TABLE 105-5 CRITERIA FOR CESSATION OF BRAIN FUNCTION*

ANATOMIC REGION TESTED	CONFIRMATORY SIGN
Hemispheres	Unresponsive and unreceptive to sensory stimuli including pain[†]
Midbrain	Unreactive pupils[‡]
Pons	Absent reflex eye movements[§]
Medulla	Apnea[‖]

CO_2, Carbon dioxide; P_{CO_2}, partial pressure of carbon dioxide.

*Sequential testing is necessary for a clinical diagnosis of brain death; it should be done at least every 6 hours in all cases and at least every 24 hours in the setting of anoxic-ischemic brain injury.

[†]The patient does not rouse, groan, grimace, or withdraw limbs. Purely spinal reflexes (deep tendon reflexes, plantar flexion reflex, plantar withdrawal, and tonic neck reflexes) may be maintained.

[‡]Most easily assessed by the bright light of an ophthalmoscope viewed through its magnifying lens when focused on the iris. Unreactive pupils may be either midposition, as they will be in death, or dilated, as they often are in the setting of a dopamine infusion.

[§]No eye movement toward the side of irrigation of the tympanic membrane with 50 mL of ice water. The oculocephalic response (doll's eyes maneuver) is always absent in the setting of absent oculovestibular testing.

[‖]No ventilatory movements in the setting of maximum CO_2 stimulation (≥60 mm Hg); with apnea, P_{CO_2} passively rises 2 to 3 mm Hg/min). Disconnect the ventilator from the endotracheal tube and insert a cannula with 6 L of oxygen per minute.

TABLE 105-6 EXCLUSIONARY CRITERIA FOR BRAIN DEATH

Seizures	Hypothermia (<32.2° C)
Decorticate or decerebrate posturing	Neuromuscular blockade
Sedative drugs	Shock

TABLE 105-7 CONFIRMATORY TESTS FOR BRAIN DEATH

EEG isoelectricity	Deep coma from sedative drugs or hypothermia (temperature <20° C) can produce EEG flattening.
Nuclear medicine	The most common radionuclide modality for brain imaging uses the tracer HMPAO. Absence of isotope uptake ("hollow skull phenomenon") indicates no brain perfusion and supports the diagnosis of brain death.
Transcranial Doppler	Findings of small systolic peaks without diastolic flow or a reverberating flow pattern suggest high vascular resistance and support the diagnosis of brain death. No cerebral blood flow is the most definitive confirmatory test.
CT angiography	Nonopacification of the cortical segments of MCAs and ICVs appears to be highly sensitive for confirming brain death, with a specificity of 100%. Lack of opacification of the ICVs is the most sensitive sign.

CT, Computed tomographic; EEG, electroencephalogram; HMPAO, ^{99m}Tc-labeled hexamethylpropyleneamineoxime; ICV, internal cerebral vein; MCA, middle cerebral artery.

findings of brain death, and that exclusionary criteria are absent (Table 105-6). Confirmatory tests are sometimes used but are not required for diagnosis (Table 105-7). Brain death results in asystole, usually within days (mean, 4 days), even if ventilatory support is continued. Recovery after appropriate documentation of brain death has never been reported. Removal of the ventilator results in terminal rhythms (most often complete heart block without ventricular response), junctional rhythms, or ventricular tachycardia. Purely spinal motor movements may occur in the moments of terminal apnea (or during apnea testing in the absence of passive administration of oxygen); these may include arching of the back, neck turning, stiffening of the legs, and upper extremity flexion.

SUGGESTED READINGS

Bernard SA, Gray TW, Buist MD, et al: Treatment of comatose survivors of out-of-hospital cardiac arrest with induced hypothermia, N Engl J Med 346:557–563, 2002.

Bernat JL: Chronic disorders of consciousness, Lancet 367:1181–1192, 2006.

Fins JJ, Master MG, Gerber LM, et al: The minimally conscious state: a diagnosis in search of an epidemiology, Arch Neurol 64:1400–1405, 2007.

Greer DM, Scripko PD, Wu O, et al: Hippocampal magnetic resonance imaging abnormalities in cardiac arrest are associated with poor outcome, J Stroke Cerebrovasc Dis 22:899–905, 2013.

Laureys S, Celesia GG, Cohadon F, et al: Unresponsive wakefulness syndrome: a new name for the vegetative state or apallic syndrome, BMC Med 8:68, 2010.

Laureys S, Schiff ND: Coma and consciousness: paradigms (re)framed by neuroimaging, Neuroimage 61(2):478–491, 2012.

Meaney PA, Bobrow BJ, Mancini ME: Cardiopulmonary resuscitation quality: improving cardiac resuscitation outcomes both inside and outside the hospital–a consensus statement From the American Heart Association, Circulation 124:417–435, 2013.

Peberdy MA, Callaway CW, Neumar RW, et al: Cardiac arrest care: 2010 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care, Circulation 122(18 Suppl 3):S768–S786, 2010. [Errata in Circulation 123:e237, 2011, and Circulation 124:e403, 2011.].

Plum F, Posner JB: The diagnosis of stupor and coma. Contemporary Neurology Series, vol 71, ed 4, New York, 2007, Oxford University Press.

Rodriguez RA, Nair S, Bussiere M, et al: Long-lasting functional disabilities in patients who recover from coma after cardiac operations, Ann Thorac Surg 95:884–891, 2013.

Wijdicks EFM: The diagnosis of brain death, N Engl J Med 344:1215–1221, 2001.

Wijdicks EFM, Hijdra A, Young GB, et al: Practice parameter: prediction of outcome in comatose survivors after cardiopulmonary resuscitation (an evidence-based review), Neurology 67:203–210, 2006.

Wu O, Soresnen AG, Benner T, et al: Comatose patients with cardiac arrest: predicting clinical outcome with diffusion-weighted MR imaging, Radiology 252:173–181, 2009.

Young GB: Neurologic prognosis after cardiac arrest, N Engl J Med 361:605–611, 2009.

Zandbergen EGJ, Hijdra A, Koelman JH, et al: Prediction of poor outcome within the first 3 days of postanoxic coma, Neurology 66:62–68, 2006.