

EDITORIAL

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How I do a brain death examination: the tools of the trade

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Brain death has been accepted universally, although practice differences have eluded consensus [1, 2]. Laws and guidelines have not appreciably changed [3, 4] nor have tools of the trade. The following principles remain: establish the reason for coma (most important), exclude known/unknown confounders (equally important), ascertain the futility of intervention (decided before), prepare the patient for testing (to optimize resolution), and acknowledge clinical examination as the benchmark (essential) [5]. One should ask three questions: Have I tried everything to change the clinical picture? Can I proceed? Can I be fooled?

Brain death examination is hands-on (Fig. 1) and focused on brainstem function: from mesencephalon down to the dorsal medulla oblongata. These seemingly few tests are more than sufficient; other tests (e.g., IV atropine, nasal tickle, and ciliospinal reflex) add nothing. In the mesencephalon, test only one reflex circuit, the pupil response to a high-intensity flashlight. Pupils in brain death are not “fixed and dilated” but mid-position (4–6 mm) due to loss of sympathetic and parasympathetic input. I use a magnifying glass while others use a pupilometer; the only difference between them is several thousand dollars. Several reflex circuits are tested in the pons: absent corneal reflexes; squirt water on the cornea or strike with cotton from the conjunctiva toward and on the cornea. (Sadly, one in five surveyed members of professional organizations does not test correctly [6]). To elicit the oculocephalic reflex, hold the head firmly with two hands while keeping the

eyelids open with thumbs. Eye movement (opposite to head movement) is induced by fast head turning from a middle portion to 90° on both sides. (Obviously, omit this test in a trauma patient with a cervical collar.) Also, eye movements should be absent after irrigating the tympanum with 30 cc ice water. (The normal response in a comatose patient is a very slow deviation of the eyes toward the syringe.) I place pen marks on the eyelid to reference the level of the pupil. Pain grimaces should be absent upon deep pressure to nail beds (reflex hammer), pressure on the supraorbital nerve (thumb), or deep pressure on the temporomandibular joint condyles (index fingers).

In the medulla oblongata, test the gag response with a tongue depressor or suction device into the oral cavity. As it is difficult to see, I insert a gloved finger past the uvula, a more reliable stimulus. Catheter passages through the endotracheal tube while providing suctioning pressure should not elicit a cough response.

Noxious stimuli should not produce a motor response. While there might be a spinally mediated response (i.e., brief, slow movements in the upper limbs, flexion in the fingers, or arm lifting), they are never coordinated decerebrate or decorticate responses [3–6] and diminish with repeated stimulation. Plantar reflexes are absent, but upward toe flexion may occur with a triple-flexion response.

Next is the apnea test. Keep it simple [7]. Review the chest X-ray and blood gas and pre-oxygenate to $\text{PaO}_2 > 200$ mmHg. The factors predicting a problematic apnea test are (1) insufficient pre-oxygenation, (2) high A-a gradient (> 300), (3) oxygen through a T-piece, (4) systolic hypotension (< 90 mmHg), and (5) baseline acidosis (arterial $\text{pH} < 7.30$). Pulmonary edema (or

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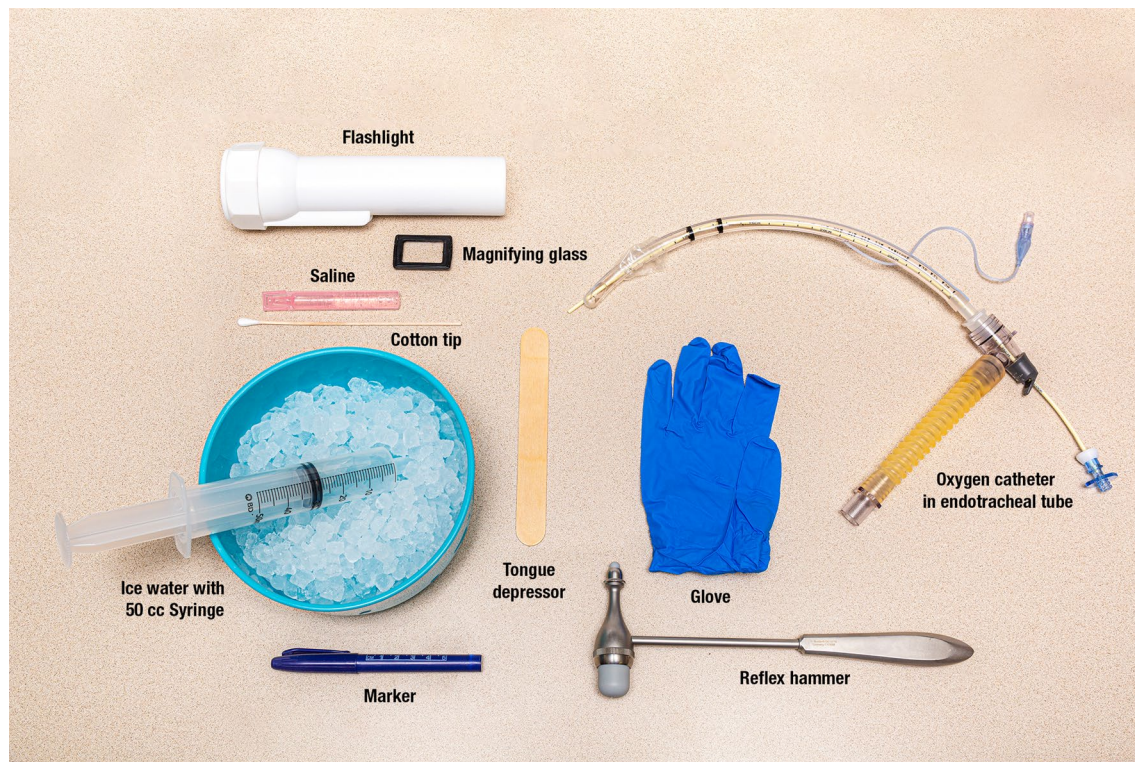


Fig. 1 Simple (low-tech) bedside tools needed to perform a brain death examination. Each object has a function (see text for a description). Note the small oxygen insufflation catheter is placed just out of the endotracheal tube, which can be preset in a dummy endotracheal tube before connection to the patient

massive infiltrates) produces a significant A-a gradient and failure to oxygenate during the test. In some patients, neurogenic pulmonary edema resolves in 48 h, still allowing an apnea test. Especially germane today, apnea testing is unsafe in COVID-19 pneumonia with neurologic complications due to diffuse exudative epithelial denudation of alveoli. A pretest high PEEP may complicate oxygenation after disconnecting the patient; pretest recruitment maneuver and a 20-cm H₂O CPAP valve may be used.

Disconnect the ventilator and flow oxygen (6 L/min) through a catheter advanced to the carina (Fig. 1). Monitor oxygen saturation, pulse, and blood pressure while looking for breathing. Breathing occurs quickly (maybe only an early single gasp). When breathing is absent, declare brain death at a pCO₂ target of 60 mmHg or with a 20 mmHg increase. Conventionally, time of death is the time of the second blood gas result. Complications, usually minor with good preparation, become major with bad or non-standard preparation [7–10]. Our decades-long experience with this oxygen diffusion technique has been safe and aborted in only 3% of 212 tests [9].

ECMO requires adjustment. Blending CO₂ into the oxygenator is the best option. We estimate that an 8% volume of CO₂ results in paCO₂ of 65–70 mmHg. If blending is not available, CO₂ can only be increased by markedly diminishing sweep gas, but this technique risks hypoxia. Additionally, reducing the sweep gas increases the number of expensive blood gasses; it is anyone's guess where PaCO₂ will end up [8, 10].

Ultimately, the physician determining brain death must use his own best judgment. Sequential steps are essential (Fig. 2). Whether one absent pontomesencephalic reflex should prompt an ancillary test is debatable, because death comes with loss of medulla oblongata function. Focus on the functionality of the lower brainstem because there is a vertical loss. It is a one-way door. Ancillary (“confirmatory”) tests remain mandated in a minority of countries as a safeguard or when unable to complete the apnea test. But studies of ancillary tests lacked appropriate controls; comparisons between tests show major discrepancies and technical problems (or even timely availability). In several countries, repeated comprehensive evaluations are required. No literature-based evidence supports a second

25 ASSESSMENTS TO DECLARE A PATIENT BRAIN DEAD

PREREQUISITES (ALL MUST BE CHECKED)

1. Coma, irreversible and cause known
2. Neuroimaging explains coma
3. Sedative drug effect absent
(if indicated, order a toxicology screen)
4. No residual effect or paralytic drug
(if indicated, use peripheral nerve stimulator)
5. Absence of severe acid-base, electrolyte, or endocrine abnormality
6. Normal or near normal temperature
(core temperature $\geq 36^{\circ}\text{C}$)
7. Systolic blood pressure $\geq 100\text{mmHg}$
8. No spontaneous respirations

EXAMINATION (ALL MUST BE CHECKED)

9. Pupils non-reactive to bright light
(typically mid-position at 5-7 mm)
10. Corneal reflexes absent
(use both saline jet and tissue touch)
11. Eyes immobile, oculocephalic reflexes absent
(tested only if C-spine integrity ensured)
12. Oculovestibular reflexes absent
(50 cc of ice water in each ear sequentially)
13. No facial movement to noxious stimuli at supraorbital nerve or temporomandibular joint compression
(absent snout and rooting reflexes in neonates)
14. Gag reflex absent
(gloved index finger to posterior pharynx)
15. Cough reflex absent to tracheal suctioning
(at least 2 passes)
16. No motor response to noxious stimuli in all 4 limbs
(triple flexion response is most common spinal-mediated reflex)

APNEA TESTING (ALL MUST BE CHECKED)

17. Patient is hemodynamically stable
(systolic blood pressure $\geq 100\text{mmHg}$)
18. Ventilator adjusted to normocapnia
(PaCO_2 35-45mmHg)
19. Patient pre-oxygenated with 100% oxygen for 10 minutes ($\text{PaO}_2 \geq 200\text{mmHg}$)
20. Patient maintains oxygenation with a PEEP of 5cm H_2O (if not, consider recruitment maneuver)
21. Disconnect ventilator
22. Provide oxygen via an insufflation catheter to the level of the carina at 6 liters/min or attach T-piece with CPAP valve @ 10-20 cm H_2O and resuscitation bag
23. Spontaneous respirations absent
24. Arterial blood gas drawn at 8-10 minutes, patient reconnected to ventilator
25. $\text{PaCO}_2 \leq 60\text{mmHg}$, or 20mmHg rise from normal baseline value or Apnea test aborted and confirmatory ancillary test (EEG or cerebral blood flow study)

DOCUMENTATION

- Time of death (use time of final blood gas result or use time of completion of ancillary test)

DISCLAIMERS

- A guideline from a professional organization is an educational tool not a mandate.
- US state laws may have additional requirements (type of specialties, need to repeat the examination by a separate examiner).
- Major differences exist throughout the world.
- Religious and cultural objections may exist.

Fig. 2 Steps in declaring brain death

examination contradicting the first. Longer wait times are unsupported by evidence or facts.

Training is warranted but current mannequin-based programs lack validity. Without built-in brainstem reflexes, mannequins cannot simulate spared brainstem reflexes with the notable exception of preserved breathing drive. Simulation is best used to teach the recognition of confounders [11].

Every intensive care physician is able to perform a full clinical brain death examination. Do not resolve clinical uncertainties with an ancillary test with poor specificity. Proceed when you can—with colleagues

if they are available. If available, ask to involve a neurointensivist. For now, we must trust the examiner is fully knowledgeable and competent in all aspects.

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