



BRAIN DEATH DECLARATION

SPECIAL WEBINAR SERIES



Brain Death Declaration: Better Quality and Uniformity - The Physicians' Perspective*

November 4, 2020 | 2-3:30 pm ET

Speakers: David M. Greer, MD | J. Javier Provencio, MD | Fernando D. Goldenberg, MD

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WEBINAR SPEAKERS



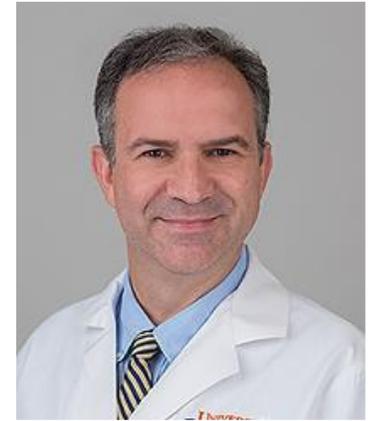
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Brain Death

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Outline

- Pathophysiology
- History
- Variability
- 2010 AAN Practice Parameter Update
- Clinical determination
- Ancillary testing
- World Brain Death Project
- The Future of Brain Death



Why did brain death not exist until the 1950's?

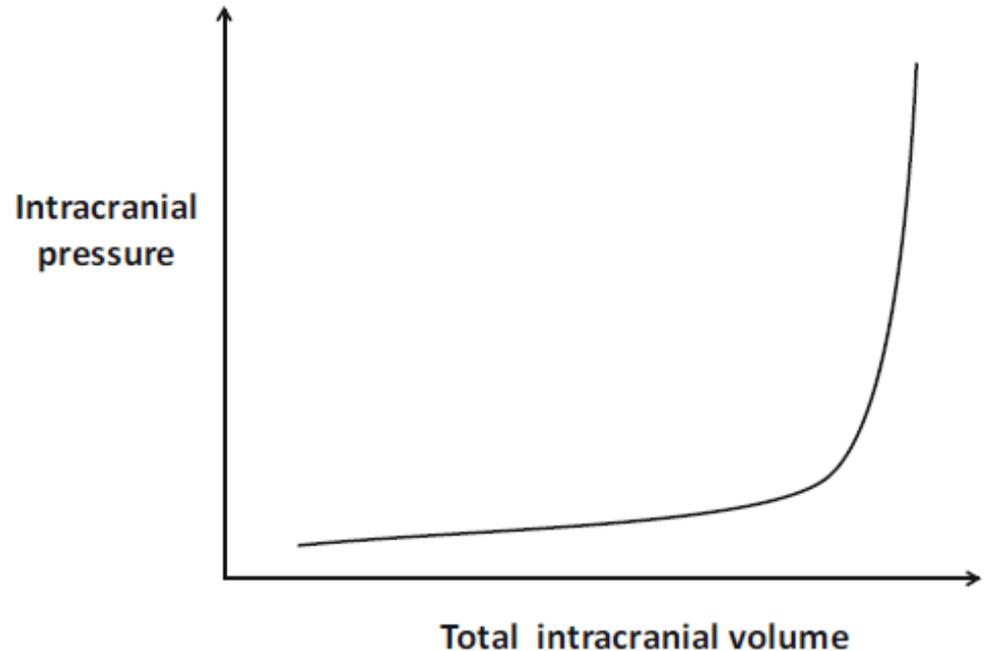
- Patients with neurological catastrophes just became hypoxic and died.
- With Brain Death, issues go beyond medical, now involving cultural, ethical and legal.

The correct determination of brain death is essential in medical care to:

- ensure **inappropriate measures** are not undertaken
- **provide finality** for families unclear about prognosis
- preserve vital **critical care resources**
- open possibility of **organ donation**

How does brain death occur?

1. Increased intracranial pressure compromises cerebral perfusion
2. Herniation compromises vital structures
3. Insufficient blood flow and hypoxia kills neurons



Duret hemorrhages



Background



- Mollaret and Goulon initially introduced the term in 1959, when they described 23 patients with “irreversible coma,” with
 - Unresponsiveness
 - Loss of brainstem reflexes
 - Loss of spontaneous respirations
 - Flat EEGs

Mollaret P, Goulon M. Le coma dépassé. *Rev Neurol.* 1959;101:3-15.

Brain Death History

**Harvard Report
(1968)**

*"Irreversible Coma"
No brainstem reflexes
"Flat" EEG
Proposed brain death*

**NIH Collaborative Study
(1977)**

*Defined the
futility of brain
death*

President's Commission Report (1981)

*Affirmed the
validity of
brain death*

*Proposed
guidelines on how
to approach brain
death diagnosis*

Uniform Determination of Death Act

Practice parameters for determining brain death in adults

(Summary statement)

Report of the Quality Standards Subcommittee of the American Academy of Neurology

Practice Parameters published in 1995, based on the Uniform Determination of Death Act (UDDA): “An individual who has sustained either 1) irreversible cessation of circulatory and respiratory functions, or 2) irreversible cessation of all functions of the entire brain, including the brain stem, is dead. A determination of death is made with acceptable medical standards.”

Uniform Determination of Death Act, 12 uniform laws annotated 589 (West 1993 and West suppl 1997)



Evidence-based guideline update: Determining brain death in adults

Report of the Quality Standards Subcommittee of the American Academy of Neurology



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ABSTRACT

Objective: To provide an update of the 1995 American Academy of Neurology guideline with regard to the following questions: Are there patients who fulfill the clinical criteria of brain death who recover neurologic function? What is an adequate observation period to ensure that cessation of neurologic function is permanent? Are complex motor movements that falsely suggest retained brain function sometimes observed in brain death? What is the comparative safety of techniques for determining apnea? Are there new ancillary tests that accurately identify patients with brain death?

Methods: A systematic literature search was conducted and included a review of MEDLINE and EMBASE from January 1996 to May 2009. Studies were limited to adults (aged 18 years and older).

Results and recommendations: In adults, there are no published reports of recovery of neurologic function after a diagnosis of brain death using the criteria reviewed in the 1995 American Academy of Neurology practice parameter. Complex-spontaneous motor movements and false-positive triggering of the ventilator may occur in patients who are brain dead. There is insufficient evidence to determine the minimally acceptable observation period to ensure that neurologic functions have ceased irreversibly. Apneic oxygenation diffusion to determine apnea is safe, but there is insufficient evidence to determine the comparative safety of techniques used for apnea testing. There is insufficient evidence to determine if newer ancillary tests accurately confirm the cessation of function of the entire brain. *Neurology*® 2010;74:1911-1918

Question #1: Are there patients who fulfill the clinical criteria of brain death who recover neurologic function?

- “In adults, recovery of neurologic function has not been reported after the clinical diagnosis of brain death has been established using the criteria given in the 1995 AAN practice parameter.” (Level U)

Question #2: What is an adequate observation period to ensure that cessation of neurologic function is permanent?

- “There is insufficient evidence to determine the minimally acceptable observation period to ensure that neurologic functions have ceased irreversibly.” (Level U)

Question #3: Are complex motor movements that falsely suggest retained brain function sometimes observed in brain death?

“For some patients diagnosed as brain dead, complex, non-brain-mediated spontaneous movements can falsely suggest retained brain function. Additionally, ventilator autocycling may suggest patient-initiated breathing.” (Level C)

Spinally mediated reflexes include DTR's, triple flexion, Babinski's sign. Also the “Lazarus sign” with slight spontaneous abduction or adduction of an extremity, raising of the torso to a 40-60° angle, head turning to one side, arm raising, and back arching. In some patients this may be seen in synchrony with ventilator-delivered breaths.

Question #4: What is the comparative safety of techniques for determining apnea?

“Apneic oxygenation diffusion to determine apnea is safe, but there is insufficient evidence to determine the comparative safety of techniques for apnea testing.” (Level U)

Question #5: Are there new ancillary tests that accurately identify patients with brain death?

“Because of a high risk of bias and inadequate statistical precision, there is insufficient evidence to determine if any new ancillary tests accurately identify brain death.” (Level U)

Practical (non-evidence-based) guidance

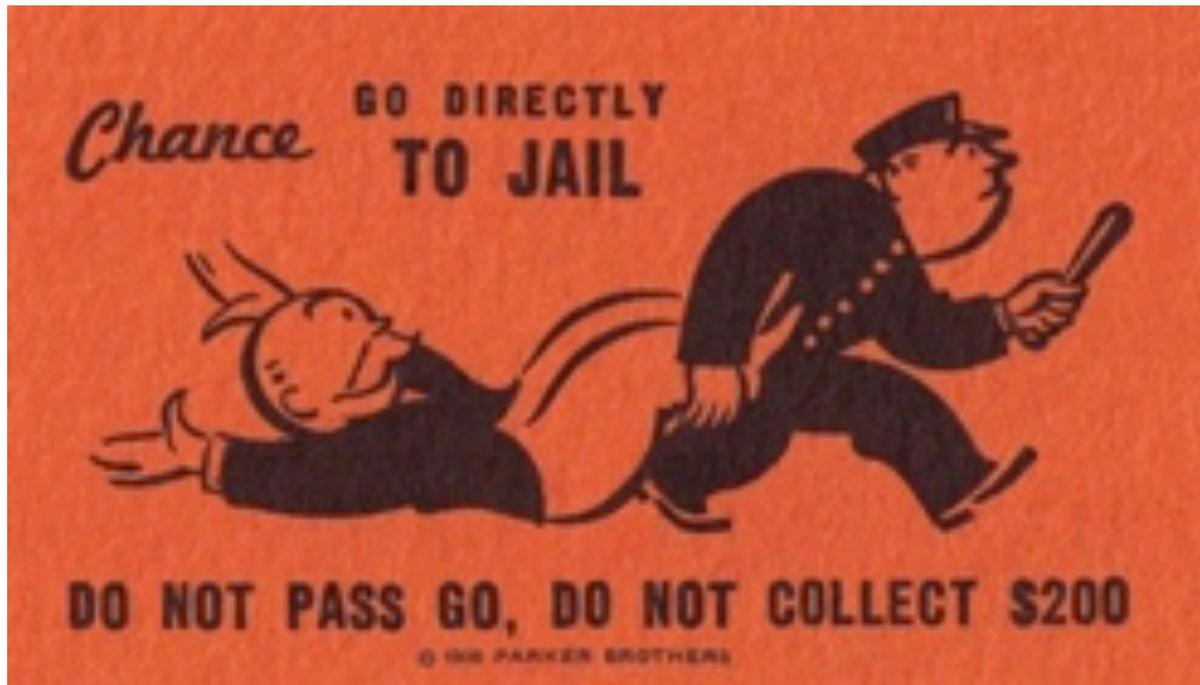
“Many of the details of the clinical neurological examination to determine brain death cannot be established by evidence-based methods. The detailed brain death evaluation protocol that follows is intended as a useful tool for clinicians. It must be emphasized that this guidance is opinion-based.”

Brain Death Determination: 4 Steps

1. Prerequisites
2. Neuro exam, including apnea test
3. Ancillary testing (if needed)
4. Documentation

Clinical Evaluation – Prerequisites

- CARDINAL RULES:
 - Establish cause of coma
 - Establish irreversibility



Establish Cause + Avoid Pitfalls

- Cause determined by history, examination, neuroimaging or lab tests
- Exclude CNS-depressant drug effect:
 - History
 - drug screen
 - calculation of clearance using 5 times the drug's half-life (assuming normal hepatic and renal function)
 - drug plasma levels in the therapeutic range
 - BAL of $< 0.08\%$ is a practical threshold
- N.B.: Prior use of hypothermia may delay drug metabolism

Clinical Evaluation – Prerequisites

- No paralysis (train of 4, or DTRs)
- No “severe” electrolyte, acid-base, or endocrine disturbance (defined by severe acidosis or laboratory values markedly deviated from the norm)
- Core temperature: **>36° C**
- Systolic blood pressure: **≥100 mm Hg**

Clinical Evaluation – Prerequisites

- Number of examinations: “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), 1 neurologic examination should be sufficient to pronounce brain death. However, some US state statutes require 2 examinations.”
- All physicians are allowed to determine brain death in most US states. “Some US state or hospital guidelines require the examiner to have certain expertise.”

Clinical Evaluation – Neurologic Assessment

3 cardinal features:

1. Coma
2. Absence of brainstem reflexes
3. Apnea

Clinical Evaluation – Neurologic Assessment

- **Coma**: complete unresponsiveness
- No eye opening or eye movement to noxious stimulation
- Noxious stimulation produces only spinally-mediated responses (or none)
- Noxious stimulation in all 4 extremities, ***and the cranium***
- Distinguishing between cerebrally- or spinally-mediated responses requires expertise (and sometimes ancillary testing may be necessary)

Blink to threat



Nasal tickle

- Note grimace



Motor testing



Clinical Evaluation – Neurologic Assessment

No pupillary response to bright light in either eye.

Pupils fixed and usually 4-6 mm

Constricted pupils (<2mm)
should suggest possible drug
intoxication.

A magnifying glass/
pupillometer should be used



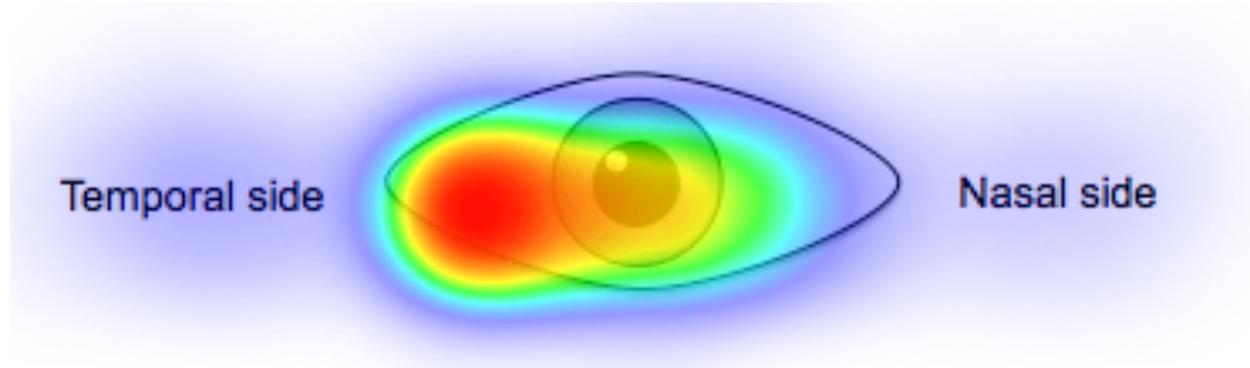
Pupillary reflex

- Using handheld magnifying glass
 - Note ocular dipping
- Using pupilometer



Corneal Reflex

Absent corneal reflex: touch cornea with *adequate* stimulus



Corneal Reflex Testing



What are “Doll’s Eyes”???

What are “Doll’s Eyes”???



Oculocephalic reflex



Clinical Evaluation – Neurologic Assessment

No eye movements to OCR or OVR testing

OCR: Once integrity of C-spine ensured, head is briskly rotated horizontally (and vertically)

OVR:

1. Ensure integrity of auditory canal and TM
2. Elevate head to 30 degrees
3. Irrigate one ear at a time with ice water continuously
4. Observe for eye movements for ~1 minute
5. Wait 5 minutes before testing opposite ear

Oculovestibular reflex



Clinical Evaluation – Neurologic Assessment

Confounding factors for OCR/OVR:

- ◆ **Ototoxic drugs** - aminoglycosides, vanco, some antiepileptic drugs, TCAs, some chemo agents, and anticholinergics
- ◆ **Trauma** to the globes, orbits, or petrous bone
- ◆ Severe globe or facial **edema**

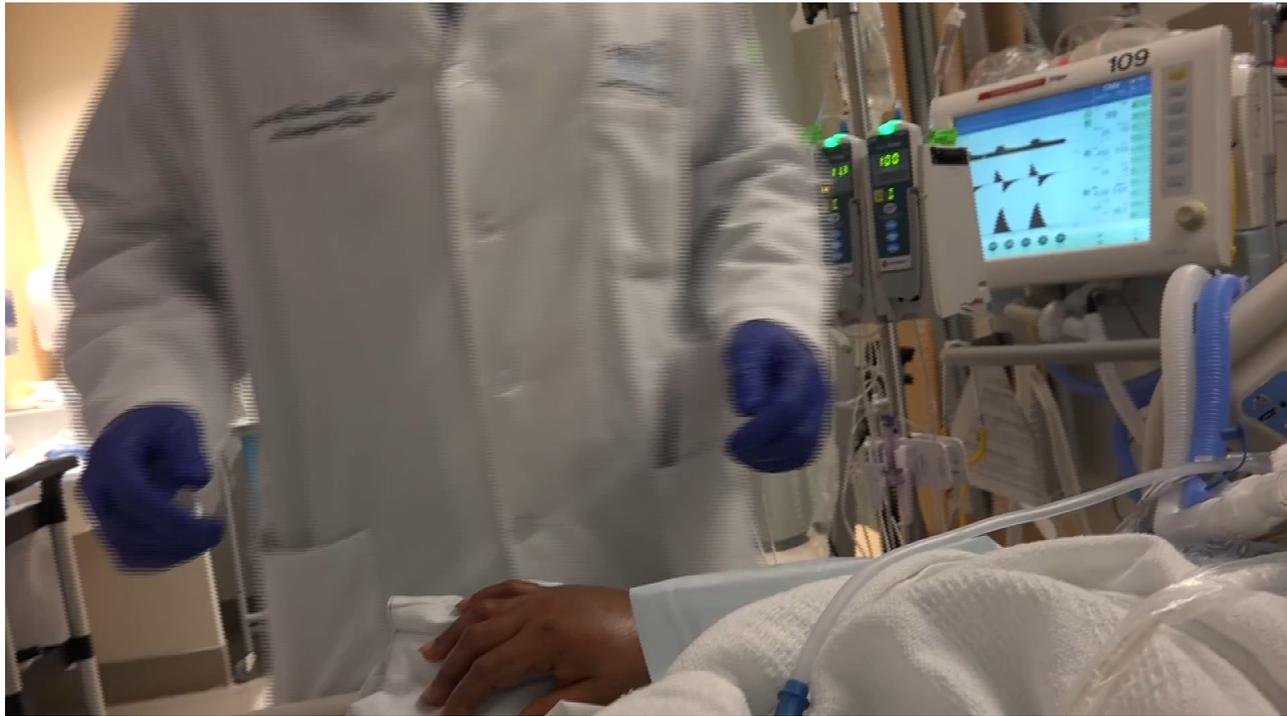
Clinical Evaluation – Neurologic Assessment

- Absent facial movement to noxious stimulation: nasal tickle, pressure on TMJ, supraorbital ridge.
- Facial myokymias are permissible.
- Absent gag: stimulate posterior pharynx with a tongue blade or suction device.
- Assess for cough reflex with tracheal suctioning to level of carina.
- No spontaneous respirations

Gag reflex



Cough reflex



APNEA TESTING

- **Prerequisites:**

- Normotension (≥ 100 mm Hg, with/without pressors)*
- Normothermia ($>36^{\circ}$ C)
- Euvolemia
- Eucapnia (PaCO₂ 35-45)
- No hypoxia
- Consider possibility of CO₂ retention (e.g. COPD, OSA, severe obesity) – need to aim for pCO₂ 20 above elevated baseline

Give yourself a buffer – aim for SBP $>110-120$

APNEA TESTING

- Preoxygenate for at least 10 minutes with 100% oxygen to a PaO₂ of >200 mm Hg
- Reduce minute ventilation to establish eucapnia
- Reduce PEEP to 5 cm H₂O (O₂ desaturation with PEEP=5 should give pause)
- If pulse oximetry O₂ sat remains >95%, obtain baseline ABG
- ***Disconnect the patient from the ventilator***

APNEA TESTING

- Preserve oxygenation by providing oxygen to the level of the carina with 100% O₂ at 4-6 liters/min via a catheter in the ET tube
- Catheter no greater than 70% of diameter of ET tube lumen
- Observe closely for respiratory movements
- Abort if:
 - SBP <**90** mm Hg
 - O₂ sat <**85%** for >**30 seconds**
- If hypoxic can retry procedure with T-piece, CPAP 10 cm H₂O, and 100% O₂ 12 l/min

APNEA TESTING

- If no respiratory drive is observed, repeat ABG after ~10 minutes (can also send at 5 min, 8 min, etc)
- If respiratory movements are absent and arterial PCO₂ is ≥ 60 mm Hg (or 20 mm Hg increase in arterial PCO₂ over an elevated baseline), the apnea test is positive.
- If the test is inconclusive, but the patient was stable during testing, repeat for longer (10-15 minutes), after again adequately preoxygenating and reestablishing normocapnea

Trick of the Trade

- If the patient becomes hypotensive during apnea testing, reconnect the ventilator ASAP and **hyperventilate**



Apnea Testing – potential complications

- The most common complication is hypotension, which typically occurs when there is inadequate pre-oxygenation.
- Tension pneumothorax and cardiac arrest have been reported, both rare.

Common Pitfalls in Brain Death Testing

- **Medications** influencing the examination
- Severe facial trauma
- Pre-existing pupillary abnormalities
- Acid-base disorders, electrolyte disorders
- Sleep apnea or severe pulmonary disease resulting in chronic CO₂ retention

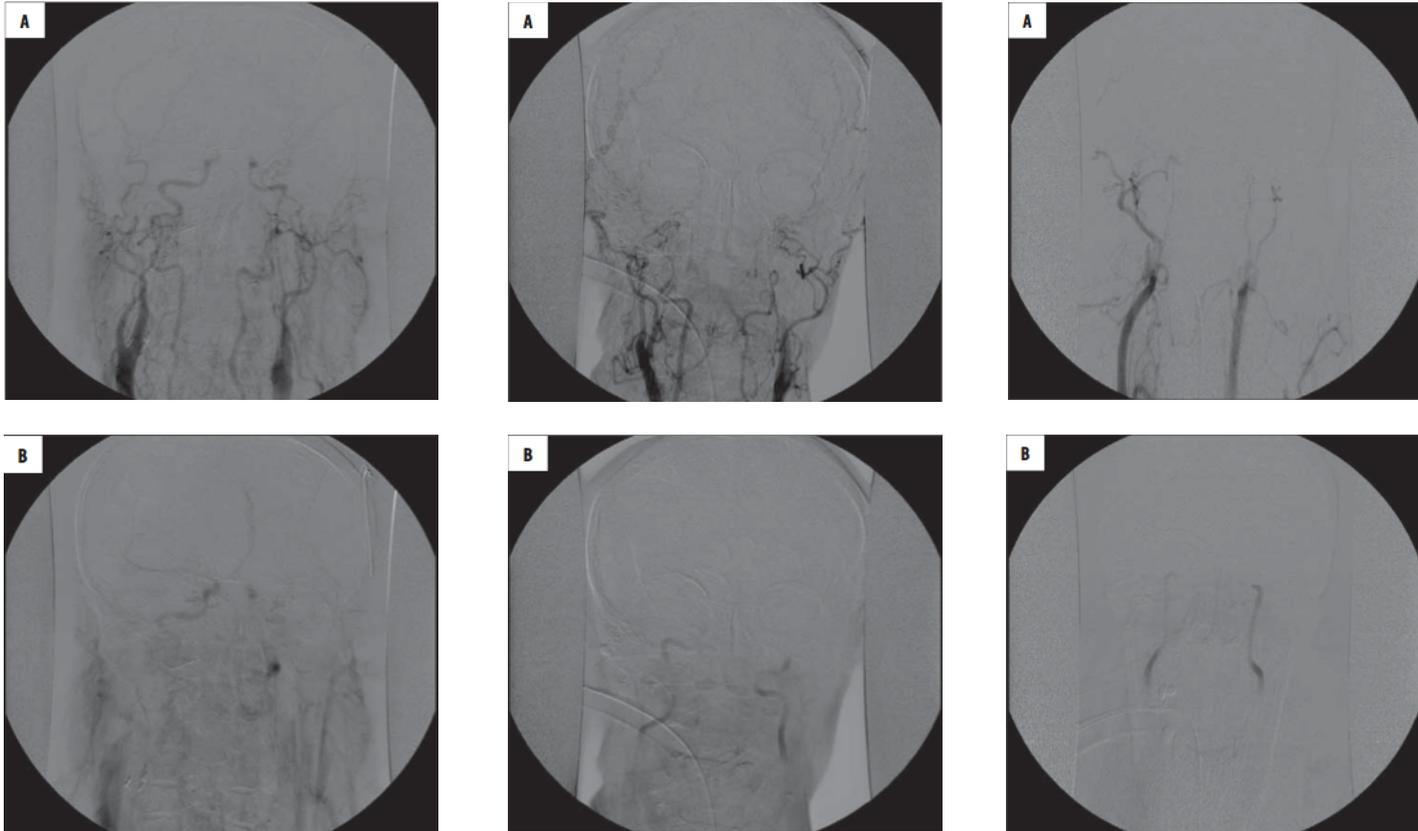
Ancillary Testing

- Brain death is a clinical diagnosis.
- Ancillary testing is not required, unless the clinical exam is drawn into question.
- Even ancillary testing is potentially confounded in certain circumstances.
- **Clinical judgment remains paramount.**
- Preferred tests: SPECT, cerebral angiography, TCD
 - EEG no longer favored, especially without EP

Ancillary Tests – cerebral angiography

- Cerebral angiography should show an absence of flow in all intracranial arteries
- Contrast will typically fill the external carotid circulation, also supplying the meningeal arterial system.
- ICA and vertebral artery flow should arrest at the point of entry at the dura.

4 Vessel Conventional Cerebral Angiogram



Ancillary Testing - SPECT

- SPECT uses ^{99m}Tc -HMPAO, injected 15-30 minutes before scanning.
- There should be an absence of intracranial perfusion, seen as a lack of uptake of tracer.
- Given the persistent extracranial circulation, there is flow to the meningeal and skull vessels, giving rise to such signs as:
 - “hollow skull”
 - “empty light bulb”
 - “hot nose”

Facco E, et al. *Intensive Care Med.* 1998;24:911-917.

37-year-old woman, S/P cardiac arrest

IN DEATH STATICS 12/16/02



100



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Ant 1013K Duration:263sec 256x256 Pix:1.9mm 99m Technetium

Post 898K Duration:263sec 256x256 Pix:1.9mm 99m Technetium



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EEG in Brain Death

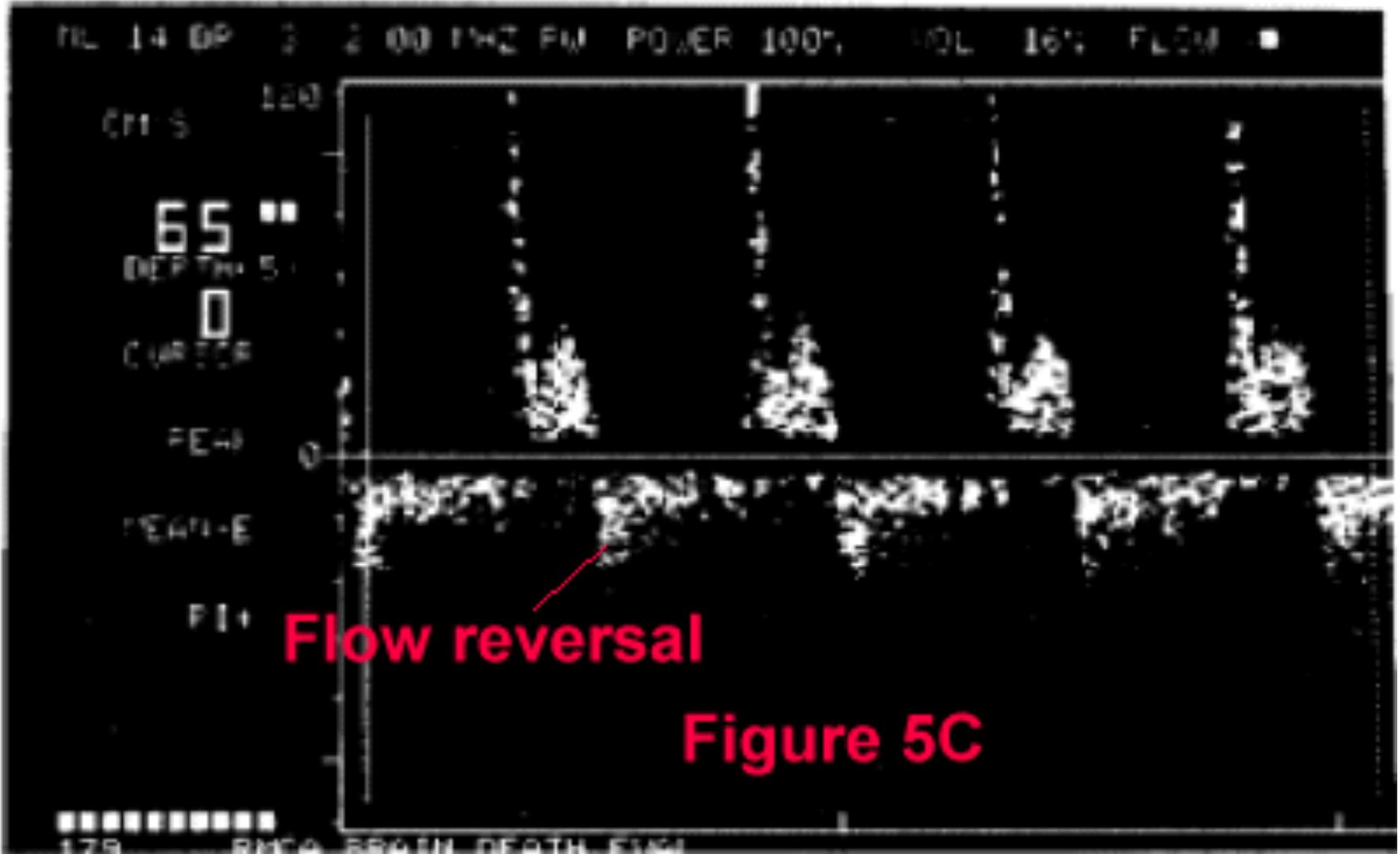


Problems: does not measure brainstem viability, subject to environmental artifact

Ancillary Tests – Transcranial Doppler

- Confirmation of cerebral circulatory arrest with extra- and intracranial Doppler sonography
- Bilateral, anterior and posterior
- Two examinations, 30 minutes apart.
- Systolic spikes or oscillating flow in any cerebral artery (anterior or posterior).
- Disappearance of intracranial flow signals is not reliable

TCD Brain Death



Other Ancillary Tests

- **MRA, CTA** – no prospective studies, NOT VALIDATED!
- Need to be studied vs. gold standard flow study

Documentation

- Time of death is:
 - The time the arterial PCO₂ reached the target value, as reported by the lab
 - The time when the ancillary test has been officially reported by the attending physician

Federal and state law requires the physician to contact an organ procurement organization following determination of brain death. (Hopefully, this has already been done prior to this point.)

APPENDIX 2

Checklist for determination of brain death

Prerequisites (all must be checked)

- Coma, irreversible and cause known
- Neuroimaging explains coma
- CNS depressant drug effect absent (if indicated toxicology screen if barbiturates given, serum level < 10 µg/mL)
- No evidence of residual paralytics (electrical stimulation if paralytics used).
- Absence of severe acid-base, electrolyte, endocrine abnormality
- Normothermia or mild hypothermia (core temperature > 36°C)
- Systolic blood pressure \geq 100 mm Hg
- No spontaneous respirations

Examination (all must be checked)

- Pupils nonreactive to bright light
- Corneal reflex absent
- Oculocephalic reflex absent (tested only if C-spine integrity ensured)
- Oculovestibular reflex absent
- No facial movement to noxious stimuli at supraorbital nerve, temporomandibular joint
- Gag reflex absent
- Cough reflex absent to tracheal suctioning
- Absence of motor response to noxious stimuli in all 4 limbs (spinally mediated reflexes are permissible)

Apnea testing (all must be checked)

- Patient is hemodynamically stable
- Ventilator adjusted to provide normocarbia (PaCO₂ 34–45 mm Hg)
- Patient preoxygenated with 100% FIO₂ for > 10 minutes to PaO₂ > 200 mm Hg
- Patient well-oxygenated with a PEEP of 5 cm of water
- Provide oxygen via a suction catheter to the level of the carina at 6 L/min or attach T-piece with CPAP at 10 cm H₂O
- Disconnect ventilator
- Spontaneous respirations absent
- Arterial blood gas drawn at 8–10 minutes, patient reconnected to ventilator
- PCO₂ \geq 60 mm Hg, or 20 mm Hg rise from normal baseline value
- OR:
- Apnea test aborted

Ancillary testing (only 1 needs to be performed; to be ordered only if clinical examination cannot be fully performed due to patient factors, or if apnea testing inconclusive or aborted)

- Cerebral angiogram
- HMPAO SPECT
- EEG
- TCD

Time of death (DD/MM/YY) _____

Name of physician and signature _____

After Brain Death Diagnosis

- The Law of Required Request: Contact OPO
- Ideal: early notification before pronouncement
- Early OPO involvement is to:
 - Engage their “process” of determination of medical suitability (impacts family discussion)
 - Allow on-site presence to step in without delay after brain death pronouncement
- Determining medical suitability and requesting for possible organ donation is only done by representatives from the OPO

Family Communication (I)

Anticipatory discussions with the family prior to death pronouncement

- Learn about the patient, family, & support system
- Explain and educate about the brain injury
 - Review scans
 - Explain relevant facts to enhance understanding
- Negotiate timetables to enable the family to have optimal support

Family Communication (II)

- For discussions about brain death:
- Review the events that led up to death
- Show and explain any new brain scans and testing
- Explain the mechanisms of death, focusing on neurological:
 - Explain why the heart is still beating in brain dead patients
 - Share the occurrence of death and timing of pronouncement
- The ventilator is a “breathing machine,” not “life support” and its withdrawal is obligatory in most States

Family Communication (III)

- Answer questions about the brain injury, related events and brain death
- Give the family time to process and grieve
- If potentially medically suitable as a donor (by OPO determination)
then discuss the presence of the role of the OPO
- Invite OPO representative in when the family is ready; Defer all
donation questions to OPO

Post OPO Discussion

- Donation: Support until OD
- No Donation: Ventilator removal; timing based on discussion with the family and determining what is best for optimal coping
- Time of death: BD Pronouncement

Determination of Brain Death/Death by Neurologic Criteria

The World Brain Death Project

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IMPORTANCE There are inconsistencies in concept, criteria, practice, and documentation of brain death/death by neurologic criteria (BD/DNC) both internationally and within countries.

OBJECTIVE To formulate a consensus statement of recommendations on determination of BD/DNC based on review of the literature and expert opinion of a large multidisciplinary, international panel.

PROCESS Relevant international professional societies were recruited to develop recommendations regarding determination of BD/DNC. Literature searches of the Cochrane, Embase, and MEDLINE databases included January 1, 1992, through April 2020 identified pertinent articles for review. Because of the lack of high-quality data from randomized clinical trials or large observational studies, recommendations were formulated based on consensus of contributors and medical societies that represented relevant disciplines, including critical care, neurology, and neurosurgery.

EVIDENCE SYNTHESIS Based on review of the literature and consensus from a large multidisciplinary, international panel, minimum clinical criteria needed to determine BD/DNC in various circumstances were developed.

RECOMMENDATIONS Prior to evaluating a patient for BD/DNC, the patient should have an established neurologic diagnosis that can lead to the complete and irreversible loss of all brain function, and conditions that may confound the clinical examination and diseases that may mimic BD/DNC should be excluded. Determination of BD/DNC can be done with a clinical examination that demonstrates coma, brainstem areflexia, and apnea. This is seen when (1) there is no evidence of arousal or awareness to maximal external stimulation, including noxious visual, auditory, and tactile stimulation; (2) pupils are fixed in a midsize or dilated position and are nonreactive to light; (3) corneal, oculocephalic, and oculovestibular reflexes are absent; (4) there is no facial movement to noxious stimulation; (5) the gag reflex is absent to bilateral posterior pharyngeal stimulation; (6) the cough reflex is absent to deep tracheal suctioning; (7) there is no brain-mediated motor response to noxious stimulation of the limbs; and (8) spontaneous respirations are not observed when apnea test targets reach pH <7.30 and PaCO₂ ≥60 mm Hg. If the clinical examination cannot be completed, ancillary testing may be considered with blood flow studies or electrophysiologic testing. Special consideration is needed for children, for persons receiving extracorporeal membrane oxygenation, and for those receiving therapeutic hypothermia, as well as for factors such as religious, societal, and cultural perspectives; legal requirements; and resource availability.

CONCLUSIONS AND RELEVANCE This report provides recommendations for the minimum clinical standards for determination of brain death/death by neurologic criteria in adults and children with clear guidance for various clinical circumstances. The recommendations have widespread international society endorsement and can serve to guide professional societies and countries in the revision or development of protocols and procedures for determination of brain death/death by neurologic criteria, leading to greater consistency within and between countries.

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 Editorial

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Determination of Brain Death/Death by Neurologic Criteria

The World Brain Death Project

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- Endorsed by 27 international societies
- “Labor of love” – started in 2014
- Sought to provide guidance, and promote consistency, to brain death determination worldwide.
- One main paper, 17 supplements!

WBBDP - supplements

- Worldwide variance
- Science of brain death
- Concept of brain death
- Minimum clinical criteria
- Beyond minimum criteria (ancillary studies)
- Pediatric brain death
- ECMO
- TTM
- Documentation
- Qualifications and Education
- Somatic support
- Religion and brain death
- Brain death and the law
- Flow diagram
- Checklist
- Research questions

Confounders (Minimum Criteria Suppl)

Disease Process	Possible exam components confounded
Hypothermia	Complete exam
Muscular paralysis	Complete exam
Sedation/analgesia	Complete exam
Hypoxia	Complete exam
Hypotension	Complete exam
Hypoglycemia	Complete exam
Endocrine or metabolic abnormality	Complete exam
Basal skull fracture with hemotympanum	Oculo-vestibular reflex
Facial trauma	Pupillary response, oculo-vestibular and oculo-cephalic reflexes, cranial pain response
Pulmonary injury/ disease	Apnea test
Cervical spine injury	Corporal pain response, apnea test
Anophthalmia	Pupillary, corneal, oculo-vestibular and oculo-cephalic reflexes

Drug half-lives (Minimum Criteria Suppl)

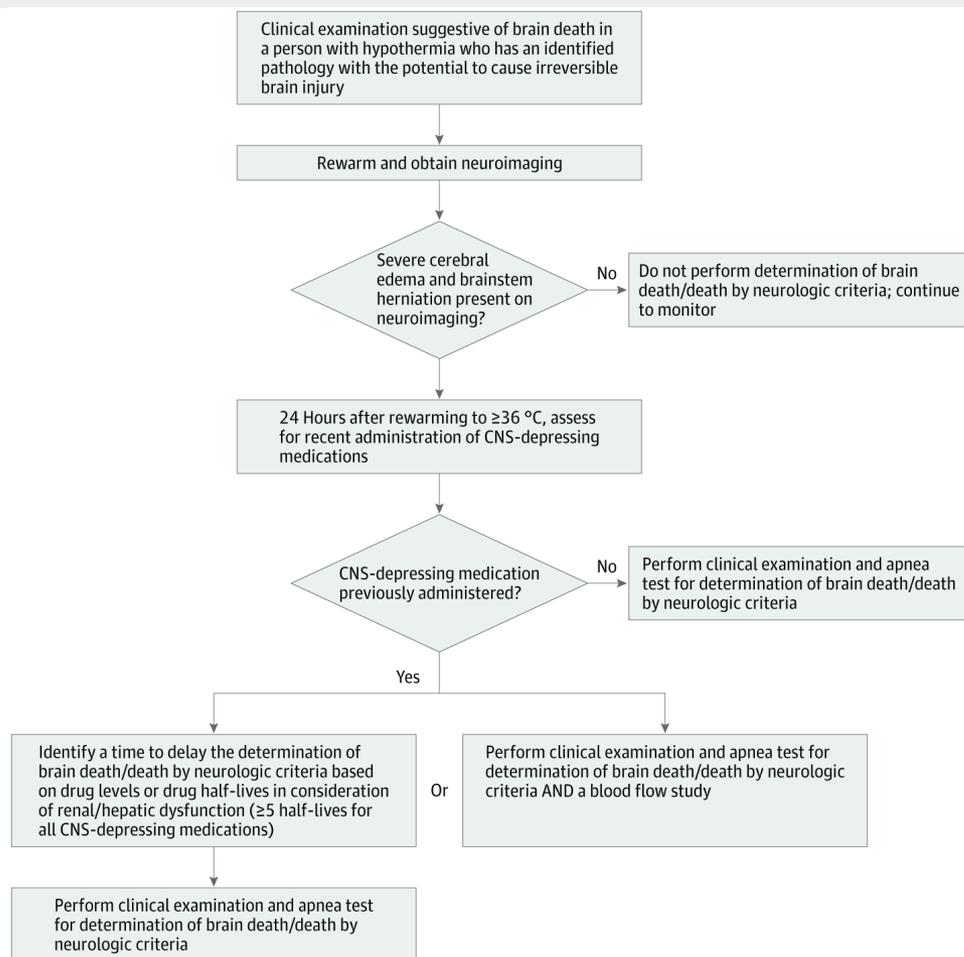
	Drug	Half-life ⁴²	
Opioids	Fentanyl	3.3-4.1 hours	↑CPBS, Aged, Prem; ↔Child
	Oxycodone	2.1-3.1 hours	
Sedatives	Dexmedetomidine	2 hours	
	Diazepam	30-56 hours	↑Aged, LD; ↔HTH
	Lorazepam	9-19 hours	↑LD, Neo, RD; ↔Aged, CPBS, AVH; ↓Burn
	Midazolam	1.3-2.5 hours	↑Aged, Obese, LD; ↔Smoking
	Pentobarbital	15-50 hours	
	Phenobarbital	81-117 hours	↑LD, Aged; ↓Child; ↔Epilepsy, Neo
	Thiopental	8-10 hours	
	Propofol	2.3-4.7 hours	A much longer terminal $t_{1/2}$ was reported following prolonged IV infusion.
	Zolpidem	1.7-2.1 hours	↑Aged, LD; ↔RD; ↓Child
Other	Baclofen	2.8-4.7 hours	
	Bupropion	10-11 hours (7.9-18.4)	↑Aged, LD; ↔Alcohol

Spinal Reflexes (Minimum Criteria Suppl)

Reflex	Description
Decerebrate-type movements ⁵⁴	Spontaneous extension of the extremities
Extensor posturing ⁵⁴	Back arching to the left or right
Eyelid opening ⁵⁴	Opening of the eyelids after nipple stimulation
Fasciculation ⁵⁶	Twitching of contiguous groups of muscle fibers
Head turning ^{54,67-69}	Intermittent head turning from side to side every 10-30 seconds with or without extension of the upper extremities
Hugging ⁵⁴	Flexion of the trunk and movement of the arms in a hugging-like manner
Lazarus sign ^{54-58,62-64}	Bilateral arm flexion, shoulder adduction and hand raising to chest, face or endotracheal tube with dystonic posturing of the fingers
Limb elevation ⁵⁴	Raising of limbs off the bed
Myoclonus ⁵⁶	Twitching or contraction of a muscle or group of muscles
Plantar response ⁵⁶	Plantar flexion
Pronator-extension ⁵⁶	Pronation and extension of the upper extremity
Respiratory-like movements ⁵⁴	Adduction of both shoulders followed by a slow cough-like movement
Repetitive leg movements ⁶⁵	Slight flexion of the leg and foot
Thumbs Up Sign ⁷⁰	Isolated thumb extension
Triple flexion ⁵⁶	Flexion of the thigh, leg and foot
Undulating toe ⁵⁴	Slow flexion then extension of the toes

From: **Determination of Brain Death/Death by Neurologic Criteria: The World Brain Death Project**

Flow Diagram for Determination of Brain Death/Death by Neurologic Criteria in Persons Treated With Therapeutic Hypothermia



From: **Determination of Brain Death/Death by Neurologic Criteria: The World Brain Death Project**

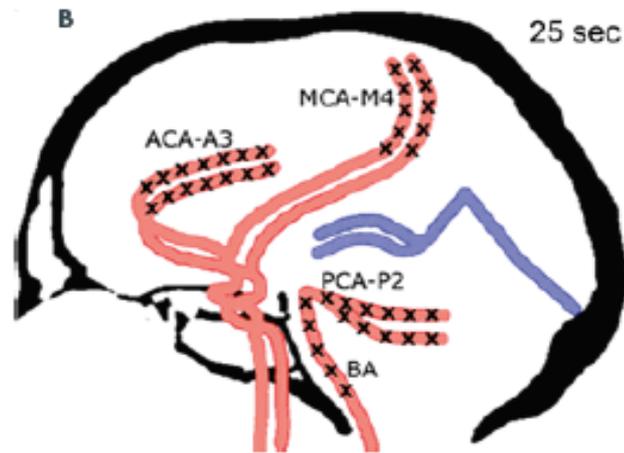
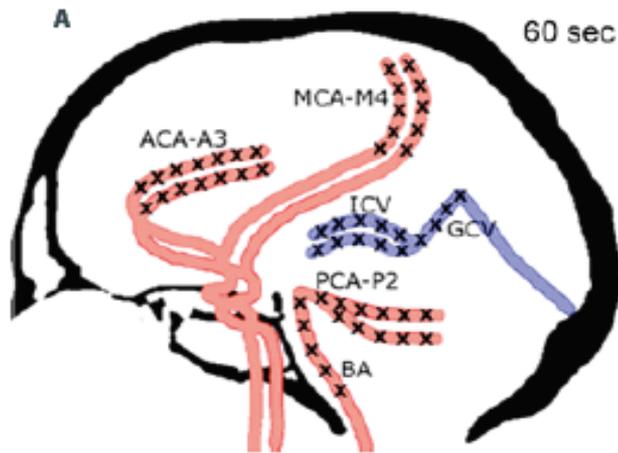
Tests of Electrophysiological Function

Table 2. Tests of Electrophysiological Function

Test	Diagnostic criteria	Advantages	Disadvantages	Sensitivity/ specificity, %	Comments
EEG	No detectable electrical activity ($\geq 2 \mu\text{V}$) over a 30-min period	<ul style="list-style-type: none"> • Noninvasive • Can be performed at bedside 	<ul style="list-style-type: none"> • Predominantly cortical assessment • Electromagnetic environmental noise can erroneously suggest cerebral electrical activity • Confounded by sedation, hypothermia, toxic states, metabolic disorders 	53-80. 4/97 ^{41,72}	Concerns on confounding and interobserver variability limit use; may be more specific used in conjunction with multimodality evoked potential testing
Somatosensory evoked potentials	Bilateral absence of any electrical transmission through the brainstem and cerebrum in the setting of an intact signal in the brachial plexus and spinal cord	<ul style="list-style-type: none"> • Noninvasive • Can be performed at bedside • Less susceptible to sedation than EEG 	<ul style="list-style-type: none"> • Confounded by cervical spinal cord injury, isolated brainstem lesions, sedation, hypothermia 	100/78 ⁷³	Limited specificity as isolated test; may be helpful as component of multimodality evoked potential testing, used in conjunction with EEG
Auditory evoked potentials	Bilateral absence of waveforms through the brainstem to auditory cortex	<ul style="list-style-type: none"> • Noninvasive • Can be performed at bedside • Less susceptible to sedation than EEG 	<ul style="list-style-type: none"> • Confounded by sedation, profound hypothermia, isolated eighth cranial nerve or brainstem lesions • Limited to auditory cortex 		Not useful as isolated test; may be helpful as component of multimodality testing
Visual evoked potentials	Bilateral absence of waveforms through brainstem to visual cortex with preserved electroretinogram	<ul style="list-style-type: none"> • Noninvasive • Can be performed at bedside • Less susceptible to sedation or hypothermia than EEG 	<ul style="list-style-type: none"> • Confounded by sedation, retinal or optic nerve lesions • Limited to visual cortex 		Not useful as isolated test; may be helpful as component of multimodality evoked potential testing

Abbreviation: EEG, electroencephalography.

Limits of CTA (Beyond Minimum Suppl)



Angiographic criteria of BD

Figure 1. Original vs. standard grading scale for CTA diagnosis of BD. In the standard grading scale, BD is diagnosed if no opacification of the following vessels is noted in the 60-second phase (A): ACA-A3, MCA-M4, PCA-P2, BA, ICV and GCV (crosses). In the original scale, the diagnosis of BD is established if 25-second phase (B) shows lack of opacification of the following arteries: ACA-A3, MCA-M4, PCA-P2, BA (crosses) and 40-second phase (C) reveals no filling of the following veins: ICV and GCV (crosses).

- Cortical segments of the right and left middle cerebral artery (MCA-M4),
- Cortical segments of the right and left posterior cerebral artery (PCA-P2),
- Basilar artery (BA),
- Right and left internal cerebral vein (ICV),
- Great cerebral vein (GCV) – the vein of Galen.

From: **Determination of Brain Death/Death by Neurologic Criteria: The World Brain Death Project**

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Perspectives of Major Religions on Brain Death/Death by Neurologic Criteria (BD/DNC)

Table 3. Perspectives of Major Religions on Brain Death/Death by Neurologic Criteria (BD/DNC)

Religion	Perspective on BD/DNC
Buddhism	BD/DNC is accepted as death by some scholars, but this position is not universally held
Christianity	<p><i>American Baptists</i>: there is no official statement on the criteria to declare death, but no opposition to use of neurologic criteria to determine death</p> <p><i>Anglicanism</i>: BD/DNC is accepted as death</p> <p><i>Eastern Orthodoxy</i>: BD/DNC is neither accepted nor rejected</p> <p><i>Evangelicalism</i>: it is accepted that no medical treatment can reverse BD/DNC and noted that “life support” should be removed in the case of BD/DNC to “facilitate the process of dying”</p> <p><i>Jehovah’s Witnesses</i>: there is no official statement on the criteria to declare death, but no opposition to use of neurologic criteria to determine death</p> <p><i>Lutheranism</i>: there are mixed opinions on use of neurologic criteria to determine death</p> <p><i>Presbyterianism</i>: BD/DNC is acknowledged to be widely accepted as death</p> <p><i>Roman Catholicism</i>: BD/DNC is generally accepted as death</p> <p><i>Seventh-day Adventists</i>: there is no official statement on the criteria to declare death, but no opposition to use of neurologic criteria to determine death</p> <p><i>Southern Baptists</i>: there is no official statement on the criteria to declare death, but no opposition to use of neurologic criteria to determine death</p> <p><i>United Methodists</i>: there is no official statement on the criteria to declare death, but no opposition to use of neurologic criteria to determine death</p> <p><i>Unitarian Universalists</i>: there is no official statement on the criteria to declare death, but no opposition to use of neurologic criteria to determine death</p>
Hinduism	BD/DNC is accepted as death by some authorities, but this position is not universally held
Islam	<p><i>Shiism</i>: BD/DNC is generally accepted as death</p> <p><i>Sunnism</i>: mixed opinions on BD/DNC</p>
Judaism	<p><i>Conservative Judaism</i>: BD/DNC is accepted as death</p> <p><i>Orthodox Judaism</i>: mixed opinions on BD/DNC</p> <p><i>Reform Judaism</i>: BD/DNC is accepted as death</p>

Guidelines: Adults \approx Peds

SPECIAL ARTICLE



Evidence-based guideline update: Determining brain death in adults

Report of the Quality Standards Subcommittee of the American Academy of Neurology

American Academy
of Pediatrics 
DEDICATED TO THE HEALTH OF ALL CHILDREN[®]

Guidance for the Clinician in
Rendering Pediatric Care

Clinical Report—Guidelines for the Determination of
Brain Death in Infants and Children: An Update of the
1987 Task Force Recommendations

Important Peds – Adults Guideline Differences

PEDS

- Minimum temp 35C
- 2 exams
- Observation period, varies by age
- Some procedural details lacking
- Different ancillary tests, indications
- Multiple different age groups with different rules

ADULTS

- Minimum temp 36C
- 1 vs. 2 exams
- No observation period (sort of)
- Most procedural details present
- Different ancillary tests, indications

- Aspects can be tightened for both groups of patients.
- Most aspects can be unified as general principles that pertain to both groups.
- There will be a natural “carve out” for peds (e.g. BP for age, cranial physiology below 2 years of age, etc.)

What are we doing to improve the field?

- Educational/training endeavors
 - **Online training and certification**
 - Simulation training
 - “Champions”
- Creation of a national/international standard
 - **Lobby for change of UDDA**
 - Nevada is already there
- AAN position statement on accommodation and pregnancy
- **Merging of adult and child guidelines**
- **Brain Death Toolkit** through Neurocritical Care Society

