



**IN THE NAME OF
GOD**

Brain death

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Most states accept some form of " brain death " as a valid determination of death . The President,s Commission provides the following guidelines:

- 1.The diagnosis of death requires both cessation of function and irreversibility of cessation of either cardiopulmonary system or entire brain (including brainstem)**
- 2. For age <5 years , see brain death in children ,**
- 3. with no "complicating conditions" listed below , there are " ... no cases of brain functions returning following a 6 hr cessation , documented by clinical examination and confirmatory EEG"**
- 4. With conditions such as massive intracerebral tumor with herniation or gunshot wound to the head . it is possible to pronounce death sooner with more certainty than , e.g with post cardiac – arrest anoxia or following a coma of unknown etiology .**
- 5. When death results from criminal assault , or there is the possibility of litigation regarding the death , extra care must be taken and legal counsel may be advisable before making the determination of brain death .**

BRAIN DEATH CRITERIA

Recommendations

A. absence of brainstem reflexes:

1. ocular examination :

A. Fixed pupils : no response to bright light (caution after resuscitation : see below) , usually mid position (4-6 mm) but may vary to dilated range (9 mm) in size

B . absent corneal reflexes

C. absent oculoccephalic (doll,s eyes) reflex (contraindicated if C-spine not cleared)

D. absent oculovestibular reflex (cold water calorics) : instill 60- 100 ml ice water in to one ear (do not do if TM perforated) with HOB at 30 0 .

Brain death is excluded if any eye movement . Wait at least 1 minute for response , and ≥ 5 min before testing the opposite side

2. absent oropharyngeal reflex (gag) to stimulation of posterior pharynx

3. no cough response to bronchial suctioning

- **B. apnea test AKA apnea challenge : no spontaneous respirations after disconnection from ventilator (assesses function of medulla . Since elevating Pa CO₂ increases ICP which could precipitate herniation and vasomotor instability . this test should be reserved for last and only used when the diagnosis of brain death is reasonably certain .**
- **1. PaCO₂ should be >60mmHg without respirations before apnea can be attributed to brain death (if patient does not breathe by this point , they won't breathe at a higher PaCO₂, not valid with severe COPD or CHF)**
- **2. to prevent hypoxemia during the test (with the danger of cardiac arrhythmia or myocardial infarction):**
 - *** Precede the test with 15 minutes of ventilation with 100% O₂**
 - *** Prior to the test , adjust the ventilator to bring the PaCO₂ ≥40 mm Hg (to shorten the test time and thus reduce the risk of hypoxemia)**
 - *** during the test , have passive O₂ flow administered at 6 L / min through either a pediatric oxygen cannula or a No . 14 French tracheal suction catheter (with the side port covered with adhesive tape) passed to the estimated level of the carina .**
- **3. starting from normocapnea , the average time to reach Pa CO₂ = 60 mm Hg is 6 minutes (classic teaching is that Pa CO₂ rises 3 mm Hg /min , but in actuality this varies widely , with an average 3.7 ± 2.3 ; or 5.1 mm Hg/ min if starting at normocarbia) . Sometimes as long as 12 minutes may be necessary**
- **4. the test is aborted prematurely if :**
 - *** the patient breathes : incompatible with brain death**
 - *** significant hypotension occurs**
 - *** if O₂ saturation drops below 80% (on pulse oximeter)**
 - *** significant cardiac arrhythmias occur.**
- **5. if patient does not breathe , send ABG at regular intervals and at the completion of test regardless of reason for termination . If the patient does not breathe for at least 2 minutes after a PaCO₂ > 60 mm Hg is documented , then the test is valid and is compatible with brain death (if the patient is stable and ABGs results are available within a few minutes , the apnea challenge may be continued while waiting for results in case the PaCO₂ is <60)**
- **6. if PaCO₂ stabilizes below 60mm Hg and the PO₂ remains adequate , try reducing the passive O₂ flow rate slightly**

C. no motor function

1. no response to deep central pain
2. ture decerebrate or decorticate posturing or seizures are incompatible with the diagnosis of brain death
3. spinal cord mediated reflex movements (including flexor plantar reflexes , flexor withdrawl , muscle stretch reflexes , and even abdominal and cremasteric reflexes) can be compatible with brain death , and may occasionally consist of complex movements , including bringing one or both arms up to the face , or sitting up (the " Lazarus" sign) especially with hypoxemia (thought to be due to spinal cord is chemia stimulating surviving motor neurons in the upper cervical cord) . If complex integrated motor movements occur , it is recommended that confirmatory testing be performed prior to pronouncement of brain death

D. absence of complicating conditions (that could simulate brain death on exam):

- 1. hypothermia : core temp should be > 32.20 C (90 0F). Below this temp , pupils may be fixed and dilated , respirations may be difficult to detect , and recovery is possible**
- 2. no evidence of remediable exogenous or endogenous intoxication , including durg or metabolic (barbiturates , benzodiazepines , meprobamate , methaqualone , trichloroethylene , paralytics , hepatic encephalopathy , hyperosmolar coma ...) .If there is doubt , depending on circumstances , lab tests including drug levels (serum and urine) may be sent**
- 3. shock (SBP should be ≥ 90 mm hg) and anoxia**
- 4. immediately post – resuscitation : shock , anoxia , and /or (uncommonly) atropine may cause fixed and dilated pupils (for the effect of atropine)**
- 5. patients coming out of pentobarbital coma (wait until level ≤ 10 mcg/ml)**
- 6. confirmation of brain death by use of clinical confirmatory tests (EEG, angiography , CRAG , BSAER ..., see below) is not required , but may be used as determined by judgement of attending or consulting physician**

E. recommended observation periods during which time the patient fulfills criteria of clinical brain death before the patient may be pronounced dead :

- 1. in situation where overwhelming brain damage from an irreversible condition is well established (e. g. massive intracerebral hemorrhage), some experts will pronounce death following a single valid brain death exam in conjunction with a clinical confirmatory test .**
- 2. if an irreversible condition is well established , and clinical confirmatory tests are used :6 hours .**
- 3. if an irreversible condition is well established and no clinical confirmatory tests are used :12 hours .**
- 4. if diagnosis is uncertain and no clinical confirmatory tests :12-24 hours**
- 5. if anoxic injury is the cause of brain death : 24 hours (may be shortened if cessation of CBF is demonstrated)**

CLINICAL CONFIRMATORY TESTS

- **CEREBRAL ANGIOGRAPHY**
- **Criteria : absence of intracranial flow at the level of the carotid bifurcation or circle of Willis) . Filling of the superior sagittal sinus may occur in a delayed fashion . Interobserver validity has not been studied . Not routinely used in the diagnosis of brain death , but may be employed in difficult situations.**

EEG

- Can be done at bedside . Requires experienced interpreter . Does not detect brainstem activity , and electrocerebral silence (ECS) does not exclude the possibility of reversible coma . Thus , at least 6 hours observation is recommended in conjunction with ECS . Using ECS as a clinical confirmatory test should be done only in patients without during intoxication , hypothermia , or shock.
- Definition of electrocerebral silence on EEG : no electrical activity $> 2 \mu V$ with the following requirements :
 - recording from scalp or referential electrode pairs ≥ 10 cm apart
 - 8 scalp electrodes and ear lobe reference electrodes
 - inter- electrode resistance $< 10,000$ (or impedance $< 6,000$) but over 100
 - sensitivity of $2 \mu V/mm$
 - time constants 0.3-0.4 sec for part recording
 - no response to stimuli (pain , noise, light)
 - record > 30 mins
 - repeat EEG in doubtful cases
 - qualified technologist and electro encephalographer with ICU EEG experience
- telephone transmission not permissible

TRANSCRANIAL DOPPLER

- 1. small peaks in early systole without diastolic flow or reverberating flow (indicative of significantly increased ICP)**
- 2. initial absence of Doppler signals cannot be used as criteria for brain death since 10% of patients do not have temporal isonation windows.**

CEREBRAL RADIONUCLIDE ANGIOGRAM (CRAG)

- Can be performed at the bedside with a general purpose scintillation camera with a low energy collimator . May not detect minimal blood flow to the brain , especially brainstem , therefore 6 hours observation in conjunction with CRAG is recommended unless there is a clear etiology of overwhelming brain injury (e.g massive hemorrhage or GSW).
- May be useful to confirm clinical brain death in the following settings:
 - where complicating conditions are present , e.g. hypothermia , hypotension (shock) , drug intoxication
 - severe facial trauma where ocular findings may be difficult or confusing
 - in patients with severe COPD or CHF where apnea testing may not be valid
 - to shorten the observation period , especially when organ donation is a possibility
- **Technique**
 - scintillation camera is positioned for an AP head neck view
 - inject 20-30 mCi of ^{99m}Tc- labeled serum albumin or pertechnetate in a volume of 0.5-1.5 ml into a proximal IV port , or a central line , followed by a 30 ml NS flush
 - perform serial dynamic images at 2 second intervals for 60 seconds
 - then , obtain static images with 400,000 counts in AP and then lateral views at 5, 15 & , 30 minutes after injection
 - if a study needs to be repeated because of a previous non- diagnostic study or a previous exam incompatible with brain death , a period of 12 hours should lapse
- **Findings**
 - No uptake in brain parenchyma= "hollow skull phenomenon " Termination of carotid circulation at the skull base , and lack of uptake in the ACA and MCA distributions (absent "candelabra effect") There may be delayed or faint visualization of dural venous sinuses even with brain death due to connections between the extra cranial circulation and the venous system .

SSEPS

- **Bilateral absence of N20- P22 response with median nerve stimulation .**

ATROPINE

In brain death , an amp of atropine (1mg) should not affect the heart rate due to the absence of vagal tone (it normally increase the heart rate). Although atropine in usual doses does not cause papillary dilatation , it is prudent to examine the pupils first to eliminate uncertainty.

Brain death in children

- **Criteria for death : irreversible loss of cardiopulmonary entire or brain function (as in adult) , but the (clinically unproven) assumption that a child,s brain is more resilient results in more difficult determination of brain death . The following guidelines are proposed for patients <5 yrs age :**
 - **these recommendations are not applicable for the premature infant**
- **determination of proximate cause of coma should be disorders , sedatives , paralytics , hypothermia , hypotension (for age), and surgically treatable conditions**

criteria

- **A: coma and apnea must coexist : including complete loss of consciousness , vocalization and volitional activity**
- **B: absence of brainstem function**
- **1. midposition or fully dilated pupils , unresponsive to light (R/O drug effects)**
- **2. EOM : absence of spontaneous , doll,s eyes and caloric movements of eyes**
- **3. absence of bulbar musculature movement : including oropharyngeal and facial muscles ; absence of corneal , gag , cough , suck , and rooting reflex**
- **4. absence of respiratory movement (usually tested after other criteria met)**
- **5. flaccid tone and absence of spontaneous or induced movements (spinal myoclonus and spinal cord movements , e . g reflex withdrawl are not included)**
- **6. examination results should remain consistent with brain death throughout observation period**

observation periods according to age:

A. in newborns born at or after term (>38wks): 7 days

**B. age 7 days-2 mos :2 examinations and 2 EEGs 48 hrs apart
(repeat exam unnecessary if cerebral radionuclide
angiogram (CRAG) fails to visualize cerebral arteries)**

**C. age 2-12 mos :2 examinations and 2 EEGs 24 hrs apart
(repeat exam unnecessary if CRAG negative)**

**D. age>12 mos : if irreversible condition exists , laboratory
testing is not necessary , and 12 hrs observation is sufficient
(unclear conditions , especially hypoxic – ischemic
encephalopathy are difficult to assess , and 24 hrs
observation is suggested unless electrocerebral silence on
EEG or a negative CRAG confirm diagnosis)**

confirmatory tests

- A. EEG : standard requirement for 10cm electrode distance may be decreased in proportion to size of head**
- B. CRAG: applicability to patient < 2 mos age unproven**

END

