Guidelines for the Determination of Brain Death in Infants and Children

DEFINITION OF BRAIN DEATH
(Term Newborns 37 Weeks Gestational Age to Children 18 Years of Age)

Brain death is a clinical diagnosis based on the absence of neurologic function with a known diagnosis that has resulted in irreversible coma. Coma and apnea must coexist to diagnose brain death.

Determination of brain death by neurologic examination should be performed in the setting of normal age-appropriate physiologic parameters. Factors potentially influencing the neurologic examination that must be corrected prior to examination and apnea testing include:

- Shock or persistent hypotension.
- Hypothermia.
- Severe metabolic disturbances.

Checklist for Documentation of Brain Death

Brain Death Examination for Infants and Children[a]

Age of Patient	Timing of First Examination	Interexamination Interval
Term newborn 37 weeks gestational age and up to 30 days old	☐ First examination may be performed 24 hours after birth OR following cardiopulmonary resuscitation or other severe brain injury	☐ At least 24 hours
		☐ Interval shortened because ancillary study (Section 4) is consistent with brain death
31 days to 18 years old	☐ First examination may be performed 24 hours following cardiopulmonary resuscitation or other severe brain injury	☐ At least 12 hours OR
		☐ Interval shortened because ancillary study (Section 4) is consistent with brain death

Section 1. Prerequisites for Brain Death Examination and Apnea Test

A. Irreversible and Identifiable Cause of Coma (please check)

- ☐ Traumatic brain injury
- ☐ Anoxic brain injury
- ☐ Known metabolic disorder
- ☐ Other (specify) _____

B. Correction of Contributing Factors That Can Interfere with the Neurologic Examination

	Examination 1		Examination 2	
a. Core body temperature is >95°F (35°C)	☐ Yes	☐ No	☐ Yes	☐ No
b. Systolic blood pressure or MAP in acceptable range (Systolic BP not less than 2 standard deviations below age-appropriate norm) based on age	☐ Yes	☐ No	☐ Yes	☐ No
c. Sedative/analgesic drug effect excluded as a contributing factor	☐ Yes	☐ No	☐ Yes	☐ No
d. Metabolic intoxication excluded as a contributing factor	☐ Yes	☐ No	☐ Yes	☐ No
e. Neuromuscular blockade excluded as a contributing factor	☐ Yes	☐ No	☐ Yes	☐ No

☐ If ALL prerequisites are marked YES, then proceed to section 2, OR

☐ _____ confounding variable was present. Ancillary study was therefore performed to document brain death (Section 4).

Section 2. Physical Examination (please check); Note: Spinal Cord Reflexes Are Acceptable				
	Examination 1, Date/Time: _____		Examination 2, Date/Time: _____	
a. Flaccid tone, patient unresponsive to deep painful stimuli	☐ Yes	☐ No	☐ Yes	☐ No
b. Pupils are midposition or fully dilated and light reflexes are absent	☐ Yes	☐ No	☐ Yes	☐ No
c. Corneal, cough, gag reflexes are absent	☐ Yes	☐ No	☐ Yes	☐ No
d. Sucking and rooting reflexes are absent (in neonates and infants)	☐ Yes	☐ No	☐ Yes	☐ No
e. Oculovestibular reflexes are absent	☐ Yes	☐ No	☐ Yes	☐ No
f. Spontaneous respiratory effort while on mechanical ventilation is absent	☐ Yes	☐ No	☐ Yes	☐ No
☐ The _____ (specify) element of the examination could not be performed because _____.				
Ancillary study (EEG or radionuclide CBF) was therefore performed to document brain death (Section 4).				

Section 3. Apnea Test

	Examination 1, Date/ Time _____	Examination 2, Date/ Time _____
No spontaneous respiratory efforts were observed despite final $PaCO_2$ ≥60mmHg and a ≥20mmHg increase above baseline (Examination 1). No spontaneous respiratory efforts were observed despite final $PaCO_2$ ≥60mmHg and a ≥20mmHg increase above baseline (Examination 2).	Pretest $PaCO_2$: _____ Apnea duration: _____ min Post-test $PaCO_2$: _____	Pretest $PaCO_2$: _____ Apnea duration: _____ min Post-test $PaCO_2$: _____

Apnea test is contraindicated or could not be performed to completion because _____.
Ancillary study (EEG or radionuclide CBF) was therefore performed to document brain death (Section 4).

Section 4. Ancillary Testing

Ancillary testing is required (1) when any components of the examination or apnea testing cannot be completed; (2) if there is uncertainty about the results of the neurologic examination; or (3) if a medication effect may be present. Ancillary testing can be performed to reduce the interexamination period; however, a second neurologic examination is required. Components of the neurologic examination that can be performed safely should be completed in close proximity to the ancillary test.

Date/time: _____

☐ EEG report documents electrocerebral silence OR	☐ Yes ☐ No
☐ CBF study report documents no cerebral perfusion	☐ Yes ☐ No

Section 5. Signatures

Examiner 1

I certify that my examination is consistent with cessation of function of the brain and brainstem. Confirmatory examination to follow.

Printed name _____

Signature _____

Specialty _____

Pager #/license # _____

Date mm/dd/yyyy _____

Time _____

Examiner 2

I certify that my examination ☐ and/or ancillary test report ☐ confirms unchanged and irreversible cessation of function of the brain and brainstem. The patient is declared brain dead at this time.

Date/time of death _____

Printed name _____

Signature _____

Specialty _____

Pager #/license # _____

Date mm/dd/yyyy _____

Time _____

[a]Two physicians must perform independent examinations separated by specified intervals.
BP = blood pressure; CBF = cerebral blood flow; EEG = electroencephalography; MAP = mean arterial pressure.

TABLE 3: Neurologic Examination Components to Assess for Brain Death in Neonates, Infants, and Children,[a] Including Apnea Testing

Reversible conditions or conditions that can interfere with the neurologic examination must be excluded prior to brain death testing. See text for discussion.
1. Coma. The patient must exhibit complete loss of consciousness, vocalization, and volitional activity.
Patients must lack all evidence of responsiveness. Eye opening or eye movement to noxious stimuli is absent.
Noxious stimuli should not produce a motor response other than spinally mediated reflexes. The clinical differentiation of spinal responses from retained motor responses associated with brain activity requires expertise.
2. Loss of all brainstem reflexes including:
Midposition or fully dilated pupils that do not respond to light.
Absence of pupillary response to a bright light is documented in both eyes. Usually the pupils are fixed in a midsize or dilated position (4–9mm). When uncertainty exists, a magnifying glass should be used.
Absence of movement of bulbar musculature including facial and oropharyngeal muscles.
Deep pressure on the condyles at the level of the temporomandibular joints and deep pressure at the supraorbital ridge should produce no grimacing or facial muscle movement.

Absent gag, cough, sucking, and rooting reflex.
The pharyngeal or gag reflex is tested after stimulation of the posterior pharynx with a tongue blade or suction device. The tracheal reflex is most reliably tested by examining the cough response to tracheal suctioning. The catheter should be inserted into the trachea and advanced to the level of the carina followed by 1 or 2 suctioning passes.
Absent corneal reflexes.
Absent corneal reflex is demonstrated by touching the cornea with a piece of tissue paper, a cotton swab, or squirts of water. No eyelid movement should be seen. Care should be taken not to damage the cornea during testing.
Absent oculovestibular reflexes.
The oculovestibular reflex is tested by irrigating each ear with ice water (caloric testing) after the patency of the external auditory canal is confirmed. The head is elevated to 30°. Each external auditory canal is irrigated (1 ear at a time) with approximately 10 to 50ml of ice water. Movement of the eyes should be absent during 1 minute of observation. Both sides are tested, with an interval of several minutes.

3. Apnea. The patient must have the complete absence of documented respiratory effort (if feasible) by formal apnea testing demonstrating a $PaCO_2$ $\geq$60mmHg and $\geq$20mmHg increase above baseline.

Normalization of the pH and $PaCO_2$, measured by arterial blood gas analysis, maintenance of core temperature >35°C, normalization of blood pressure appropriate for the age of the child, and correcting for factors that could affect respiratory effort are a prerequisite to testing.

The patient should be preoxygenated using 100% oxygen for 5–10 minutes prior to initiating this test.

Intermittent mandatory mechanical ventilation should be discontinued once the patient is well oxygenated and a normal $PaCO_2$ has been achieved.

The patient's heart rate, blood pressure, and oxygen saturation should be continuously monitored while observing for spontaneous respiratory effort throughout the entire procedure.

Follow-up blood gases should be obtained to monitor the rise in $PaCO_2$ while the patient remains disconnected from mechanical ventilation.

If no respiratory effort is observed from the initiation of the apnea test to the time the measured $PaCO_2$ is $\geq$60mmHg and $\geq$20mmHg above the baseline level, the apnea test is consistent with brain death.

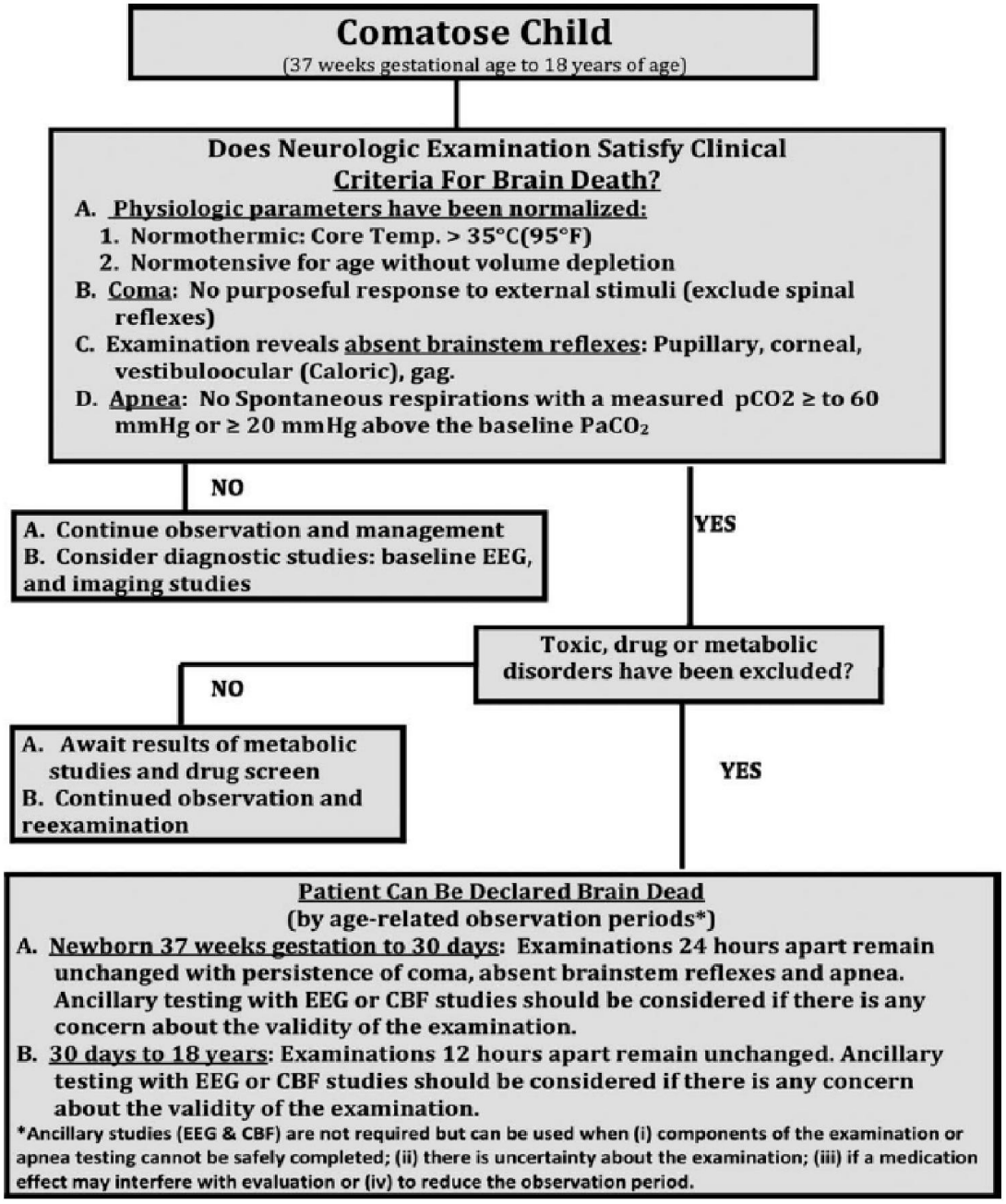
The patient should be placed back on mechanical ventilator support, and medical management should continue until the second neurologic examination and apnea test confirming brain death are completed.

If oxygen saturations fall below 85%, hemodynamic instability limits completion of apnea testing, or a $PaCO_2$ level of $\geq$60mmHg cannot be achieved, the infant or child should be placed back on ventilator support with

TABLE 3 (Continued)

appropriate treatment to restore normal oxygen saturations, arterial CO_2 pressure, and hemodynamic parameters. Another attempt to test for apnea may be performed at a later time, or an ancillary study may be pursued to assist with determination of brain death. Evidence of any respiratory effort is inconsistent with brain death, and the apnea test should be terminated.
4. Flaccid tone and absence of spontaneous or induced movements, excluding spinal cord events such as reflex withdrawal or spinal myoclonus.
The patient's extremities should be examined to evaluate tone by passive range of motion, assuming that there are no limitations to performing such an examination (eg, previous trauma, etc), and the patient should be observed for any spontaneous or induced movements. If abnormal movements are present, clinical assessment to determine whether these are spinal cord reflexes should be done.

[a]Criteria adapted from 2010 American Academy of Neurology criteria for brain death determination in adults.[11]



JRE: Algorithm to diagnose brain death in infants and children. CBF = cerebral blood flow; EEG = troencephalography.

- Declaration of Death (for All Age Groups) :Death is declared after the second neurologic examination and apnea test confirm an unchanged and irreversible condition. An algorithm provides recommendations for the process of diagnosing brain death in children. When ancillary studies are used, documentation of components from the second clinical examination that can be completed, including a second apnea test, must remain consistent with brain death. All aspects of the clinical examination, including the apnea test, or ancillary studies must be appropriately documented.

4. References

1. Guidelines for the Determination of Brain Death in Infants and Children:An Update of the 1987 Task Force Recommendations—Executive Summary. Thomas A. Nakagawa, MD, FAAP, FCCM

2.Report of Special Task Force. Guidelines for determination of brain death in children. American Academy of Pediatrics Task Force on Brain Death in Children. Pediatrics 1987;80:298–300.

3. Nakagawa TA, Ashwal SA, Mathur M, Mysore M. Guidelines for the Determination of Brain Death in Infants and Children. Critical Care Medicine 2011;39:2139–2155.

4. Nakagawa TA, Ashwal SA, Mathur M, Mysore M. Guidelines for the Determination of Brain Death in Infants and Children. Pediatrics 2011;128: www.pediatrics.org/cgi/doi/10.1542/peds. 2011-1511