



Determination of Brain Death

A Little History...

- Advanced cardiopulmonary support created the awareness of neurologic death
- 1959 - Mollaret and Goulon published “le coma dépassé”
 - Foundation for understanding that cessation of neurological function is as important as cessation of cardiorespiratory function for determining death
- 1968 - Harvard Brain Death criteria - set forth clinical standards for the diagnosis of Brain Death/Death by Neurologic Criteria (BD/DNC)
 - Established two categories to declare death: (1) cessation of cardiorespiratory function and (2) BD/DNC
- Early 1980s - Uniform Determination of Death Act
 - Legal basis for establishing BD/DNC
 - BD/DNC equivalent to cardiac arrest – BD/DNC=death (legally)
- 2020 – World Brain Death Project – consensus guidelines

Establishing BD/DNC

- **BD/DNC is a medical & legal definition**
- Does **NOT** require consent or participation by family/surrogate decision-maker
- Efforts should be made to discuss the patient's medical condition & the BD/DNC process with family/surrogate decision-makers
 - but should NOT delay the process
- If family request to continue somatic support after the declaration of BD/DNC:
 - Reasonable brief accommodation (typically $\leq 48\text{h}$) for family to visit & come to terms prior to discontinuation

Establishing BD/DNC

- Patient has sustained a catastrophic, **permanent** brain injury
 - Caused by a mechanism known to lead to BD/DNC
 - Neuroimaging c/w mechanism & injury severity
- Assessment initiated when clinical exam suggests permanent cessation of *all* brain functions
- Should wait a "sufficient" amount of time after injury to ensure no potential recovery
 - Period based on pathophysiology of brain injury
 - Hypoxic-ischemic brain injury – requires min 24h observation after acute injury
 - During this period NO sedating drugs given

Establishing BD/DNC: Rule Out Mimics

- **Hypothermia:** Temperature restored & maintained $\geq 36^{\circ}\text{C}$
 - If temperature was $\leq 35.5^{\circ}\text{C}$ - 24h wait after rewarming to $\geq 36^{\circ}\text{C}$
- **Hypotension:**
 - Pts ≥ 18 years maintain SBP ≥ 100 mmHg & MAP ≥ 75 mmHg
 - Pediatric - maintain SBP & MAP ≥ 5 th percentile for age
 - If baseline BP varies significantly from age-based normal range, target an SBP & MAP that approximate pt baseline
- **Intoxication:** Exclude metabolic derangements, intoxication, or CNS depressing medications
 - Consider renal or hepatic dysfunction, body mass index, age

Table 1: Metabolic Derangements That May Confound BD/DNC Evaluation

Metabolic:	
Ammonia	>75 $\mu\text{mol/L}$
Blood urea nitrogen	>75 mg/dL
Calcium (or ionized calcium)	<7 mg/dL or >11 mg/dL (or <1 mmol/L or >1.3 mmol/L)
Glucose	<70 mg/dL or >300 mg/dL
Magnesium	<1.5 mg/dL or >4 mg/dL
Potassium	<3 mmol/L or >6 mmol/L
Sodium	<130 mmol/L or >160 mmol/L
Acid-Base:	
pH	<7.3 or >7.5
Endocrine:	
Total T4	<3 mg/dL or >30 mg/dL
Free T4	≤ 0.4 ng/dL or >5 ng/dL

Establishing BD/DNC: Clinical Exam

- **Two** clinicians perform a separate & independent examination
 - Pediatric patients 12h minimum separating two exams is required
 - No minimum in adult
- Documentation of each required

Performing BD/DNC Clinical Exam

Examination Component	How to Perform the Examination Component	Response Consistent with BD/ DNC	Clinical Considerations
Coma	<ul style="list-style-type: none">• Visual response is determined by assessing for a blink to visual threat, taking care during the technique not to create a wind wave, thereby inadvertently testing a corneal reflex.• Auditory response is tested with clapping and loud yelling of the person's name, assuming that the patient is hard of hearing at baseline and a loud stimulus is necessary.	<ul style="list-style-type: none">• No evidence of arousal or awareness to maximal external stimulation (including noxious visual, auditory, and tactile stimulation)	Drugs and metabolic derangements may cause reversible coma. Permanency must be established before performing a BD/DNC examination.

Performing BD/DNC Clinical Exam

Motor responses of the face & limbs	<ul style="list-style-type: none">• Apply deep pressure to all of the following:<ul style="list-style-type: none">- the condyles at the level of the temporomandibular joints- the supraorbital notch bilaterally- the sternum- all 4 extremities, both proximally and distally• Insert a cotton swab on a stick in each nostril to perform “nasal tickle” testing	<ul style="list-style-type: none">• Noxious stimuli should not produce grimacing, facial muscle movement, or a motor response of the limbs other than spinally mediated reflexes.• Noxious stimuli above the foramen magnum should not produce any movement in the face or body.• Noxious stimuli below the foramen magnum should not produce any movement in the face but may elicit spinally mediated peripheral motor reflexes.	<ul style="list-style-type: none">• Ancillary testing is recommended if a person has a pre-existing severe neuromuscular disorder, such as amyotrophic lateral sclerosis or a pre-existing severe sensory neuropathy.• Ancillary testing is not required if a person does not have all 4 limbs. Painful stimulation can still be provided centrally and on the torso as close to the termination of the limb as possible.• Severe facial trauma and swelling may preclude evaluation of facial motor response, so ancillary testing is recommended in this setting.
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Performing BD/DNC Clinical Exam

- Spinal reflexes are excluded as motor responses
 - Deep tendon reflexes
 - Plantar reflexes
 - Triple flexion of the legs
 - Toe flexion/extension on plantar stimulation

Table 2: Described Spinal Reflexes in BD/DNC

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

Performing BD/DNC Clinical Exam

Pupillary reflex	<ul style="list-style-type: none">• Dim the room light for several minutes before testing to maximize responsiveness• A bright (e.g., LED) light can be used• Shine a bright light into each of the person's eyes, looking for pupillary constriction and measuring the diameter of the pupils. Use of a magnifying glass may be considered.	<ul style="list-style-type: none">• Ipsilateral and contralateral pupillary response should be absent in both eyes. Pupils in both eyes should be fixed in a midsize or dilated position. Constricted pupils (<2 mm) are not consistent with BD/DNC and suggest possibility of intoxication or locked-in syndrome.	<ul style="list-style-type: none">• Pupils can be any shape (round/oval/irregular).• Corneal trauma or prior ophthalmic surgery may influence pupillary reactivity and preclude adequate evaluation, necessitating ancillary testing.• Ocular instillation of drugs (e.g., anticholinergic) may artificially produce transiently nonreactive pupils.• In the setting of anophthalmia or inability to see the pupils, ancillary testing is recommended.• Automated pupillometers may be a useful adjunct in the examination, as this may detect responsiveness not appreciated by the naked eye. However, automated pupillometers are not validated for use in isolation in BD/DNC. If performed, it must be consistent with no pupillary responses to light bilaterally.• Any pupillary reactivity, whether to bright light or dimming of the ambient light, is not consistent with BD/DNC.
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Performing BD/DNC Clinical Exam

Corneal reflex	<ul style="list-style-type: none">• Touch the cornea of each eye with a cotton swab on a stick at the external border of the iris, applying light pressure and observing for any eyelid movement.• Effective stimulus location is at the border of the iris; testing farther out on the sclera/conjunctiva is less sensitive	<ul style="list-style-type: none">• No eyelid movement should be seen, other than that directly caused by the stimulus.	<ul style="list-style-type: none">• In the setting of anophthalmia, severe orbital edema, prior corneal transplantation, or scleral edema or chemosis, ancillary testing is recommended.
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Performing BD/DNC Clinical Exam

Gag & cough reflexes	<ul style="list-style-type: none">• Stimulate the posterior pharyngeal wall bilaterally with a tongue depressor or rigid suction device. • Stimulate the tracheobronchial wall to the level of the carina with deep endotracheal placement of a suction catheter.	<ul style="list-style-type: none">• Absence of cough and gag.	<ul style="list-style-type: none">• The efferent limb for the cough reflex includes the phrenic nerve, which may be injured in persons with high cervical cord injuries, so ancillary testing is recommended in this setting
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Performing BD/DNC Clinical Exam

Oculocephalic (OCR) & oculovestibular (OVR) reflexes	<p>OCR: Confirm integrity of the cervical spine and skull base, securing the endotracheal tube to prevent accidental dislodgement.</p> <ul style="list-style-type: none">• Rotate the head briskly horizontally to both sides. There should be no movement of the eyes relative to head movement. Testing vertically is optional.• OVR: Examine the auditory canal to ensure patency and the integrity of the tympanic membrane. Presence of a ruptured tympanic membrane does not negate the clinical testing.• Evaluate the head to 30° to place the horizontal semicircular canals in the correct vertical position. Irrigate with ≥50-60mL of ice water for at least 60 seconds using a syringe or a syringe attached to a catheter placed inside the canal. Test both sides separately, with a 5-minute interval between to allow the endolymph temperature to equilibrate.	<ul style="list-style-type: none">• There should be absence of extraocular movements (i.e., the eyes follow the head movement exactly, staying mid-position the entire time).• Detection of any extraocular movements is not compatible with BD/DNC	<ul style="list-style-type: none">• If the OCR cannot be performed, but the OVR is performed bilaterally and there are no extraocular movements, ancillary testing is not required.• A fracture of the base of the skull or petrous temporal bone may obliterate the response on the side of the fracture, and ancillary testing is recommended in this instance.• Severe orbital or scleral edema or chemosis may affect the free motion of the globes, and ancillary testing is recommended in this instance.• In the setting of anophthalmia, ancillary testing is recommended.
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Performing BD/DNC: Apnea Test

- Age ≥ 18 : At **least one** test
- Pediatric: **Two** apnea tests
 - 1 after each BD/DNC clinical exam
- Adjust ventilator to achieve normal PaCo₂ (35-45 mm Hg) & pH (7.35-7.45)
 - If CO₂ retainer – adjust to meet patient's baseline
- Preoxygenate 100% Fio₂ for 10min (aiming for Pao₂ > 200 mm Hg)
- Check ABG to establish baseline pH, Pao₂ , Paco₂ within parameters
- Fully disconnect the patient from the ventilator and start timer
- Provide apneic oxygenation
- Monitor closely for respiratory movements for 8-10 minutes

Performing BD/DNC: Apnea Test

- If no respiratory drive after 8-10 minutes - serial ABG's (~ every 2min)
- Continue until ABG results c/w the following criteria:
 - No respirations or effort occurs *and*
 - Arterial pH <7.30 *and*
 - Paco₂ ≥60 mm Hg & ≥20 mm Hg above pre-apnea test baseline level (or chronic baseline level in CO₂ retainers)
- Terminate apnea test for:
 - Spontaneous respirations
 - Hemodynamic instability or hypoxemia:
 - SBP ≤100 mm Hg or MAP ≤75 mm Hg in adults, or SBP or MAP ≤5th percentile for age in children (despite pressor titration)
 - O₂ sat < 85%
 - Cardiac arrhythmia with hemodynamic instability

BD/DNC Special Considerations

- Pregnancy:
 - Not a contraindication to BD/DNC
 - BD/DNC should be assessed & diagnosed
 - After BD/DNC determination - multidisciplinary team should discuss with pt decision-makers the risks/benefits to the fetus of continuing maternal organ support
- Primary Infratentorial/Posterior Fossa Injury:
 - Need to ensure no retained supratentorial function (whole brain death) *before* BD/DNC eval -
 - Demonstration the infratentorial/posterior fossa process has led to catastrophic supratentorial injury on conventional neuroimaging study