been created in light of the legislatively mandated removal of the specific details of brain death determination from New Jersey regulations. It incorporates the guidelines of the American Academy of Neurology (AAN), initially released in 1995 and revised in 2010.

Revisions to the regulatory Determination of Death by Neurological Criteria Guidelines

New Jersey regulations no longer specify the performance of particular clinical tests or protocols to determine death by neurological criteria. Rather, the law requires that the physician making the determination exercise best medical judgment, “in accordance with currently accepted medical standards that are based upon nationally recognized sources of practice guidelines, including, but not limited to, those adopted by the American Academy of Neurology.” NJS § **26:6A-4**. These guidelines are intended to follow this standard. As such these guidelines make two significant modifications to prior, now legislatively-rescinded regulatory requirements, resolve a number of potential ambiguities in those requirements, and update certain clinical parameters.

As to the first significant modification, prior regulations required a clinical assessment followed by either a second clinical assessment or a confirmatory test. The current AAN guideline, however, supports performing one comprehensive clinical assessment including an apnea test. Evidence has since revealed that there are several disadvantages with no concomitant benefits in requiring a second brain stem assessment. Extensive review of medical journals and studies conducted to date supports the use, after an appropriate waiting period, of a single proper assessment of brain and brainstem function including an apnea test, the results of which are diagnostic of death determined by neurological criteria. *See, e.g. Reference 12.*

In addition, conducting a second brain stem assessment within a reasonable timeframe is sometimes not possible, particularly in facilities that have only one physician privileged to perform brain death determinations. Current national guidelines now deem the second assessment unnecessary. Delays have been shown to be traumatic to families watching their loved ones in intensive care units and waiting for confirmation of their death. Moreover, while

waiting for a second assessment, patients are susceptible to cardiac arrest and vulnerable to rapid deterioration of other organ systems, which could lead to a needlessly prolonged confirmation of death. Accordingly, the updated guidelines contained in this document allow for a single, rigorous clinical examination, including an apnea test, confirming that brain function has ceased.

Regarding the second modification, this updated document, like prior guidelines, includes a waiting period to exclude the possibility of recovery, but differs in important ways from previous waiting period requirements. The prior regulation required an arbitrary waiting period of six hours and delineated the waiting period between the first and second examinations of brain stem reflexes.

There is insufficient evidence to pinpoint a minimally-acceptable number of hours to ensure that brain function has permanently ceased. To exclude the possibility of recovery, this document recommends that physicians wait an appropriate period of time after the onset of brain insult, sufficiently long as is relevant to the individual patient's condition (in practice, usually several hours), prior to proceeding to the brainstem reflex exam.

Addressing the appropriate waiting period early in the process – before the clinical assessment of brain death is initiated – provides greater assurance that there is no potential for improvement and this approach is consistent with current clinical practice. Only after it is clear that the patient will not recover should the examination for the determination of brain death, including brainstem reflex tests and apnea test, be conducted. In all cases, this document advocates a high degree of caution and vigilance to ensure that there is no possibility for recovery of a patient whose death is declared by neurological criteria.

Please note that the guidelines for the determination of death in children contained in this document do not substantively alter the State's prior iteration.

DEFINITION

New Jersey law states: *Subject to the standards and procedures established in accordance with this act, an individual whose circulatory and respiratory functions can be maintained solely by artificial means, and who has sustained irreversible cessation of all functions of the entire brain, including the brain stem, shall be declared dead. See N.J. Stat. § 26:6A-3 (2005).* The three essential findings in death declared by neurological criteria are irreversible coma, absence of brain stem reflexes, and apnea. An evaluation for brain death should be considered in patients who have suffered a massive, irreversible brain injury of identifiable cause. A patient properly determined to be dead by neurological criteria is legally and clinically dead.

The diagnosis of death determined by neurological criteria is primarily clinical. No other tests are required if the full clinical examination, including an assessment of brain stem reflexes and an apnea test, is performed and supports the diagnosis conclusively. In the absence of either complete clinical findings or ancillary tests indicative of death, death based upon neurological criteria cannot be diagnosed.

Hospital Responsibilities Regarding Brain Death Determination

To assure consistent practice, New Jersey hospitals are required to implement written policies for determining death by neurological criteria, including:

- The tests and procedures required for determining death; and
- Consideration of the individual's personal religious beliefs if a declaration of death determined by neurological criteria would violate those beliefs
- Written policies for the privileging of physicians who may make death by neurological criteria determinations in accordance with accepted medical standards

In addition best practices require that reasonable efforts be made to notify next of kin or health care agents or surrogate decision makers that brain death determination is in progress.

These policies are described in detail below.

Death Determination Policies

Hospitals should establish written policies specifying the process for determining death by neurological criteria, including a description of examinations and tests to be employed. The following pages provide additional information on the clinical steps that should be conducted and on various ancillary tests available to guide clinicians and facilities. These guidelines may be used by hospitals in developing their own written policies while tailoring ancillary testing to the specific resources available in their facility.

Notification

Hospital policies should assure that reasonable efforts are made to notify the patient's family, personal representative or health care agent that the process of evaluating death by neurological criteria has begun. Staff notifying such persons should be prepared to respond to basic questions concerning the patient's condition and the procedures for determining death.

Consideration of Religious Beliefs

Hospitals should establish written procedures for the acknowledgement of the patient's religious beliefs, if the examining physician has reason to believe, on the basis of information in the patient's available medical records, or information provided by a member of the patient's family or any other person knowledgeable about the patient's personal religious beliefs, that such a declaration of death by neurological criteria would violate the personal religious beliefs of the patient. In these cases, death shall be declared, and the time of death fixed, solely upon the basis

of cardio-respiratory criteria. Policies may also provide guidance on the use of other resources, such as clergy members, ethics committees, palliative care clinicians, bereavement counselors, and conflict mediators to address objections or concerns. Psychological denial that death has occurred or an alleged inadequacy of the death determination are not derived from the individual's religious beliefs, and therefore declaration of death by neurological criteria is not precluded in those instances and appropriate clinical examination may proceed. However, hospital staff should demonstrate sensitivity to these concerns and consider using similar resources to help family members accept the determination and fact that death has occurred.

Privileging

The application of the clinical criteria described in this policy requires the sound judgment of a plenary- licensed physician competent in determining brain death. The privileging of physicians is essential to ensuring the proper performance of brain death examinations. Each hospital should establish a process for identifying and privileging physicians to make brain death determinations and a mechanism by which all nursing and medical staff can verify physician privileges.

Adult and pediatric neurologists, neurosurgeons, critical care specialists and trauma surgeons who have received relevant training are deemed to be duly qualified physicians for declaring brain death in patients over 12 months of age. For those patients below two months of age, the examining physician shall be a specialist in neonatology, pediatric neurology or pediatric neurosurgery, and for those between two months and 12 months, the examining physician shall be a specialist in pediatric critical care, pediatric neurology or pediatric neurosurgery. Endnote 1

Hospital policies should specify rigorous standards for training in determination of brain death and should include procedures for periodic review of clinicians' credentials under the applicable standards to ensure that such physicians possess current clinical competence and knowledge consistent with current scientific understanding and generally-accepted clinical practice in this area.

A patient's attending physician should participate in the determination of death by neurological criteria whenever possible. If the attending physician is not privileged by the hospital in the determination of death by neurological criteria, another physician having such privileges must perform the assessment and make the final pronouncement.

Responsibilities of Physicians Determining Brain Death

The diagnosis of brain death is primarily clinical, and, absent confounding factors consists of three essential findings: irreversible and unresponsive coma, absence of brainstem reflexes, and apnea. No other tests are required if the full clinical examination, including an assessment of brain stem reflexes and an apnea test, are conclusively consistent with death. In the absence of either complete clinical findings consistent with death, or ancillary tests demonstrating death, death by neurological criteria cannot be diagnosed and certified.

These guidelines apply to patients one year of age or older. *Please see Appendix 1 for the determination of death by neurological criteria in children less than 1 year old.*

The steps for determining brain death are summarized below, and explained in more detail in the following pages. There is no need for consent to be obtained for the clinical assessment. The exam should commence following notification of surrogate decision makers in accordance with hospital policies:

1. Establish proximate cause and irreversibility of coma and monitor the patient for an appropriate waiting period in order to exclude the possibility of recovery;
2. Conduct and document the clinical assessment of coma and brain stem reflexes;
3. Perform and document the apnea test;
4. Perform ancillary testing, if indicated;
5. Pronounce brain death; and
6. Discontinue cardio-respiratory support in accordance with hospital policies, including policies relevant to organ donation. Cardio-respiratory support may not be removed from potential organ donors until their donation status is known, and acted upon if applicable.

Step 1: Establish Proximate Cause and Irreversibility of Coma

A prerequisite to the determination of death by neurological criteria is the identification of the proximate cause and irreversibility of coma. Severe head injury, intracerebral hemorrhage, aneurysmal subarachnoid hemorrhage, hypoxic-ischemic brain insults and fulminant hepatic failure are examples of potential causes of irreversible loss of brain function. The physician should assess the extent and potential reversibility of any damage, and also exclude confounding factors such as drug intoxication, neuromuscular blockade, hypothermia, or metabolic abnormalities that cause coma but are potentially reversible.

Establishing the cause and irreversibility of coma requires the physician to wait an appropriate period of time sufficiently long as is relevant for the individual patient (in practice, usually several hours) in order to rule out any confounding factors and the possibility of recovery. The evaluation of a potentially irreversible coma should also include, as may be appropriate to the particular case:

- Clinical or neuro-imaging evidence of an acute CNS catastrophe that is compatible with the clinical diagnosis;
- Exclusion of complicating medical conditions that may confound clinical assessment (*e.g.*, no severe uncorrected electrolyte, acid-base, or endocrine disturbance);

- Exclusion of significant hypothermia or hypotension;

Therapeutic hypothermia may modify outcome prediction after cardiac arrest and there are published case reports suggesting that determination of brain death might be confounded either by hypothermia itself or by impaired clearance of associated medications. It is therefore recommended that when induced hypothermia has been used after resuscitation from cardiorespiratory arrest, clinical testing for brain death be delayed for at least 24 hours after rewarming. Brain death, however, may be determined prior to 24 hours by demonstration of absent cerebral blood flow.
- Normal core temperature should be:
 - (age \geq 18 years) $> 36^{\circ}\text{C}$ (96.8°F)
 - (age \geq 1 year $<$ 18 years) Consider age specific norms
 - (age $<$ 1 year) See Appendix 1
- Normal systolic blood pressure should be:
 - (age \geq 18 years) ≥ 100 mm Hg (Option: mean arterial pressure ≥ 65 mm Hg)
 - (age \geq 1 year $<$ 18 years) Consider age specific norms
 - (age $<$ 1 year) See Appendix 1
- Exclusion of drug intoxication or poisoning. Patients admitted for the treatment of drug overdose should have confirmatory tests performed to ensure that drug levels have decreased to clinically insignificant levels.

If intoxicants such as barbiturates, benzodiazepines, or opioids are present, levels need not be zero, but should be in a range that would not normally be expected to interfere significantly with consciousness. Since it is impossible to stipulate specific levels for every drug, experienced clinical judgment is necessary. If levels are unknown, a reasonable practice is to wait 5 half-lives (assuming normothermia and normal hepatic and renal function), or in the case of alcohol usage, the legal limit for driving (blood alcohol content 0.08%) may serve as a practical threshold below which an examination to determine death could reasonably proceed. A cerebral blood flow study that demonstrates absent intracranial blood flow is consistent with the diagnosis of death even in the presence of CNS depressants.

If neuromuscular junction blocking agents have been used, there should be evidence of neuromuscular transmission, *i.e.*, deep tendon reflexes, other clinical muscle function, or responses to electrical stimulation of motor nerves (e.g. muscle contraction in response to a train of 4 stimuli using maximal ulnar nerve stimulation), before beginning the determination of death.

Step 2: Clinical Assessment of Coma and Brain Stem Reflexes

If an appropriate period of time has passed since the onset of the brain insult to exclude the possibility of recovery, one clinical assessment of brain function and an apnea test should be sufficient to pronounce death by neurological criteria. Only after the possibility of recovery has been excluded should the examination to assess for death by neurological criteria, including brainstem function tests and the apnea test be performed. If the possibility of recovery has not been excluded, these examinations should be deferred.

Note: Repeat examinations are advisable before proceeding to an apnea test in young children. *Please see Appendix 1 for the determination of brain death in children less than 1 year old.*

Where these, and all conditions in Step 1, are fully met, the following clinical findings verify the occurrence of brain death:

- Coma: No evidence of responsiveness. Eye opening or eye movement in response to noxious stimuli is absent. Noxious stimuli should not produce a motor response other than spinally mediated reflexes.
 - Absence of brain stem reflexes:
 - Absence of pupillary response to bright light in both eyes. Usually the pupils are fixed in midsize or dilated position (4-9 mm).
 - Absence of ocular movements using oculocephalic testing (only when no fracture or instability of the cervical spine or skull base is apparent or may be suspected clinically)
 - Absence of ocular movements using oculovestibular reflex testing (after verifying that the external auditory canal is patent and tympanic membranes are intact).
 - Absence of corneal reflexes.
 - Absence of facial muscle movement in response to a noxious stimulus.
- Absence of pharyngeal (gag) and tracheal (cough) reflexes.

Confounding Factors: The following conditions may interfere with the clinical diagnosis of death. In such instances, ancillary tests may be necessary.

- Severe facial or cervical spine trauma or facial deformity confounding cranial nerve assessment.
- Toxic levels of CNS-depressant drugs or effective levels of neuromuscular blocking agents.

- Severe electrolyte, acid-base, or endocrine disturbance (defined by severe acidosis or other laboratory values markedly deviated from the norm).
- Severe chronic pulmonary disease or severe obesity resulting in chronic retention of CO₂.

Clinical observations compatible with the diagnosis of brain death: The following manifestations are occasionally seen and should not be misinterpreted as evidence for brain stem function:

- Spontaneous movements of limbs (when due to spinal activity).
- Deep tendon reflexes; superficial abdominal reflexes; triple flexion response.
- Babinski reflex.
- Respiratory-like movements (shoulder elevation and adduction, back arching, intercostal expansion without significant tidal volumes).
- Sweating, flushing, tachycardia.
- Normal blood pressure without pharmacologic support or sudden increases in blood pressure.
- Absence of diabetes insipidus.

Step 3: Apnea Test

Generally, the apnea test is the final step in the determination of death by neurological criteria, and is performed after establishing the irreversibility and unresponsiveness of coma, and the absence of brainstem reflexes.

Before performing the apnea test, the physician must determine that the patient meets the following conditions:

- Core temperature > 36°C or 96.8°F.
- Normalized PaCO₂ 35-45 mm Hg. and no prior evidence of CO₂ retention (e.g. chronic obstructive pulmonary disease or severe obesity). If PaCO₂ cannot be normalized, an ancillary test should be done to assess for brain death.
- Normal PaO₂. Option: pre-oxygenation for at least 10 minutes with 100% oxygen to PaO₂ > 200 mm Hg.
- Normotension. Adjust fluids and (if necessary) vasopressors to a systolic blood pressure ≥ 100 mm Hg (option: mean arterial pressure ≥ 65 mm Hg).

After determining that the patient meets the prerequisites above, the physician should conduct the apnea test as follows:

- Connect a pulse oximeter.
- Disconnect the ventilator.
 - Apnea can be assessed reliably only by disconnecting the ventilator, as the ventilator can sense small changes in tubing pressure and provide a breath that could suggest breathing effort by the patient where none exists.
- Deliver 100% O₂, 6 L/min by placing a catheter through the endotracheal tube and close to the level of the carina. Option: use a T-piece with 10 cm H₂O CPAP and deliver 100% O₂, 12 L/min.
- Draw a baseline arterial blood gas.
- Look closely for respiratory movements (abdominal or chest excursions including a brief gasp) for 8-10 minutes.
- Measure PaO₂, PaCO₂, and pH after approximately 8-10 minutes and reconnect the ventilator.
- If respiratory movements are absent and PaCO₂ is ≥ 60 mm Hg, the apnea test supports the diagnosis of brain death. Alternately, a 20 mm Hg increase in PaCO₂ over a baseline normal PaCO₂ would also support the diagnosis of death.
- If respiratory movements are observed, the apnea test result is negative (*i.e.*, does not support the diagnosis of brain death).
- Connect the ventilator if, during testing, the systolic blood pressure becomes < 90 mm Hg (or below age-appropriate thresholds in children less than 18 years of age) or the pulse oximeter indicates significant oxygen desaturation ($< 85\%$ for > 30 seconds), or cardiac arrhythmias develop; immediately draw an arterial blood sample and analyze arterial blood gas.
 - If PaCO₂ is ≥ 60 mm Hg or PaCO₂ increase is ≥ 20 mm Hg over baseline normal PaCO₂, the apnea test result supports the diagnosis of brain death;
 - If PaCO₂ is < 60 mm Hg and PaCO₂ increase is < 20 mm Hg over baseline normal PaCO₂, the result does not support the diagnosis of brain death.
 - If adequate blood pressure and oxygenation can be maintained, the apnea test can be repeated for a longer period of time (10-15 minutes) or an ancillary test can be considered if the result is indeterminate.

Step 4: Ancillary Testing as Indicated

When the full clinical examination, including the assessment of brain stem reflexes and the apnea test, is conclusively performed, no additional testing is required to determine brain death. In some patients, however, facial or cervical injuries, cardiovascular instability, or other factors may make it impossible to complete parts of the assessment safely. In such circumstances, an ancillary test verifying brain death is necessary. These tests may also be used to reassure family members and medical staff of the certainty of death determined by neurological criteria. Based on clinical indications, ancillary testing may sometimes precede other aspects of the determination of brain death.

Documentation should indicate which parts of the clinical examination could not be completed safely, along with the reason. Even when ancillary testing is consistent with brain death, as when absent cerebral blood flow is documented, brain death protocols still require assessment of coma, brain stem reflexes, and an apnea test, except in the circumstances where such tests cannot be performed.

Any of the suggested ancillary tests may produce similar results in patients with catastrophic brain damage who do not (yet) fulfill the clinical criteria of brain death. The diagnosis of brain death rests on the clear determination of the cause of coma, the elimination of potentially confounding factors, the results of the clinical examination and the results of any ancillary tests utilized as appropriate to the clinical situation.

The choice of an ancillary test is dictated in large part by practical considerations, *i.e.*, availability, advantages and disadvantages. Currently available ancillary tests are listed below, in alphabetical order, along with the findings consistent with brain death and complicating factors. For more details, see Appendix 2.

- Angiography (conventional, computerized tomographic, and magnetic resonance): Brain death confirmed by demonstrating the absence of intracerebral filling at the level of the carotid bifurcation or Circle of Willis. On CT angiography, opacification may be seen in proximal portions of the anterior and middle cerebral arteries. The external carotid circulation is usually patent, and filling of the superior sagittal sinus may be delayed.
 - MRI angiography can be quite challenging in an ICU patient because of magnet incompatibility with lines, ventilator tubing and other hardware.
 - CT angiography commonly demonstrates some blood flow in patients who are brain dead.
 - Cerebral arteriography is often difficult to perform in a critically ill, unstable patient.
- Electroencephalography (EEG): Brain death is confirmed by documenting the absence of electrical activity during at least 30 minutes of recording that adheres to criteria listed in Appendix 2.

- The ICU setting may result in false readings due to electronic background noise creating innumerable artifacts.
- Cerebral Scintigraphy (HMPAO) (Nuclear Brain Scanning): Brain death is confirmed by absence of uptake of isotope in brain parenchyma and/or vasculature, depending on isotope and technique used. ("hollow skull phenomenon"). (See reference 3 below.)
- Transcranial Doppler Ultrasonography: Brain death is confirmed by small systolic peaks in early systole without diastolic flow, or reverberating flow, indicating very high vascular resistance associated with greatly increased intracranial pressure.
 - Since as many as 10% of patients may not have temporal insonation windows because of skull thickness, the initial absence of Doppler signals cannot be interpreted as being consistent with brain death.

Step 5: Pronouncement of Brain Death

Brain death is determined by a single physician privileged to make brain death determinations. However, if the patient may become an organ donor, the physician who makes the pronouncement that death has occurred shall not be the organ transplant surgeon, the attending physician of the organ recipient, nor otherwise an individual subject to a potentially significant conflict of interest relating to procedures for organ procurement.

Medical Record Documentation: All phases of the determination of brain death must be documented in the medical record. The medical record must indicate:

- Etiology and irreversibility of coma.
- Absence of cerebral responsiveness.
- Absence of brain stem reflexes.
- Absence of respiration with $\text{PaCO}_2 \geq 60$ mm Hg (or ≥ 20 mm Hg increase over baseline normal PaCO_2).
- Justification for, and result of, ancillary tests if used.

A sample checklist is provided at the end of this document (see Appendix 3). Use of this or any other checklist is optional, but strongly recommended.

Step 6: Discontinue Cardio-respiratory Support in Accordance with Hospital Policies, Including Those for Organ Donation

When a patient is pronounced brain dead and the ventilator is to be discontinued, the family should be treated with sensitivity and respect. If family members wish, they may be offered the

opportunity to attend while the ventilator is discontinued. However, family members should be prepared for the possibly disturbing clinical activity that they may witness. When organ donation is to occur, ventilatory support will conclude in the operating room and family attendance in that situation would not be appropriate.

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Endnote 1: This Committee notes that the training, qualifications and experience of intensivists, including pediatric intensivists are more than adequate to include this specialty in the list of specialists approved to perform the brain death determination in patients under 2 months of age, and that such inclusion would reflect current accepted medical practice in this State and nationally.

Appendix 1: Determination of Brain Death in Children Less Than One Year of Age

1. General Policy Statement.
2. The brains of infants and young children have increased resistance to damage and may recover substantial functions even after exhibiting unresponsiveness on neurological examination for longer periods as compared to adults. When applying neurological criteria to determine death in children younger than one year, two examinations and longer waiting periods are required.
3. The patient must not be significantly hypothermic or hypotensive for age.
4. Waiting Periods According to Age:

The recommended waiting period depends on the age of the patient and the ancillary tests utilized. Ages listed assume the child was born at full term. Between the ages of 2 months and 1 year, an interval of at least 24 hours should be used. Between the ages of 7 days and 2 months, the minimum interval should be 48 hours.

- Reliable criteria have not been established for the determination of brain death in children less than 7 days old.
- Seven days to two months: Two examinations and two electroencephalograms (EEGs) should be separated by at least 48 hours.
- Two months to one year: Two examinations and two EEGs should be separated by at least 24 hours. A repeat examination and EEG are not necessary if a concomitant radionuclide or other angiographic study demonstrates no visualization of cerebral arteries.

Appendix 2: Methods of Ancillary Testing for the Determination of Brain Death

Cerebral Angiography

- The contrast medium should be injected in the aortic arch under high pressure and reach both anterior and posterior circulations.
- No intracerebral filling should be detected at the level of entry of the carotid or vertebral artery to the skull.
- Opacification may be seen in proximal portions of the anterior and middle cerebral arteries.
- The external carotid circulation should be patent.
- The filling of the superior longitudinal sinus may be delayed.

Electroencephalography

- A minimum of 8 scalp electrodes should be used.
- Interelectrode impedance should be between 100 and 10,000
- The integrity of the entire recording system should be tested.
- The distance between electrodes should be at least 10 cm.
- The sensitivity should be increased to at least 2 μ V for 30 minutes with inclusion of appropriate calibrations.
- The high-frequency filter setting should not be set below 30 Hz, and the low-frequency setting should not be above 1 Hz.
- Electroencephalography should demonstrate a lack of reactivity to intense somatosensory or audiovisual stimuli.

Transcranial Doppler Ultrasonography (TCD)

- TCD is useful only if a reliable signal is found. The abnormalities should include either reverberating flow or small systolic peaks in early systole. A finding of a complete absence of flow may not be reliable owing to inadequate transtemporal windows for insonation. There should be bilateral insonation and anterior and posterior insonation. For the carotid arteries the probe should be placed at the temporal bone, above the zygomatic arch; for the vertebrobasilar arteries, insonation should be through the suboccipital

transcranial window.

- Insonation through the orbital window can be considered to obtain a reliable signal. TCD may be less reliable in patients with a prior craniotomy.

Cerebral Scintigraphy (Nuclear Brain Scan) (technetium Tc 99m hexametazime (HMPAO))

- The isotope should be injected within 30 minutes after its reconstitution.
- Anterior and both lateral planar image counts (500,000) of the head should be obtained at several time points: immediately, between 30 and 60 minutes later, and at 2 hours.
- A correct IV injection may be confirmed with additional images of the liver demonstrating uptake (optional).
- No radionuclide localization in the middle cerebral artery, anterior cerebral artery, or basilar artery territories of the cerebral hemispheres (hollow skull phenomenon).
- No tracer in superior sagittal sinus (minimal tracer can come from the scalp).

**Appendix 3: Optional Sample Checklist for Determination of Brain Death for Adults
Prerequisites (each item must be checked) (Steps 1 and 2 of the Guidelines)**

YES NO

- Coma, irreversible and cause known
- Appropriate waiting period has been followed (_____ hours)

If patient was previously induced into hypothermia, additional vigilance is recommended

- Neuroimaging is compatible with the diagnosis, if applicable
- CNS depressant drug effect absent (if indicated, toxicology screen; if barbiturates given, serum level < 10 µg/mL) (_____ serum level)
- No evidence of residual paralytics (clinical or electrical stimulation if paralytics used)
- Absence of severe acid-base, electrolyte, endocrine abnormality
- Normothermia or mild hypothermia (core temperature > 36°C) (____ Temperature)
- Systolic blood pressure ≥ 100 mm Hg (option: mean arterial pressure ≥ 65 mm Hg) (_____ mm Hg)
- No spontaneous respirations

Explanation/comments for any of the prerequisites above: _____

Clinical Neurological Examination (each item must be checked) (Step 3 of the Guidelines)

YES NO

- Pupils nonreactive to bright light
- Corneal reflex absent
- Oculocephalic reflex absent (tested only if C-spine and skull base integrity assured)
- Oculovestibular reflex absent (tested only if external auditory canal patent and tympanic membranes intact)
- No facial movement to noxious stimuli at supraorbital nerve, temporomandibular joint
- Gag reflex absent
- Cough reflex absent to tracheal suctioning
- Absence of response to noxious stimuli (spinally mediated reflexes are permissible)

Explanation/comments for any of the examination steps above: _____

Apnea Testing (check if performed) (Step 4 of the Guidelines)

- Core temperature > 36°C (_____ temperature)
- Systolic blood pressure \geq 100 mm Hg (option: mean arterial pressure \geq 65 mm Hg) (_____ mm Hg)
- Ventilator adjusted to provide normocarbica (PaCO₂ 35–45 mm Hg) (PaCO₂ _____ mm Hg)
- Patient pre-oxygenated with 100% FiO₂ for \geq 10 minutes to PaO₂ > 200 mm Hg, if applicable
- Draw a baseline arterial blood gas
- Provide oxygen via a catheter to the level of the carina at 6 L/min or attach T-piece with CPAP at 10 cm H₂O at 12 L/min
- Connect a pulse oximeter
- Disconnect ventilator
- If tolerated, leave the patient off the ventilator for 8–10 minutes (Duration _____ minutes)
- Observe the patient for respiratory movements
- Measure PaO₂, PaCO₂, and pH at the end of 8–10 minutes, and reconnect the patient to ventilator

Explanation/comments for any of the apnea testing steps above: _____

Results of the Apnea Test:

- Confirms brain death: If respiratory movements are absent and PaCO₂ is \geq 60 mm Hg or PaCO₂ increase is \geq 20 mm Hg over baseline normal PaCO₂, the apnea test result supports the diagnosis of brain death.

OR

- Does not confirm brain death: If respiratory movements are observed, the apnea test result does not support the diagnosis of brain death.

OR

- Results are indeterminate:
 - If PaCO₂ is < 60 mm Hg and PaCO₂ increase is < 20 mm Hg over baseline normal PaCO₂, the result does not support the diagnosis of brain death. If adequate blood pressure and oxygenation can be maintained, the apnea test can be repeated for a longer period of time (10-15 minutes) or an ancillary test can be considered.
 - The patient does not tolerate the apnea test, as evidenced by significant drops in blood pressure and/or oxygen saturation, or the development of cardiac arrhythmias, or an apnea test cannot be performed on the patient. If possible, the apnea test should be repeated, or an ancillary test can be considered.

Comments to the results of the apnea test: _____

Ancillary Testing (to be ordered only if clinical neurological examination cannot be fully performed due to patient factors, or if apnea testing is inconclusive, aborted, or is not performed due to patient factors; only one ancillary test needs to be performed) (Step 5 of the Guidelines)

- Cerebral angiogram (conventional, CT or MR angiogram)
- Nuclear Brain Scan (HMPAO SPECT)
- EEG
- TCD
- Other

What was the interpretation of the test? _____

Date and time of death: _____
Print name of physician: _____
Signature: _____

Considerations in the Discussion of Brain Death

1. Context: Brain death typically occurs in a sudden and unexpected setting – a previously healthy person is involved in a car accident or suffers other trauma, or has an intracerebral hemorrhage or cardiac arrest. Denial, anger, and fear are all normal human reactions for friends and family. In this setting families absorb a very small proportion of what they are told, but at the same time are very sensitive to subtle inconsistencies in what they hear if this holds even the vaguest hint of hope. Be clear, compassionate and consistent. Indicate the situation is grave, that everything possible is being done but at the same time the situation may be irretrievable. Introduce the concept of brain death and indicate that in modern medicine we have the ability to determine if somebody's brain has ceased to function completely and that this is now known to define death, just as much as if somebody's heart and breathing have stopped.
2. What is meant by brain death: This concept is broadly misunderstood, even by those one might expect to be knowledgeable. In simple terms it is the state where all functioning of the brain has stopped, and we know, based on the cause and on what we observe in the patient, that nobody in this state has ever recovered. It is different from persistent vegetative state, coma, locked in state, sleep, etc., in all of which some brain functioning remains. Stories in the tabloid press are generally as accurate as everything else in the tabloid press. There are no substantiated cases in the medical literature where somebody has survived this state.
3. Process: The family needs to understand the process by which we establish that the patient is indeed brain dead. This involves testing - primarily clinically – the various functions of the brain. A detailed physical exam will determine the functioning – or not – of the key parts of the nervous system. As part of this process, since the brainstem controls breathing, we test the breathing reflexes with an apnea test. Testing will also address other possible causes of the patient's state. If any part of the test cannot be performed with a result that is clear and certain, additional laboratory testing such as an EEG or brain blood flow study will be performed to allow certainty.
4. End of life: Once we establish that there is no brain function, the patient is biologically, medically and legally dead. (S)he may remain connected to IVs, medications or even a ventilator for a period of time, either to allow the family to say their goodbyes or to enable transplant, but these are not life support machines. In the case of transplant donors, the machines allow the organs to continue to function to maximize the good that can come to the transplant recipients. In non-donor circumstances, this is done to allow a slightly less uncomfortable final interaction for the family in very difficult time.