Neuroimaging in Coma, Brain Death and Related Conditions

Edgar Zamora, MD¹; Carlos Zamora, MD, PhD²

¹Montefiore Medical Center, The Bronx, NY ²University of North Carolina at Chapel Hill, Chapel Hill, NC

Purpose

Present an overview of mechanisms leading to alterations of consciousness & describe the current role of neuroimaging.

Approach

Cases including conditions that resulted in coma and other alterations of consciousness.

Discussion

Reticular activating system (RAS):

- Neuronal network regulating arousal and consciousness.
- Tegmentum of upper pons and midbrain → thalamus/hypothalamus → cerebral cortex

Coma

- State of unarousable unresponsiveness; broad Ddx—supra, infratentorial or diffuse injury.
- Clinical history and physical exam are essential but insufficient for Dx and prognosis.
- Can evolve to vegetative state (VS) or minimally conscious state (MCS).

Causes of coma are varied, largely classified into:

- Direct injuries to RAS.
- Large unilateral lesions exerting mass effect on brainstem.
- Diffuse involvement of cerebral hemispheres (e.g. toxic, drugs, metabolic, encephalitides, status epilepticus).
- Younger pts: traumatic brain injuries (TBI) & intoxications
- Older age: metabolic disturbance, or perfusion deficits (stroke & anoxia) are more typical.

- CT: 1st line → edema, herniation, brainstem compression.
- MRI: gold standard for assessing extent of injury.
- Pts with midline shift > 11 mm usually comatose.

- **Beyond structural injury** → Abnormal connectivity in VS: DTI shows ↓ FA in WM tracts & ↑ ADC in GM/thalamus.
- Functional deficits: EEG & evoked potentials.
- fMRI: has typically been done in subacute & chronic stages
- rs fMRI: strength of default mode network connectivity has shown correlation with level of consciousness.
- ASL & ¹⁵O-H₂O PET: ↓ Global and regional CBF.
- ¹⁸F-FDG-PET: ↓ ↓ global brain metabolism in VS.

Various conditions may mimic coma, including:

- Locked-in Sx: only vertical eye movement but conscious
- Akinetic mutism, psychogenic unresponsiveness.

Brain Death (BD)

- Irreversible cessation of brain function, including brainstem.
- Complete clinical examination usually sufficient but need to exclude confounders: e.g. hypothermia, intoxication., etc.
- Imaging indicated in pts with unexaminable cranial nerves, neuromuscular paralysis, heavy sedation, and others.
- Absent CBF – generally accepted as BD but may be affected by hypotension.
- Cerebral angiography best approximates gold standard but invasive and frequently impractical in highly unstable patients.
- Dx of BD in children requires 1 ancillary test for <1-year, and 2 ancillary tests for <2-month-olds; Dx cannot be made if < 37-week gestational age.

Summary

- Causes of coma are varied and can be 2ry to direct injury and/or abnormalities in functional connectivity.
- Neuroimaging is useful in determining cause and extent of injury.
- Imaging is ancillary in BD & selected on a patient basis with special consideration in children.