



# UPDATE: DETERMINING BRAIN DEATH IN ADULTS

This is a non-evidence-based supplement to the American Academy of Neurology (AAN) guideline update (*Neurology*® 2010;74:1911–1918) on determining brain death in adults.

*This content is slightly abridged. For the complete text, please refer to the full guideline. Please refer to “AAN Summary of Evidence-based Guideline for Clinicians” for a summary of the evidence-based content. Both are found at [www.aan.com](http://www.aan.com).*

## Practical (Non-Evidence-Based) Guidance for determination of brain death

Many of the details of the clinical neurologic examination to determine brain death cannot be established by evidence-based methods. The detailed brain death evaluation protocol that follows is intended as a useful tool for clinicians. It must be emphasized that this guidance is opinion-based. Alternative protocols may be equally informative.

The determination of brain death can be considered to consist of four steps.

### I. The clinical evaluation (prerequisites)

#### A. Establish irreversible and proximate cause of coma

The cause of coma can usually be established by history, examination, neuroimaging, and laboratory tests.

Exclude the presence of a CNS-depressant drug effect by history, drug screen, calculation of clearance using five times the drug's half-life (assuming normal hepatic and renal function), or, if available, drug plasma levels below the therapeutic range. Prior use of hypothermia (e.g., after cardiopulmonary resuscitation) for cardiac arrest may delay drug metabolism. The legal alcohol limit for driving (blood alcohol content 0.08%) is a practical threshold below which an examination to determine brain death could reasonably proceed.

There should be no recent administration or continued presence of neuromuscular blocking agents (this can be defined by the presence of a train of four twitches with maximal ulnar nerve stimulation).

There should be no severe electrolyte, acid-base, or endocrine disturbance (defined by severe acidosis or laboratory values markedly deviated from the norm).

#### B. Achieve normal core temperature

In most patients, a warming blanket is needed to raise the body temperature and maintain a normal or near-normal temperature (>36°C). After the initial equilibration of arterial carbon dioxide (CO<sub>2</sub>) with mixed central venous CO<sub>2</sub>, the partial pressure of CO<sub>2</sub> (PaCO<sub>2</sub>) rises steeply, but then more slowly when the body metabolism raises PaCO<sub>2</sub>. To avoid delaying an increase in PaCO<sub>2</sub>, normal or near-normal core temperature is preferred during the apnea test.

#### C. Achieve normal systolic blood pressure

Hypotension from loss of peripheral vascular tone or hypovolemia (diabetes insipidus) is common; vasopressors or vasopressin are often required. Neurologic examination is usually reliable with a systolic blood pressure ≥100 mm Hg.

#### D. Perform one neurologic examination (sufficient to pronounce brain death in most US states)

If a certain period of time has passed since the onset of the brain insult to exclude the possibility of recovery (in practice, usually several hours), one neurologic examination should be sufficient to pronounce brain death. However, some US state statutes require two examinations.

Legally, all physicians are allowed to determine brain death in most US states. Neurologists, neurosurgeons, and intensive care specialists may have specialized expertise. It seems reasonable to require that all physicians making a determination of brain death be intimately familiar with brain death criteria and have demonstrated competence in this complex examination. Brain death statutes in the United States differ by state and institution. Some US state or hospital guidelines require the examiner to have certain expertise.

### II. The clinical evaluation (neurologic assessment)

#### A. Coma

##### • 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.

#### B. Absence of brainstem reflexes

##### • Absence of pupillary response to a bright light is documented in both eyes

Usually the pupils are fixed in a midsize or dilated position (4–9 mm). Constricted pupils suggest the possibility of drug intoxication. When uncertainty exists, a magnifying glass should be used.

##### • Absence of ocular movements using oculoccephalic testing and oculovestibular reflex testing

Once the integrity of the cervical spine is ensured, the head is briskly rotated horizontally and vertically. There should be no movement of the eyes relative to head movement. 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 degrees. Each external auditory canal is irrigated (one ear at a time) with approximately 50 ml 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.

- **Absence of corneal reflex**

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.

- **Absence of facial muscle movement to a noxious stimulus**

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.

- **Absence of the pharyngeal and tracheal reflexes**

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 one or two suctioning passes.

### C. Apnea

- **Absence of a breathing drive**

Absence of a breathing drive is tested with a CO<sub>2</sub> challenge. Documentation of an increase in PaCO<sub>2</sub> above normal levels is typical practice. It requires preparation before the test. Prerequisites: 1. normotension, 2. normothermia, 3. euolemia, 4. eucapnia (PaCO<sub>2</sub> 35–45 mm Hg), 5. absence of hypoxia, and 6. no prior evidence of CO<sub>2</sub> retention (i.e., chronic obstructive pulmonary disease, severe obesity).

Procedure:

- Adjust vasopressors to a systolic blood pressure  $\geq$ 100 mm Hg.
- Preoxygenate for at least 10 minutes with 100% oxygen to a PaO<sub>2</sub>  $>$ 200 mm Hg.
- Reduce ventilation frequency to 10 breaths per minute to eucapnia.
- Reduce positive end-expiratory pressure (PEEP) to 5 cm H<sub>2</sub>O (oxygen desaturation with decreasing PEEP may suggest difficulty with apnea testing).
- If pulse oximetry oxygen saturation remains  $>$ 95%, obtain a baseline blood gas (partial pressure of oxygen [PaO<sub>2</sub>], PaCO<sub>2</sub>, pH, bicarbonate, base excess).
- Disconnect the patient from the ventilator.
- Preserve oxygenation (e.g., place an insufflation catheter through the endotracheal tube and close to the level of the carina and deliver 100% O<sub>2</sub> at 6 L/min).
- Look closely for respiratory movements for 8–10 minutes. Respiration is defined as abdominal or chest excursions and may include a brief gasp.

- Abort if systolic blood pressure decreases to  $<$ 90 mm Hg.
- Abort if oxygen saturation measured by pulse oximetry is  $<$ 85% for  $>$ 30 seconds. Retry procedure with T-piece, continuous positive airway pressure (CPAP) 10 cm H<sub>2</sub>O, and 100% O<sub>2</sub> 12 L/min.
- If no respiratory drive is observed, repeat blood gas (PaO<sub>2</sub>, PaCO<sub>2</sub>, pH, bicarbonate, base excess) after approximately 8 minutes.
- If respiratory movements are absent and arterial PCO<sub>2</sub> is  $\geq$ 60 mm Hg (or 20 mm Hg increase in arterial PCO<sub>2</sub> over a baseline normal arterial PCO<sub>2</sub>), the apnea test result is positive (i.e., supports the clinical diagnosis of brain death).
- If the test is inconclusive but the patient is hemodynamically stable during the procedure, it may be repeated for a longer period of time (10–15 minutes) after the patient is again adequately preoxygenated.

### III. Ancillary tests

In clinical practice, EEG, cerebral angiography, nuclear scan, and transcranial Doppler (TCD) are currently used ancillary tests in adults. Most hospitals will have the logistics in place to perform and interpret an EEG, nuclear scan, or cerebral angiogram, and these three tests may be considered the preferred tests. Ancillary tests can be used when uncertainty exists about the reliability of parts of the neurologic examination or when the apnea test cannot be performed. In some protocols, ancillary tests are used to shorten the duration of the observation period.

The interpretation of each of these tests requires expertise. In adults, ancillary tests are not needed for the clinical diagnosis of brain death and cannot replace a neurologic examination. Physicians ordering ancillary tests should appreciate the disparities between tests and the potential for false-positives (i.e., the test suggests brain death, but the patient does not meet clinical criteria). Rather than ordering ancillary tests, physicians may decide not to proceed with the declaration of brain death if clinical findings are unreliable.

### IV. Documentation

The time of brain death is documented in the medical records. Time of death is the time the arterial PCO<sub>2</sub> reached the target value. In patients with an aborted apnea test, the time of death is when the ancillary test has been officially interpreted. A checklist is filled out, signed, and dated. Federal and state law requires the physician to contact an organ procurement organization following determination of brain death.

This is an educational service of the American Academy of Neurology. It is designed to provide members with evidence-based guideline recommendations to assist the decision making in patient care. It is based on an assessment of current scientific and clinical information and is not intended to exclude any reasonable alternative methodologies. The AAN recognizes that specific patient care decisions are the prerogative of the patient and the physician caring for the patient, and are based on the circumstances involved. Physicians are encouraged to carefully review the full AAN guidelines so they understand all recommendations associated with care of these patients.