

# Brain Death



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# Altered states of consciousness

- Consciousness – state or quality of awareness or, of being aware of an external object or something within oneself.
- Sleep - Normal state of unconsciousness with prompt reversibility on threshold sensory stimulus and maintain wakefulness following recovery.
- Depressed consciousness – supra threshold required and wakefulness cannot be maintained unless the stimulation continued
- Stuporous - Arousable only with vigorous noxious stimuli, while awake cant demonstrate normal content of consciousness

- Coma - A state of unconsciousness from which the patient cannot be aroused even with stimulation such as pressure on the supraorbital nerve, temporo-mandibular angle of the mandible, sternum, or nail bed
- Locked-in state - State of paralysis without loss of consciousness. Patient completely paralysed except for muscles served by midbrain structure[e.g. vertical eye movement and blinking]

- Persistent vegetative state-
  - also known as cerebral death.
  - normal sleep-wake cycles.
  - no response to environmental stimuli.
  - diffuse brain injury with preservation of brain stem function.



# Brain death-

- Refers to determination of physical death by brain based, rather than cardio-pulmonary based criteria.
- It is defined as a irreversible destruction of the brain, with the resulting total absence of all cortical and brainstem functions, although spinal cord reflexes may remain intact.

- It should not be confused with severe but incomplete brain damage or with vegetative state in which some function of vital brain centers still remains, and decisions regarding on going life support clearly depend on the wishes of the patient or his/her proxy.
- Brain death should be suspected in any patient rendered deeply comatose and apneic from a profound or diffuse brain insult

- Pathogenesis of brain death- Direct cellular injury potentiated by a vicious cycle of failure of blood flow, hypoxia, cerebral acidosis and endothelial swelling to brain edema, aseptic necrosis and herniation of the brain.
- When the lower brain herniates through the skull onto the brainstem and pons, cutting off the blood supply to the brain.

## **Prerequisites for testing of brain death**

- Clinical or neuro-imaging evidence of acute catastrophe leading to a diagnosis of brain death.
- No severe electrolyte , acid base, endocrine disturbances
- no drug intoxication
- core temperature > 90 degree Fahrenheit



# Brain Death Diagnosis

Made by the separate examination of 2 doctors:

1. One of the doctors must be a specialist recognized by the appropriate College as having demonstrated skill and knowledge in the performance of brain death certification. This should usually be an intensivist, critical care physician, neurologist or neurosurgeon .
2. The other medical practitioner should preferably be of the same qualification as described above. but should be at least 6 years experience & possess the skill and knowledge in the performance of brain death certification .

## Criteria for CNS Determination of Death (Brain Death)

- Irreversible coma
- Absence of cortical function
- Absence of brainstem function
- Apnea testing
- 2 examinations with interval according to patient's age

# Irreversible Coma

- Known etiology and or reversible causes ruled out
- Must have an absence of
  - Hypothermia
  - Neuromuscular blockade
  - Shock or significant hemodynamic instability
  - Significant levels of sedatives
  - Severe metabolic disturbance
  - Poisoning
  - Endocrine abnormalities

# Absence of cortical functions-

- *No spontaneous movement, eye opening, or movement or response after auditory, verbal, or visual commands*
- Cerebral motor response to pain
  - Supraorbital ridge, the nail beds, trapezius
  - Motor responses may occur spontaneously during apnea testing (spinal reflexes)



# Absence of brain stem function-

- 1) Pupillary reflex
- 2) Corneal reflex
- 3) Gag reflex
- 4) Cough reflex
- 5) Oculocephalic reflex (doll's eye reflex)
- 6) Oculovestibular reflex (caloric reflex)

7) *No integrated motor response to pain*

8) *Apnea testing*

# Pupils-

- Midsize (4-6 mm), but may be totally dilated
- Absent pupillary light reflex
  - Although drugs can influence pupillary size, the light reflex remains intact only in the absence of brain death
  - IV atropine does not markedly affect response
  - Paralytics do not affect pupillary size
  - Topical administration of drugs and eye trauma may influence pupillary size and reactivity

- Pre-existing ocular anatomic abnormalities may also confound pupillary assessment in brain death



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Pupils fixed and unresponsive to light



# Corneal reflex-

- Corneal reflexes are absent in brain death
  - Corneal reflexes - tested by using a cotton wisp



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There is no blink response to direct corneal stimulation.

## Gag and Cough reflex-

- Both gag and cough reflexes are absent in patients with brain death
  - Gag reflex can be evaluated by stimulating the posterior pharynx with a tongue blade.
  - Cough reflex can be tested by using ETT suctioning



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There is no gag or cough reflex.

# Oculocephalic reflex

- Rapidly turn the head  $90^\circ$  on both sides in lying down position
  - Normal response = deviation of the eyes to the opposite side of head turning
  - Brain death = oculocephalic reflexes are absent (no Doll's eyes) = no eye movement in response to head movement



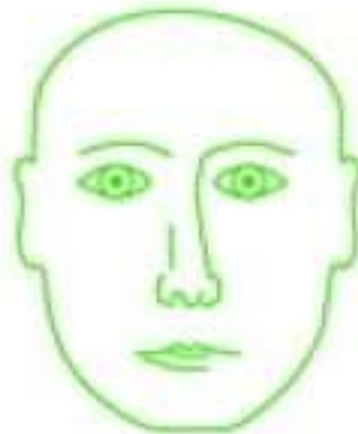
## Oculocephalic (Doll's eye)

Head to left



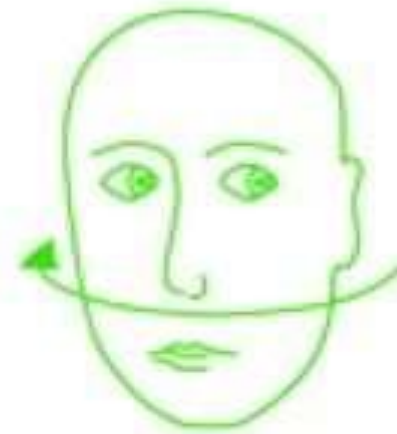
Eyes to right

Central



A normal  
response

Head to right



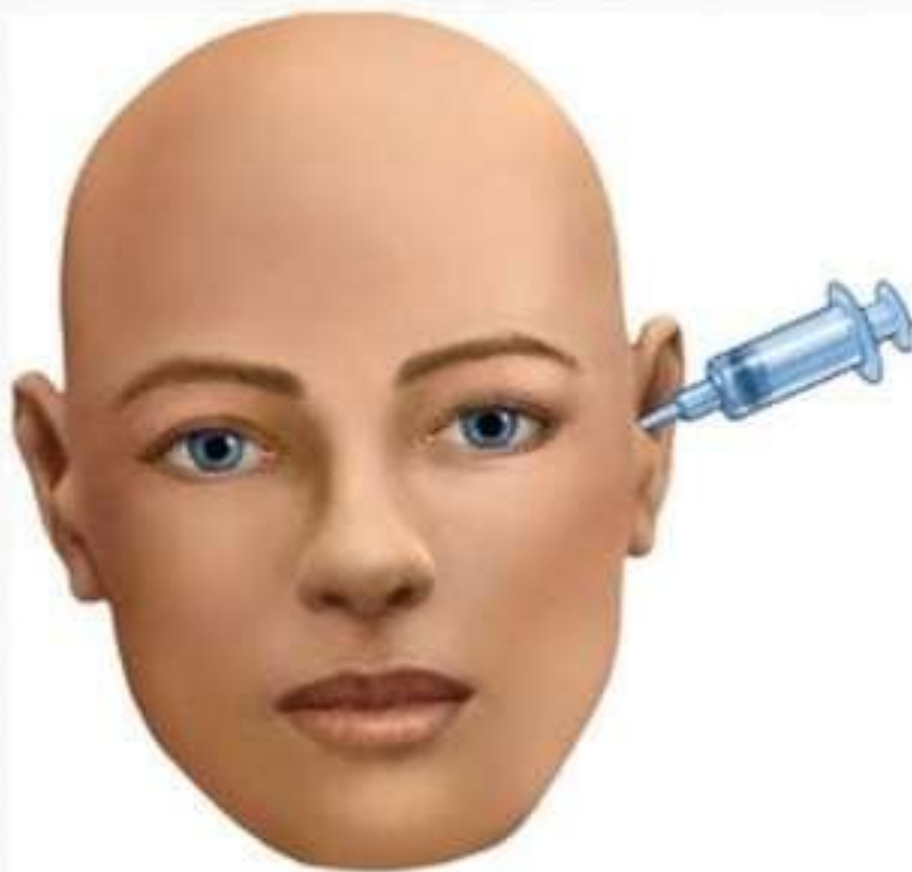
Eyes to left

# Vestibulo-ocular reflex

- *No eye movements within 3 minutes after irrigating each tympanic membrane (if intact) sequentially with 50 ml ice water for 30 to 45 seconds while the head of the supine patient is elevated 30 degrees*



Retained vestibulocular reflex



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**Eyes do not deviate away cold water  
instilled into an auditory canal.**

# Cold calorics interpretation

- Not comatose
  - Nystagmus seen
- Coma with intact brainstem
  - Both eyes tonically deviate away cold water
- No eye movement
  - Brainstem injury / death
- Movement only of eye on side of stimulus
  - Internuclear ophthalmoplegia
  - Suggests brainstem structural lesion




# Apnea test-

- *Prerequisites:-*

- Core temp  $36.5^{\circ}\text{C}$
- SBP  $>90$  mm Hg
- No electrolyte imbalance
- Arterial pH 7.35-7.45 and  $\text{pCO}_2$  35-45 mm Hg
- Pre-oxygenation with 100%  $\text{FiO}_2$  for 10 to 15 mints
- Euvolemia

- Give 100% O<sub>2</sub> at 8-10 Lpm at the level of carina immediately after disconnecting the ventilator.
- Observe closely for respiratory movements (abd and chest excursions)
- Measure pO<sub>2</sub>, pCO<sub>2</sub> and pH after apprx. 3-5 mints and reconnect the ventilator

- If respiratory movements are absent and final ABG shows-
  - $\text{pH} < 7.30$
  - $\text{pCO}_2$  increases from 40 up to 60 mm Hg or 20 mm Hg from pretest baseline then, Apnea has been demonstrated, supporting the diagnosis of brain death criteria.

- 
- If the above criteria are not met and apnea test is negative - Confirmatory tests are required



# Pitfalls in clinical brain death testing-

- *Hypotension, shock, Fluid resuscitation, pressor agents*
- *Hypothermia-Warmed fluids, ventilatory warmer*
- *Intoxication or drug overdose - Serum drug levels of the drugs given and toxicology screens, or increase waiting time between brain death examinations*

- Damage to the base of the pons, typically from a basilar artery embolism, can result in the development of the so-called locked-in syndrome, where the patient loses all voluntary movements with the exception of blinking and vertical eye movements.
- GBS can involve all peripheral and cranial nerves and mimic brain death.

- *Neuromuscular and sedative drugs, which can interfere with elicitation of motor responses- Discontinue muscle relaxants and mood- or consciousness-altering medications, increase waiting time between brain-death examinations*
- *Pupillary fixation, which may be caused by anticholinergic drugs, neuromuscular blocking agents, or preexisting disease*

- *Oculovestibular reflexes diminished after prior use of ototoxic drugs (e.g., aminoglycosides, loop diuretics, vancomycin) or agents with suppressive side effects on the vestibular system (e.g., TCADs, anticonvulsants and barbiturates) or due to preexisting disease or any foreign body [e.g blood, wax]*
- Obtain careful medication history



- Doll's eyes examination should not be performed if the cervical spine is unstable.
- Chronic obstructive pulmonary disease or sleep apnea may result in elevated baseline CO<sub>2</sub> retention, confusing the apnea examination
- Certain spinal reflexes including spontaneous movements of the torso, arms, or toes should be ignored if the clinical brain stem examination is consistent with brain death or confirmatory examinations are positive.

# Confirmatory testing-

- Used as a supportive in those patients in whom specific components of clinical testing cannot be reliably performed or evaluated.
- Confirmatory test findings are listed in the order of the most sensitive test first –
- 1)Conventional angiography. No intracerebral filling at the level of the carotid bifurcation or circle of Willis .

- 2) Electroencephalography- Absence of any cerebral activity during at least 30 min of recording
- 3) Transcranial Doppler ultrasound - should show absent diastolic flow with small early systolic peaks.
- 4) SPECT using Technetium brain scan- No uptake of isotope in the brain parenchyma
- 5) Somatosensory evoked potentials - Bilateral absence of response with median nerve stimulation confirms brain death.



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Blood flow is absent in the cranial vault when examined by cerebral scintigraphy (shown) or angiography.



- SPECT using Technetium brain scan-

Cerebral perfusion scan



ANT 10'



BLAT 10'

# Transcranial doppler for Brain death

- In Adult 2 examinations at an interval of 30 minutes if shows cerebral circulatory arrest
- Small systolic peaks in early systole without diastolic flow in any of MCA, ICA and any artery of anterior and posterior circulation.
- Intracranial examination should be confirmed with extra-cranial recording
- Lack of flow in basal arteries can be false positive

# TCD and Brain Death

- TCD can be a confirmatory tool for diagnosing brain death. The validity of TCD diagnosed brain death depends on the time lapse between brain death and the performance of TCD. TCD of both the basilar artery and the MCAs showed significant consistency in brain death diagnosis.
- The specificity of TCD is close to 100%.
- The sensitivity of TCD is 91-95%.

# Kids over 1 year old

- Absence of all brain and brainstem function
  - Comatose: no purposeful response to any stimulus
  - Brainstem function is absent when:
    - Pupils are mid-position and do not react to light
    - Eyes does not blink when touched (corneal reflex)
    - Eyes do not rotate in the socket when the head is moved from side to side (oculocephalic reflex).
    - Eyes do not move when ice water is placed in the ear canal (oculovestibular reflex)
    - Child does not cough or gag when a suction tube is placed deep into the breathing tube
    - Child does not breathe when taken off the ventilator
- Repeat in ~6 hours



# Children under 1 year

- Necessary to repeat the clinical examination after an 'appropriate' observation period has passed

## Age 7 days to 2 months

Two examinations 48 hours apart and one EEG

## Age 2 months-1 year

Two examinations 24 hours apart and one EEG or perfusion scan

- Confirmatory EEG unless it is determined that there is no blood flow to the brain

# References

- Ronald D Millers's Anaesthesia 8<sup>th</sup> edition

Thank  
you