DEATH BY NEUROLOGIC CRITERIA UPDATE FROM THE AMERICAN ACADEMY OF NEUROLOGY

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TERMINOLOGY

- Brain death/death by neurologic criteria (BD/DNC)
  - We will use the term DNC
- Child: >37-weeks-old and <18 years old

American Academy of Neurology Guidelines

- Published in 1994-5, revised in 2010 & 2023
- Attempted to provide an authoritative overview on DNC
- Overall accepted by the medical community
- Justification
  - Need for standardization of the neurologic examination criteria
    - Differences in clinical practice in performing the apnea test
    - Controversies over appropriate confirmatory/ancillary tests

Uniform Determination of Death Act (UDDA) (1981)

This act states that an individual is dead after irreversible cessation of:

- Circulatory and respiratory functions, or
- All functions of the entire brain, including the brain stem

Every state in the United States of America has a policy about declaration of DNC based on the UDDA. Each state has its own specific brain death statute which may denote number and timing of exams. Some states even stipulate the specialties that may declare DNC

Missouri UDDA

194.005. Death, legal definition. — For all legal purposes, the occurrence of human death shall be determined in accordance with the usual and customary standards of medical practice, provided that death shall not be determined to have occurred unless the following minimal conditions have been met:

1) When respiration and circulation are not artificially maintained, there is an irreversible cessation of spontaneous respiration and circulation; or
2) When respiration and circulation are artificially maintained, and there is a total and irreversible cessation of all brain function, including the brain stem and that such determination is made by a licensed physician

Kansas Brain Death Statute

In 1970 Kansas Legislature took the first legal action in an American jurisdiction recognizing the brain death criteria as one determination of death. The statute, proposed by a **physician legislator** and adopted without substantial debate, provides alternative "definitions" of death – one based upon traditional heart-lung functions and the other, upon brain functions. The Kansas Brain Death Statute was the predecessor to the UDDA.

WHY PRONOUNCE DNC?

- DNC is a diagnosis
- Diagnosing DNC relieves the families from the burden of the decision to remove life-sustaining therapy
- Regardless of the organ donation issue, proper DNC diagnosis allows acceptance and closure
- Why not?

FAMILY SUPPORT AND GUIDANCE

- Clinicians should provide support and guidance for families as they face difficult end-of-life decisions for their loved one who has sustained a catastrophic brain injury
- Communication should be clear, concise, and supportive and include simple terminology that families can understand
- **Clinicians should provide the option for the family to observe the clinical evaluation, no consent from family needed**
- Family language: *"Some families find it helpful to watch the tests we do to determine if there is any life left in the brain. Would you like to be present for the examination?"*

IDENTIFY MECHANISM OF BRAIN INJURY

- Patient has sustained a catastrophic, permanent brain injury caused by an identified mechanism that is known to lead to DNC
- Further diagnostic evaluation if there is not an identified mechanism of brain injury
- Ensure neuroimaging is consistent with mechanism and severity of brain injury

ESSENTIALS OF DNC

- DNC is the (irreversible) now replaced by permanent loss of ALL functions of the brain, including the brainstem
- Three essential findings in DNC are:
  1. Coma
  2. Absence of brainstem reflexes
  3. Apnea
- A patient determined to be DNC is LEGALLY and CLINICALLY dead
- Diagnosis of DNC is mainly clinical - no other tests are required if the full clinical exam plus apnea test are conclusively performed

How Many Examinations

- Adult
  - Clinicians **must** perform a minimum of 1 examination for DNC
  - The neurologic examination is a *required* component of the DNC examination Performance of 2 independent DNC examinations may decrease the risk of a false positive determination due to diagnostic error
  - In adults, a second clinician *may* perform a separate and independent examination for DNC
- Children
  - 2 clinicians **must each** perform a separate and independent examination for DNC
  - A minimum interval of 12 hours should separate the 2 exams

Examination - Test Everything You Can

- All elements of the DNC exam that can be assessed, **must** be assessed and findings **must** be consistent with DNC
- When the accurate evaluation of a component of the DNC examination can't be assessed safely, clinicians must perform ancillary testing to complete DNC testing
- If any components of the neurologic exam are inconsistent with DNC, the patient does NOT meet criteria for DNC
- Never go straight to ancillary testing! Test everything you can, including apnea testing

OBSERVATION FOR PERMANENCY

- Observation period should be based on pathophysiology of brain injury leading to neurologic status of the patient
  - <24 months: Observe for at least 48 hours
  - ≥24 months: Observe for at least 24 hours after hypoxic-ischemic brain injury
- After medical or surgical interventions to treat elevated ICP, clinicians must wait enough time to ensure there is no recovery of brain function before initiating DNC evaluation

SUPPORTING DATA

- The following criteria must be met prior to performing the neurologic exam
  - Absence of shock
  - Systolic blood pressure ≥100mmHg
  - Absence of confounding hypothermia with a temperature greater than 36 degrees C/96.8 degrees F for at least 24 hours
  - Absence of drug intoxication, poisoning or neuromuscular agents
  - Absence of sedatives and/or CNS depressants (5 half-lives)
    - Alcohol <80 mg/dl
  - Absence of severe metabolic disturbances and/or sever electrolyte imbalance
- Family language: *"We have checked to be sure there is nothing that could interfere with his/her ability to respond (temp, labs, meds)."*
- Nurses play a critical role to advocate for maintaining hemodynamic stability to prepare patient for DNC testing!

Hemodynamics

Pulmonary Management

Urine Output

Electrolytes Coags Temp

Catastrophic Brain Injury Guidelines

Consider obtaining a critical care consult if not already involved in patient care (if available)

Maintain SBP > 100 (MAP > 60)

1. Consider invasive hemodynamic monitoring
2. Ensure adequate hydration to maintain euvolemia
3. Consider adding vasopressor support if hypotension persists post-adequate hydration

Maintain urine output > 0.5 mL/kg/hr (< 400 mL/hr (consider DI if > 400 mL/hr x 2 hours)

1. Treat diabetes insipidus with vasopressin drip 1 – 2.5 u/hr; if UO still > 400 mL/hr, give DDAVP 0.5 mcg IVP every 2 – 3 hours
2. If UO falls below 0.5 mL/kg/hr, assess fluid status — may need rehydration or BP support

Maintain PO2 > 100 and pH 7.35 – 7.45

1. Adequate ventilation: 5.0 – 8.0 PEEP; aggressive respiratory hygiene if not contraindicated by patient's condition (suction and turn Q2 hours); respiratory treatments to prevent bronchospasm

Other orders to consider

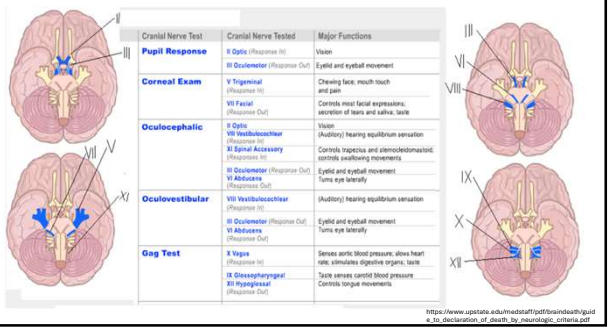
1. Monitor and treat electrolytes maintaining the following
   - Sodium: 134 – 145 mmol/L
   - Potassium: 3.5 – 5.0 mmol/L
   - Magnesium: 1.8 – 2.4 mEq/L
   - Phosphorus: 2.0 – 4.5 mg/dL
   - Ionized calcium: 1.12 – 1.3 mmol/L
2. Monitor glucose and treat with IV insulin drip if needed (keep 80 – 200) rather than SQ
3. Monitor and treat Hgb/Hct/coagulation factors (especially if GSW or other penetrating head injury)
   - Maintain Hgb > 8.0 g/dL and Hct > 24%
   - If PT > 18.0, give 2 u FFP
   - If fibrinogen 70 – 100, give 2 u FFP; if < 70, give cryoprecipitate
   - If platelets < 50, give 6 pk of platelets

   Remember to re-check labs after treatment
4. Maintain temp 36 – 37.5°C with Bair Hugger™ warming/cooling blanket

NEUROLOGIC EXAM

- **Required** to declare DNC
- Assessment of cranial reflexes
  - Response to pain, pupillary response, doll's eyes reflex, oculovestibular (cold caloric), corneal, gag and cough reflex
- Family language: *"We are going to … The normal response is to …"*
- Apnea testing if no observed reflexes during exam

CRANIAL NERVE EXAMINATION



Cranial Nerve Test	Cranial Nerve Tested	Major Functions
Pupil Response	II Optic (Response In)	Vision
	III Oculomotor (Response Out)	Eyelid and eyeball movement
Corneal Exam	V Trigeminal (Response In)	Chewing face; mouth touch and pain
	VII Facial (Response Out)	Controls most facial expressions; secretion of tears and saliva; taste
Oculocephalic	II Optic	Vision
	VIII Vestibulocochlear (Response In)	(Auditory) hearing equilibrium sensation
	XI Spinal Accessory (Response In)	Controls trapezius and sternocleidomastoid; controls swallowing movements
	III Oculomotor (Response Out)	Eyelid and eyeball movement
	VI Abducens (Response Out)	Turns eye laterally
Oculovestibular	VIII Vestibulocochlear (Response In)	(Auditory) hearing equilibrium sensation
	III Oculomotor (Response Out)	Eyelid and eyeball movement
	VI Abducens (Response Out)	Turns eye laterally
Gag Test	X Vagus (Response In)	Senses aortic blood pressure; slows heart rate; stimulates digestive organs; taste
	IX Glossopharyngeal	Taste senses carotid blood pressure
	XII Hypoglossal (Response Out)	Controls tongue movements

https://www.upstate.edu/medstaff/pdf/braindeath/guide_to_declaration_of_death_by_neurologic_criteria.pdf

APNEA TEST – PREREQUISITES

- Ensure the patient is not hypoxemic, hypotensive, or hypovolemic before starting the apnea test
- Euvolemia (especially in the setting of DI)
- Eucapnia (PaCO2 35-45)- unless CO2 retainer
- pH 7.35-7.45
- Correct hypoxia as able
- Functioning A-line for B/P monitoring and ABGs
- Nurses and R/Ts play a critical role in preparing patient for apnea testing!

APNEA TESTING

- Preoxygenate to a PaO2 of >200mm Hg
- Reduce PEEP to 5cm H2O (adults)
  - O2 desaturation with PEEP+5 should give pause
- If O2 sat remains >95%, obtain baseline ABG
- **Disconnect the patient from the ventilator**

Methods to Preserve Oxygenation

- Provide oxygen to the level of the carina with 100% O2 at 4-6 liters/min via catheter in the ET tube
  - Catheter no great than 70% of diameter of ET tube lumen
- Alternative methods
  - CPAP with O2 at 100%
  - 100% O2 through a flow inflating resuscitation bag with a functioning PEEP value
- Chronic hypercarbia baseline (if known) PCO2 level should be used prior to apnea test. If unknown, use the PCO2 level prior to apnea test
- Protocol for apnea testing in patients on ECMO introduced (see guidelines)

Apnea Testing

- Observe thorax and abdomen for respiratory movements
- Abort if:
  - One or more spontaneous respirations
  - SBP<100mm Hg or MAP <75 mm Hg in adults
    - <5th percentile in children
  - Progressive decrease in O2 sat <85%
  - Cardiac arrhythmia with hemodynamic instability
- If hypoxic can retry procedure with alternative methods:
  - CPAP with O2 at 100%; flow inflating resuscitation bag with a functioning PEEP value

Apnea Testing

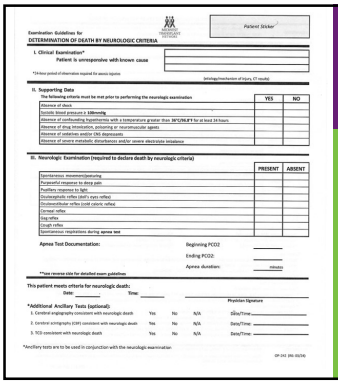
- If no respiratory drive is observed, obtain ABG after ~10 minutes (can also send at 5 min, 8 min, etc.)
- If respiratory movements are absent and arterial PCO2 is ≥60 mm Hg AND 20 mm Hg above baseline, and pH<7.30, the apnea test is positive
- If the test in inconclusive, but the patient was stable for testing, repeat for longer (10-15 minutes), after again adequately preoxygenating and reestablishing normocapnia and normal pH

APNEA TEST – FAMILY LANGUAGE

- We are now going to proceed with the apnea or breathing test. We are going to turn off the ventilator and see if he/she initiates any breaths on his/her own. At the end of the test, we will draw some blood and turn the ventilation back on. Would you like to stay in the room and observe this test?"
  - "If at any time his/her blood pressure or oxygenation drop significantly, we will stop the test and restart the ventilator."
  - "We are going to uncover his/her chest so we can closely watch to see if he/she takes any breaths."

Time of Death Documentation

- Document the time the ABG results are consistent with DNC
- Document the time the clinician reading the ancillary study records the results are consistent with DNC



Examination Guidelines for
DETERMINATION OF DEATH BY NEUROLOGIC CRITERIA

Patient Sticker

I. Clinical Examination*
Patient is unresponsive with known cause

*If there period of observation required for severe injuries

(etiology/mechanism of injury, CT results)

II. Supporting Data
The following criteria must be met prior to performing the neurologic examination

	YES	NO
Absence of shock		
Systolic blood pressure is ≥90mmHg		
Absence of confounding hypothermia with a temperature greater than 36°C/96.8°F for at least 24 hours.		
Absence of drug intoxication, poisoning or neuromuscular agents		
Absence of sedatives and/or CNS depressants		
Absence of severe metabolic disturbances and/or severe electrolyte imbalance		

III. Neurologic Examination (required to declare death by neurologic criteria)

	PRESENT	ABSENT
Spontaneous movement/posturing		
Purposeful response to stimuli		
Pupillary response to light		
Oculocephalic reflex (doll's eyes reflex)		
Oculovestibular reflex (cold caloric reflex)		
Corneal reflex		
Gag reflex		
Cough reflex		
Spontaneous respirations during apnea test		

Apnea Test Documentation:
Beginning PCO2: _____
Ending PCO2: _____
Apnea duration: _____ minutes

**See reverse side for detailed exam guidelines

This patient meets criteria for neurologic death:
Date: _____
Time: _____
Physician Signature

*Additional Ancillary Tests (optional):

1. Cerebral angiography consistent with neurologic death	Yes	No	N/A	Date/Time:
2. Cerebral scintigraphy (CSP) consistent with neurologic death	Yes	No	N/A	Date/Time:
3. TCD consistent with neurologic death	Yes	No	N/A	Date/Time:

*Ancillary tests are to be used in conjunction with the neurologic examination

OP-241 (R6-03/16)

DNC CHECKLIST

SPINAL RESPONSES

https://www.youtube.com/watch?v=Nty6bICZlyA

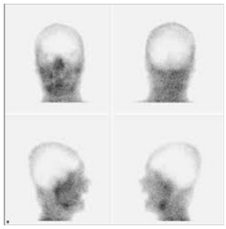
Ancillary Testing – When Is It Used?

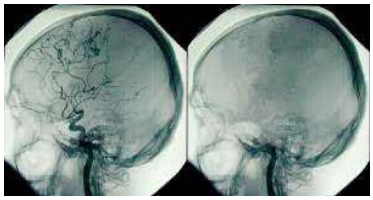
- Only used to assist with diagnosis of DNC when neurologic exam or apnea exam cannot be completed. Circumstances include:
  - Factures of face, skull, cervical spine, or orbits
  - Risk for cardiopulmonary decompensation or instability
  - Difficult to interpret neurologic exam findings
  - Metabolic derangements that cannot be corrected
  - Document why ancillary testing is being used
- Neuro exam and apnea testing must be performed to the fullest extent possible prior to ancillary testing

ANCILLARY TESTING

- **Acceptable tests <u>ONLY</u> include:**
  - 4-vessel angiography
  - Radionuclide cerebral scintigraphy (SPECT)
  - Transcranial doppler
- Unacceptable tests
  - Test of electrophysiologic function: EEG , AEP, SSEP
  - Tests of cerebral perfusion: CTA, MRA, MRI

ANCILLARY TESTS





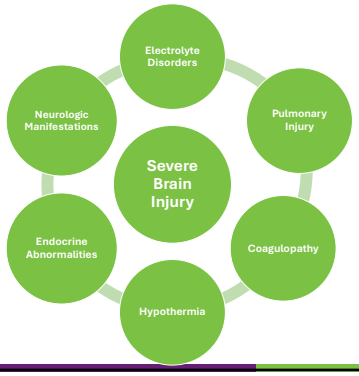
Special Considerations: DNC evaluation in a patient who is pregnant

- Pregnancy is not a contraindication to DNC evaluation
- After DNC determination in a pregnant person, clinicians with expertise in maternal-fetal medicine, child neurology and neonatology should educate surrogate decision-makers about the risks and benefits to the fetus of continuing maternal organ support

Pediatric Guidelines

Determination of brain death in term newborns, infants and children is a clinical diagnosis based on absence of neurologic function with a known irreversible cause of coma. <37 weeks not included.
2 exams including apnea test 12 hours apart by 2 separate physicians
24 hours for newborns to 30 days
Deferred for 24 hours following CPR or brain injury
Infants' exam includes absent sucking or rooting reflexes
Ancillary test include EEG and radionuclide cerebral blood flow

CARDIOVASCULAR PHYSIOLOGY OF A DNC DONOR



CEREBRAL ISCHEMIA

- During the process of herniation, the body tries to preserve cerebral blood flow
- Stimulation of vagal and sympathetic systems
- Cushing's triad – hypertension, bradycardia and abnormal breathing

BRAIN STEM ISCHEMIA

- Necrosis of nerve cells in the medulla causes unchallenged sympathetic activation
- "Autonomic storm" – 800 to 1,200 times increase in catecholamine levels in blood
- Increased SVR, CO, heart rate, MAP, cardiac O_2 demand
- Can cause myocardial ischemia and/or arrhythmias

SPINAL ISCHEMIA

- May occur minutes to hours after storm
- Loss of sympathetic overdrive
- Vasodilation, decreased BP, HR, contractility
- This stage represents greatest risk to donor organs

HORMONAL EFFECTS OF BD

- Decrease in ADH, T3, cortisol and insulin
- Electrolyte disorders
- ADH leads to DI – massive fluid losses
- T3
  - switch in cardiac cells to anaerobic metabolism
  - increased lactate and acidosis
  - myocardial dysfunction

HYPOTHERMIA

- Loss of function of hypothalamus
- Contributes to hemodynamic instability
  - Myocardial depression/arrythmias
  - Reduced tissue oxygenation
  - Impaired kidney function

COAGULOPATHY

- Release of tissue thromboplastin and plasminogen from necrotic brain tissue
- Hypothermia and dilution also contribute
- May contribute to worsening bleeding

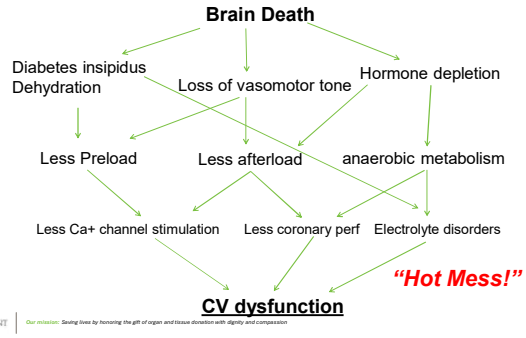
PULMONARY FLOW

During the Storm phase

- Increase in LAP - decreased LV output due to severe SVR
- Temporary cessation of pulmonary blood flow with pressures exceeding hydrostatic pressures
- Neurogenic pulmonary edema and hemorrhage
- Impairment LV > RV - CVP may not be accurate measurement of LV function

ELECTROLYTE IMBALANCES

- Hypernatremia
- Hyper/Hypokalemia
- Hypocalcemia
- Hypo/Hyperglycemia



Recap: Components of DNC Determination Process

1. Prerequisites established
   - History/physical exam findings that provide clear **etiology** of brain dysfunction
     - AND
   - **Exclusion** of any condition that might **CONFOUND** examination of cortical or brain stem function
2. Clinical examination – confirm loss of brain stem reflexes
3. Apnea testing
4. Ancillary testing [if needed]
5. Documentation
6. Communication with family/surrogate

NURSING INTERVENTIONS

- Updates on clinical changes
- Advocate for maintaining clinical parameters to prepare patient for DNC testing – (CBIGs)
- Print DNC checklist/review hospital DNC policy
- Let physicians know when MTN is onsite
- Facilitate/Support an Effective Request Process

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