# Questions?

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HYKS 2019


What was good?
What was not so good?
How could we improve?
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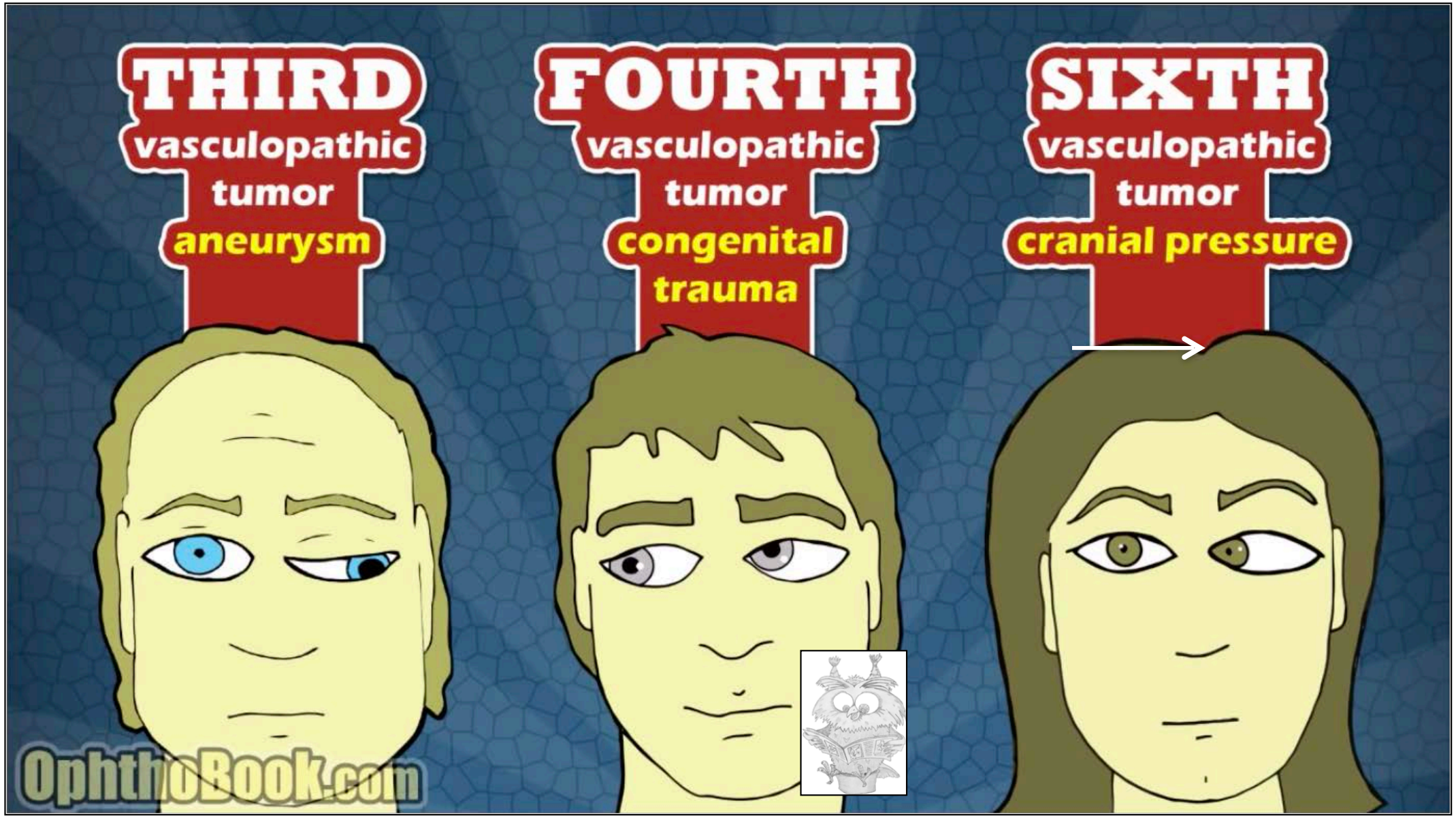
# ”FAST-neurostatus”


THIRD
vasculopathic
tumor
aneurysm
FOURTH
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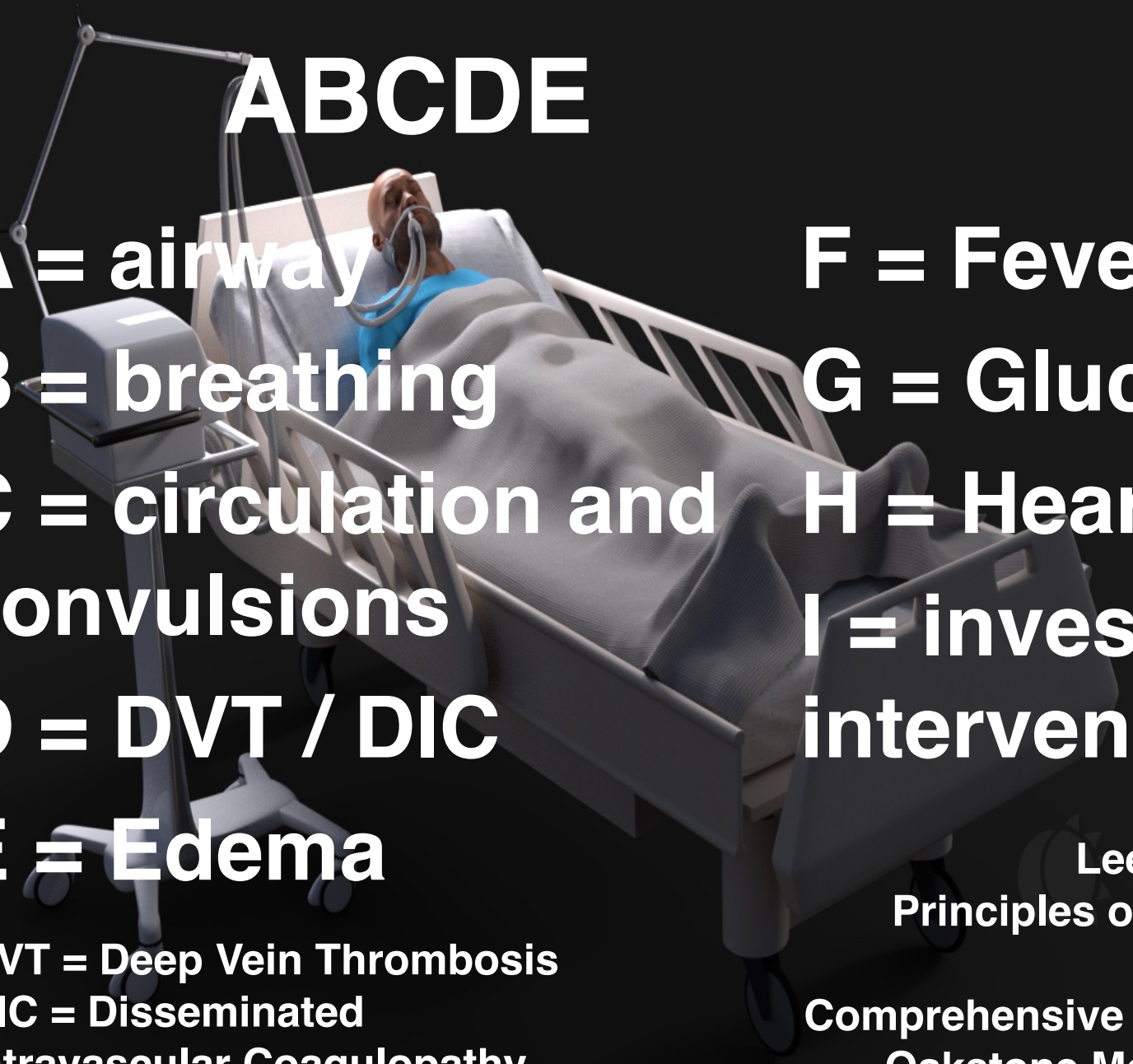
trauma
SIXTH
vasculopathic
tumor
cranial pressure
OphthoBook.com

# Neurological Intensive Care



## ABCDE

A = airway

B = breathing

C = circulation and convulsions

D = DVT / DIC

E = Edema

DVT = Deep Vein Thrombosis
DIC = Disseminated Intravascular Coagulopathy

## FGHI

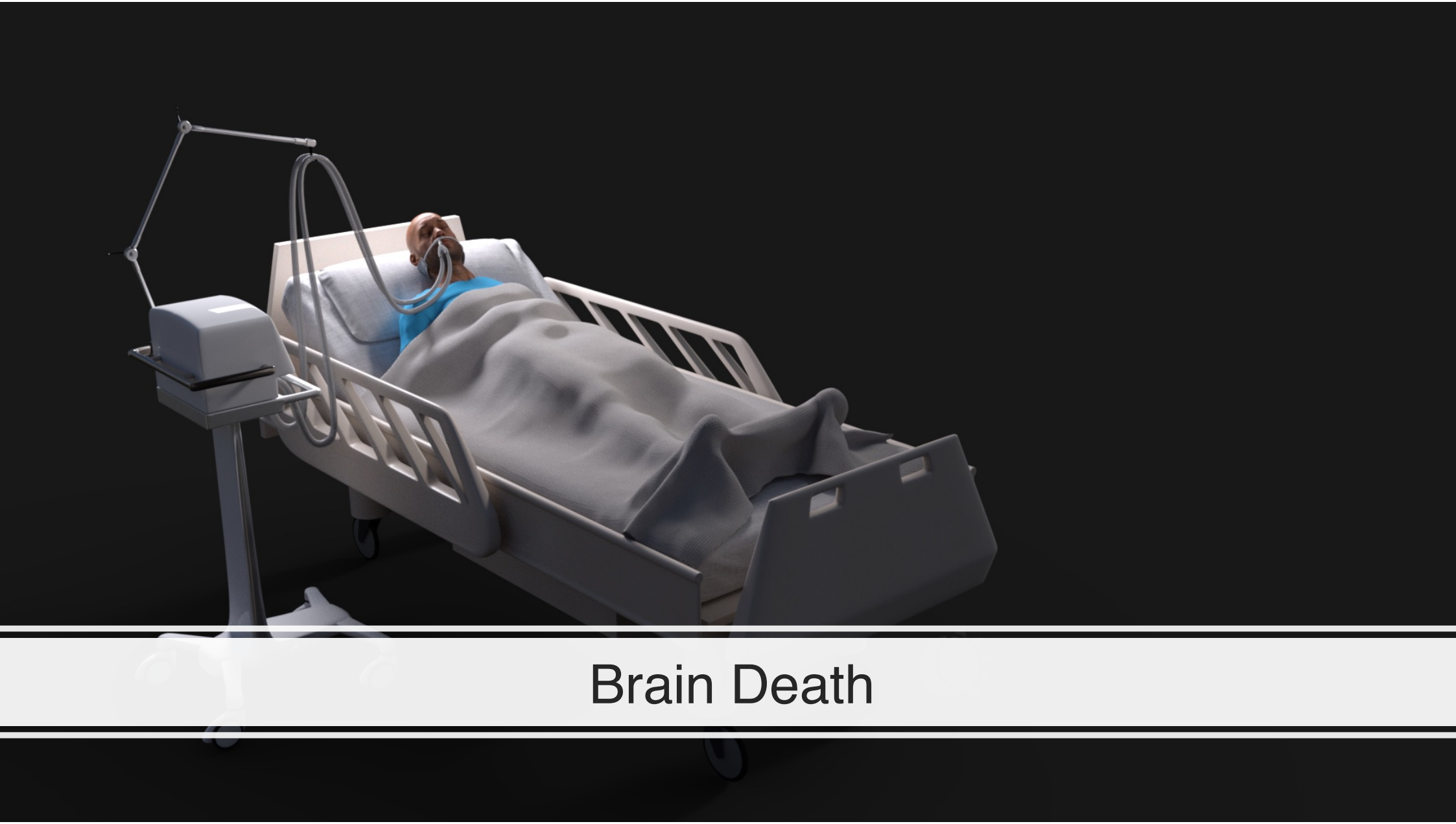
F = Fever

G = Glucose

H = Heart

I = investigate, intervene, iterate

Lee H Schwann.
Principles of Neurointensive Care.
DVD:IIa
Comprehensive Review of Neurology 2011.
Oakstone Medical Publishing, 2011



# Brain Death

Brain

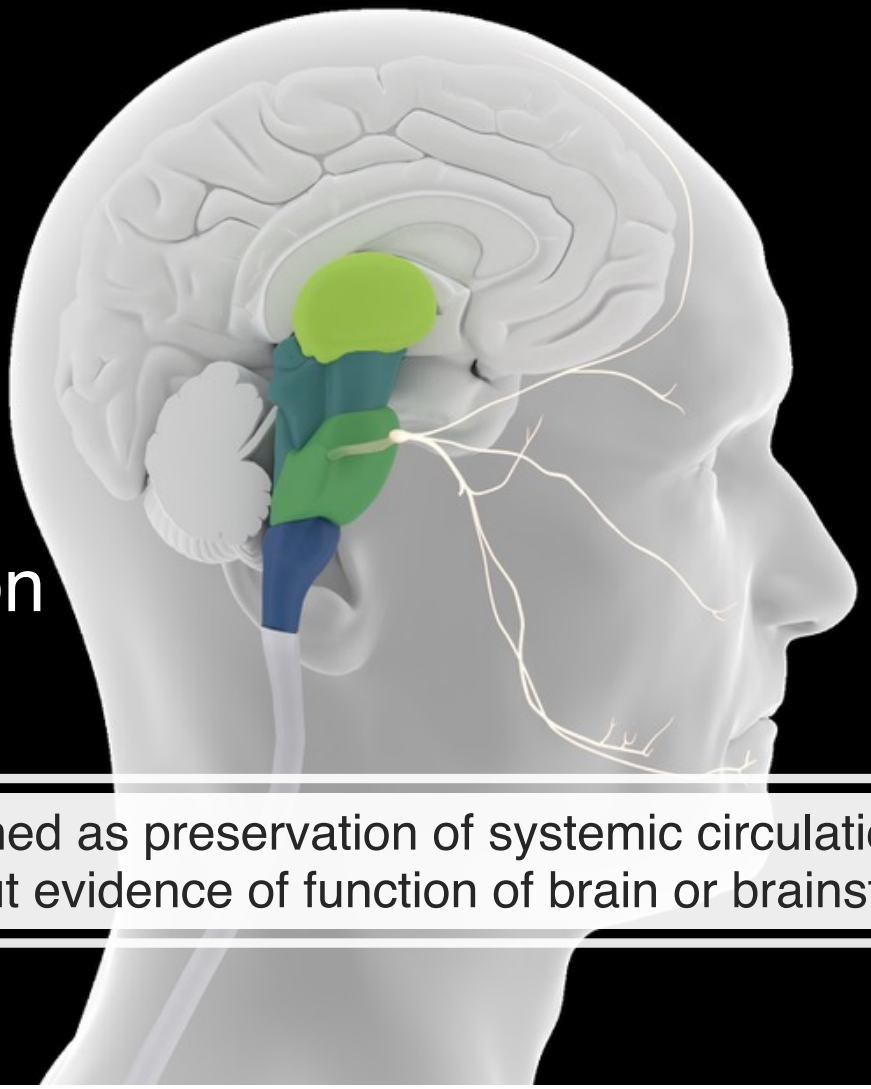
No response to external stimulation – other than spinal reflexes

Brainstem

No brainstem reflexes present

Systemic circulation preserved

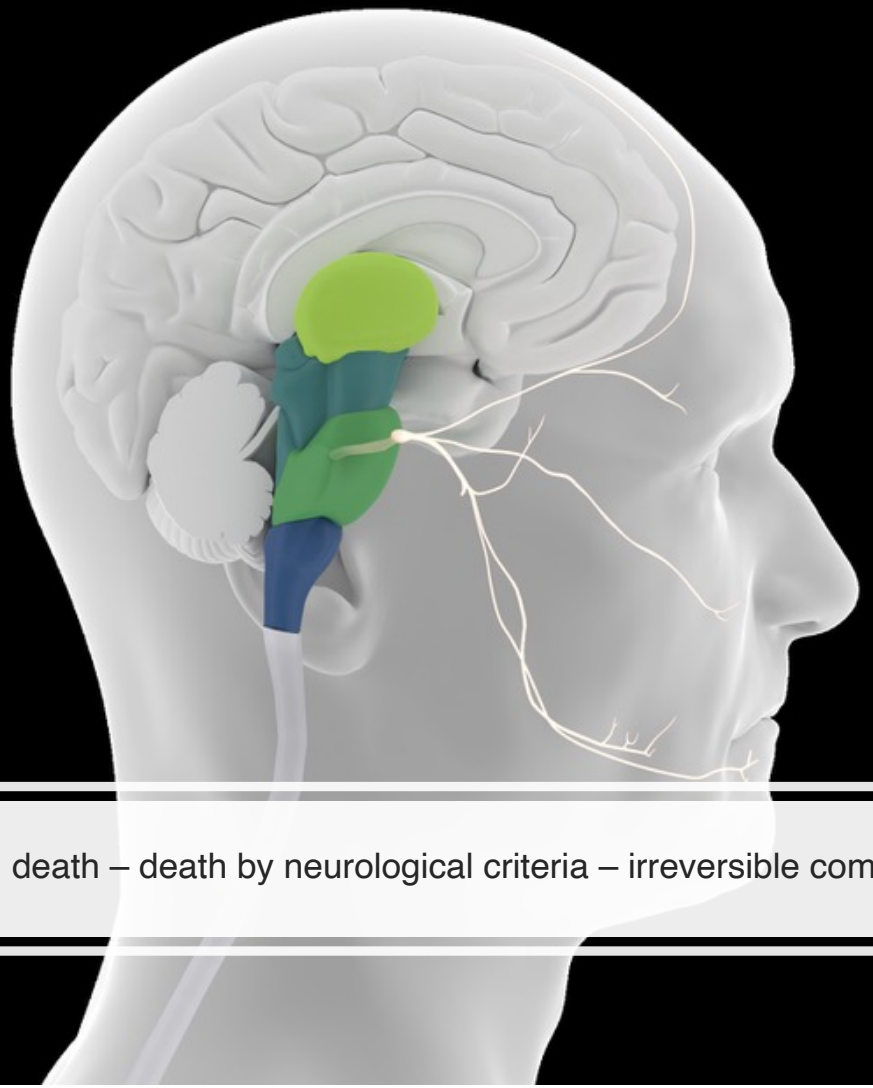
Apnea



Defined as preservation of systemic circulation without evidence of function of brain or brainstem

Patient does not awaken or interact with environment despite vigorous stimulation

No brainstem reflexes present

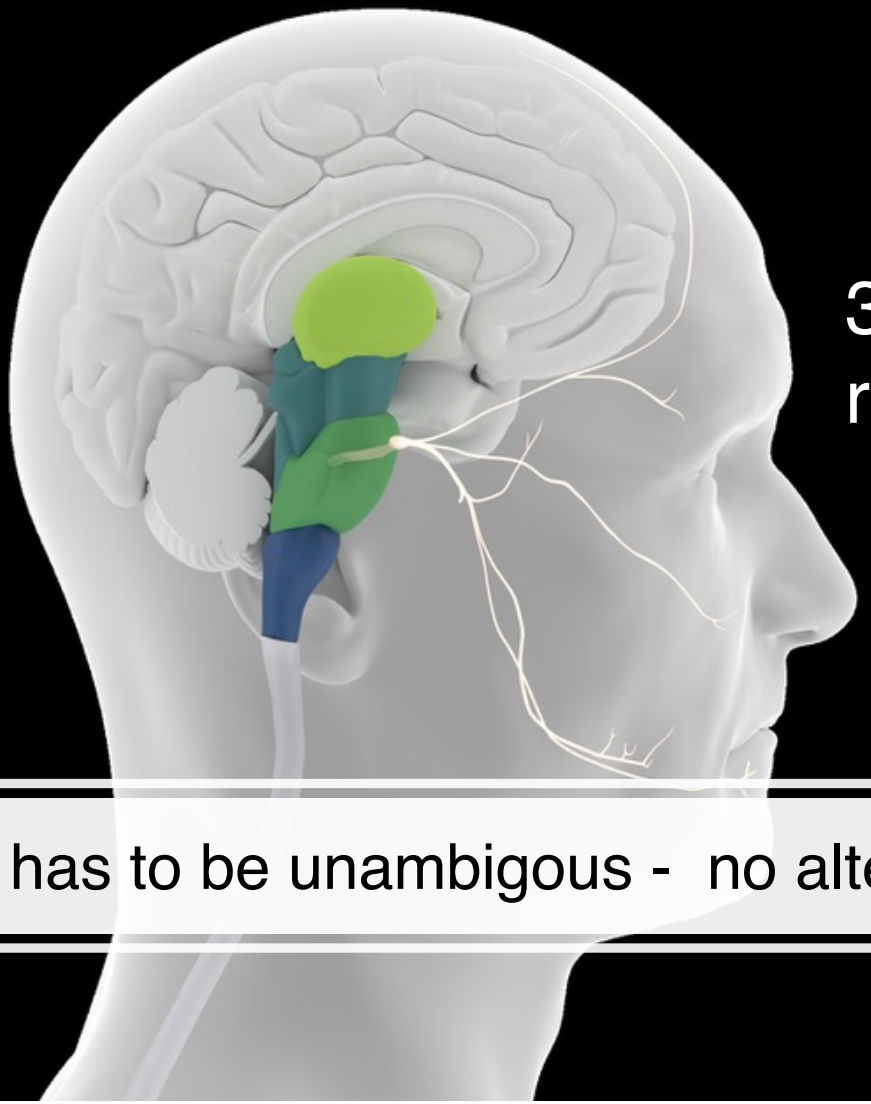


Apnea – no breathing even with maximal stimulation

Brain death – death by neurological criteria – irreversible coma

# Major criteria

1. Destructive brain injury
2. Reason for unresponsivenes s known

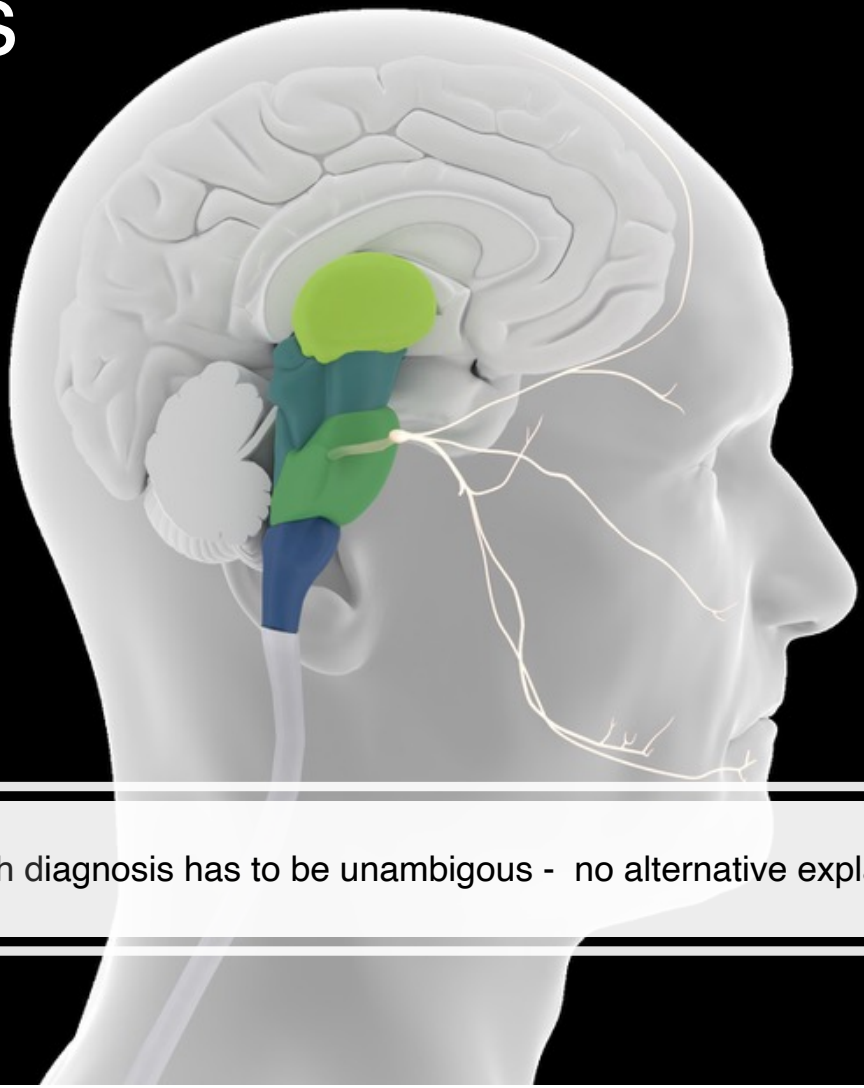


3. Confounders ruled out

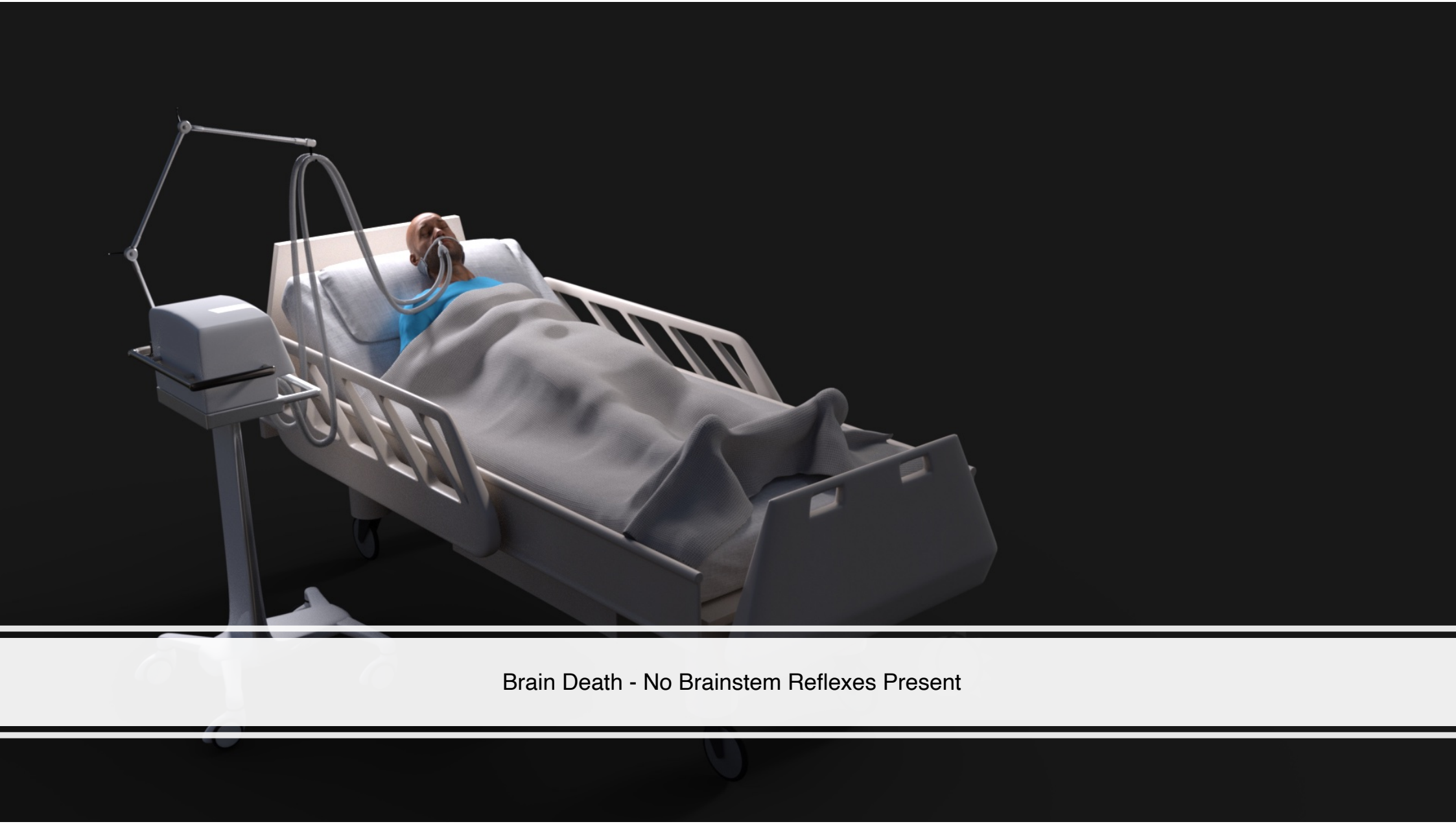
Brain death diagnosis has to be unambigous - no alternative explanation

# Major confounders

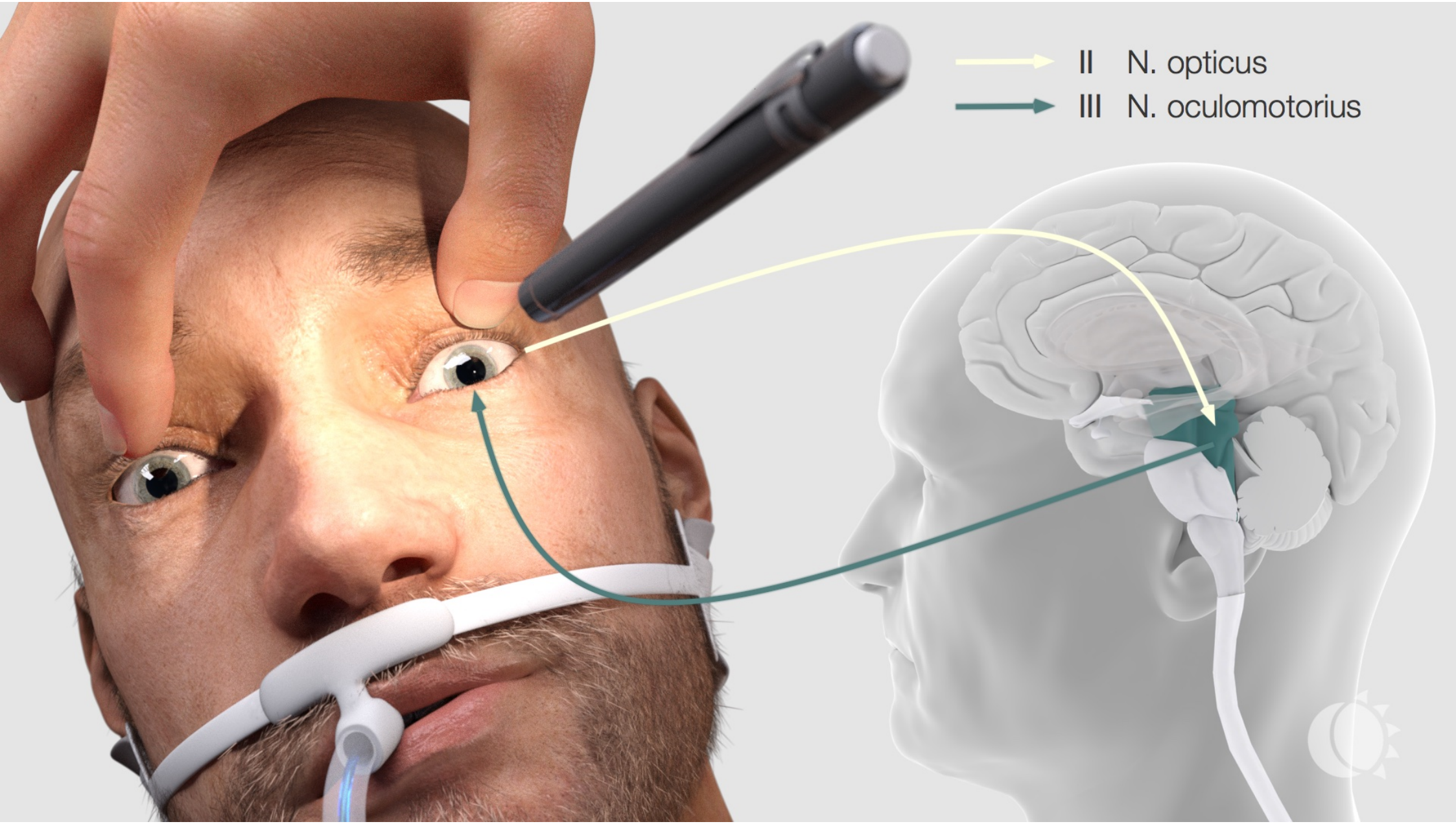
1. Drugs, intoxication
2. Hypothermia
3. Hypopotension
4. Metabolic derangement
5. Locked-in syndrome

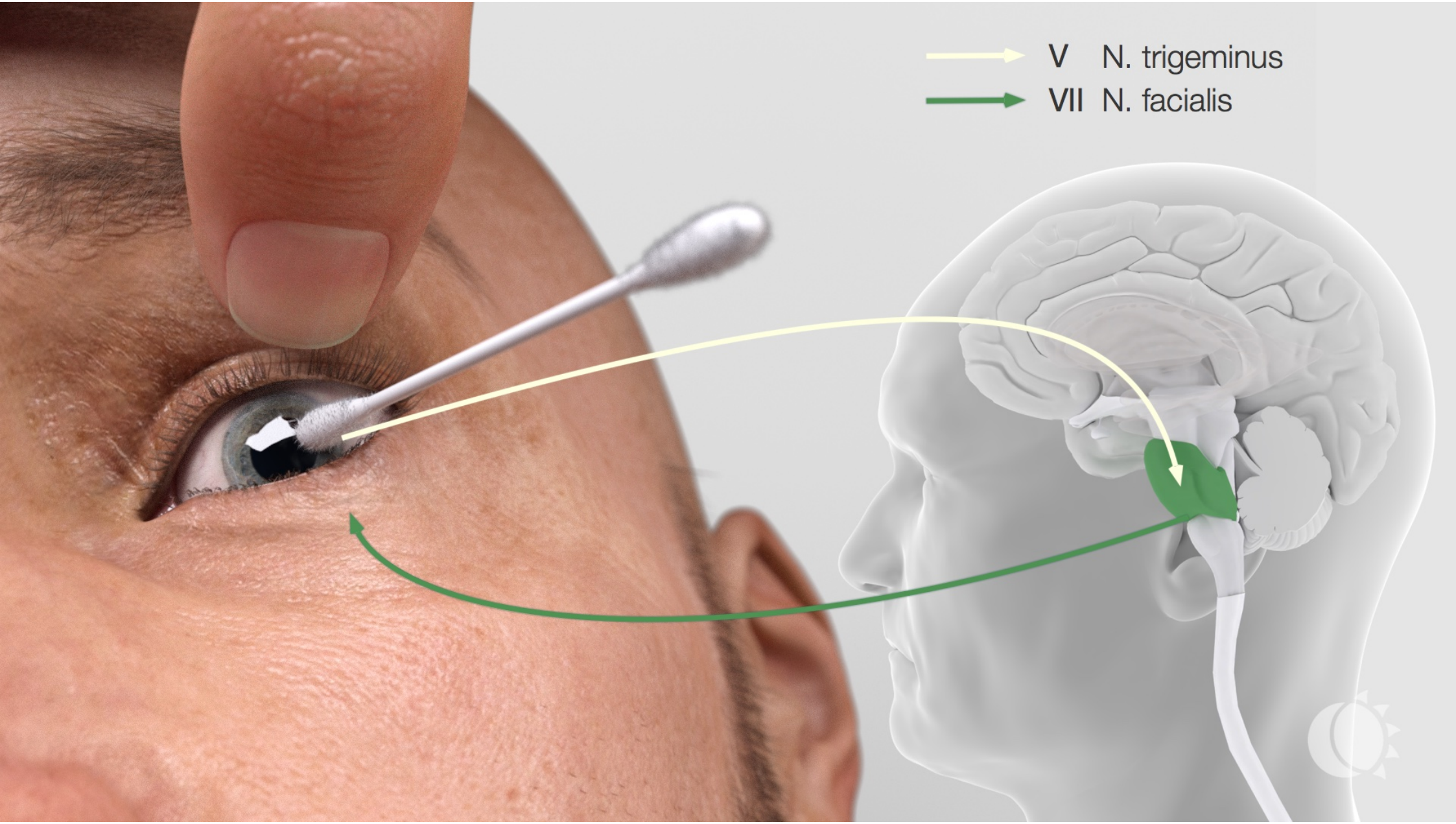


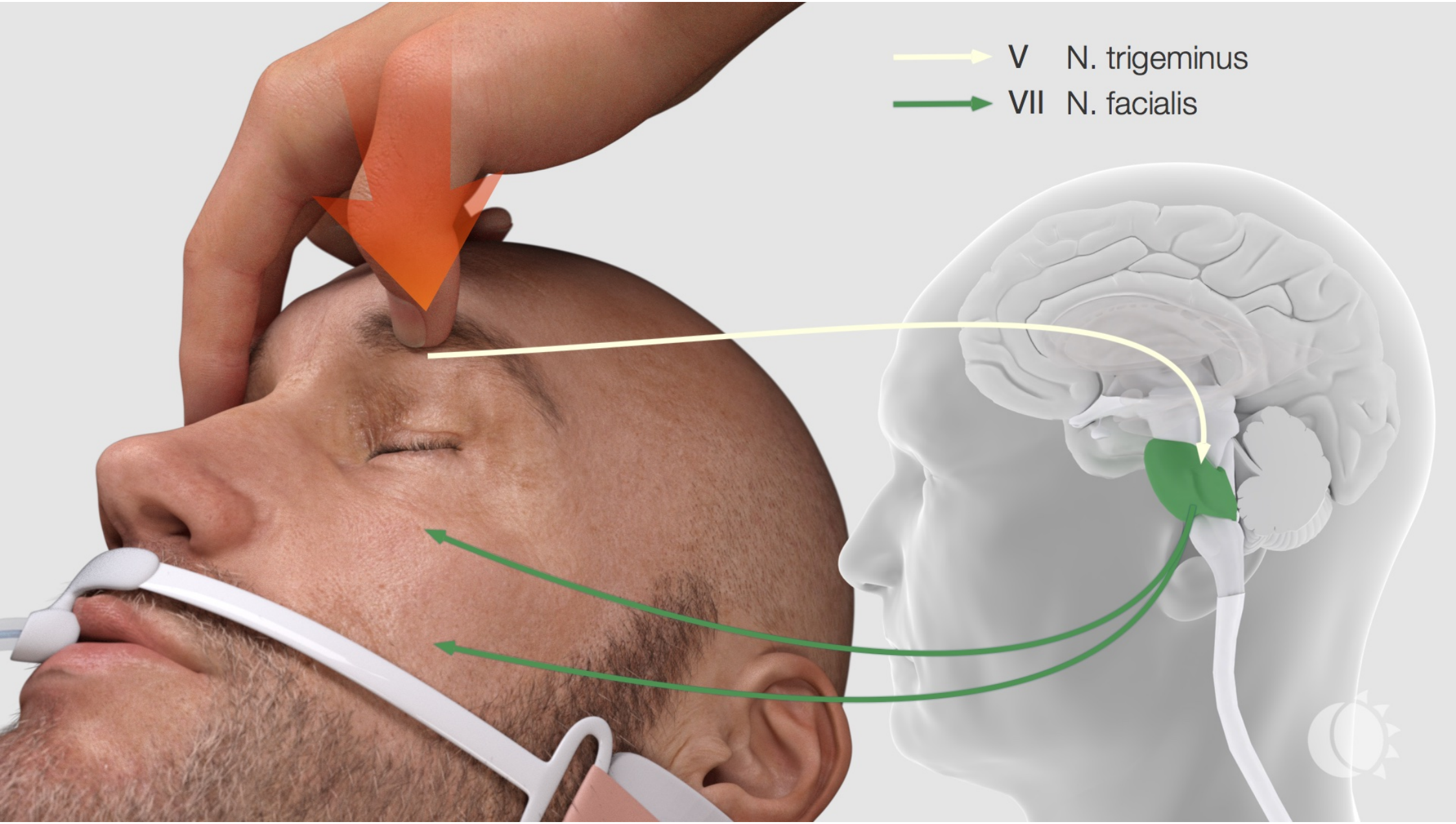
Brain death diagnosis has to be unambigous - no alternative explanation

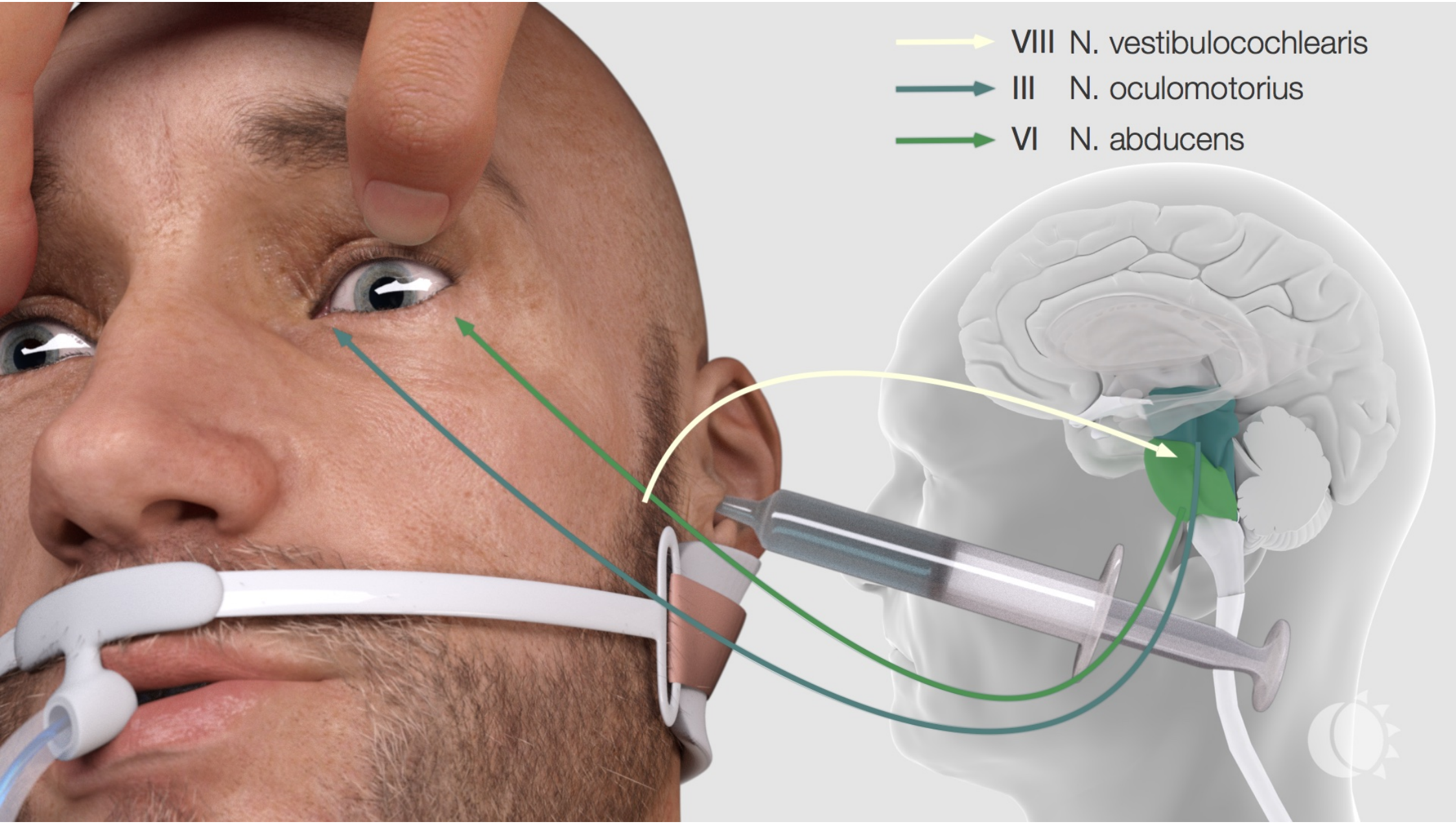


Brain Death - No Brainstem Reflexes Present

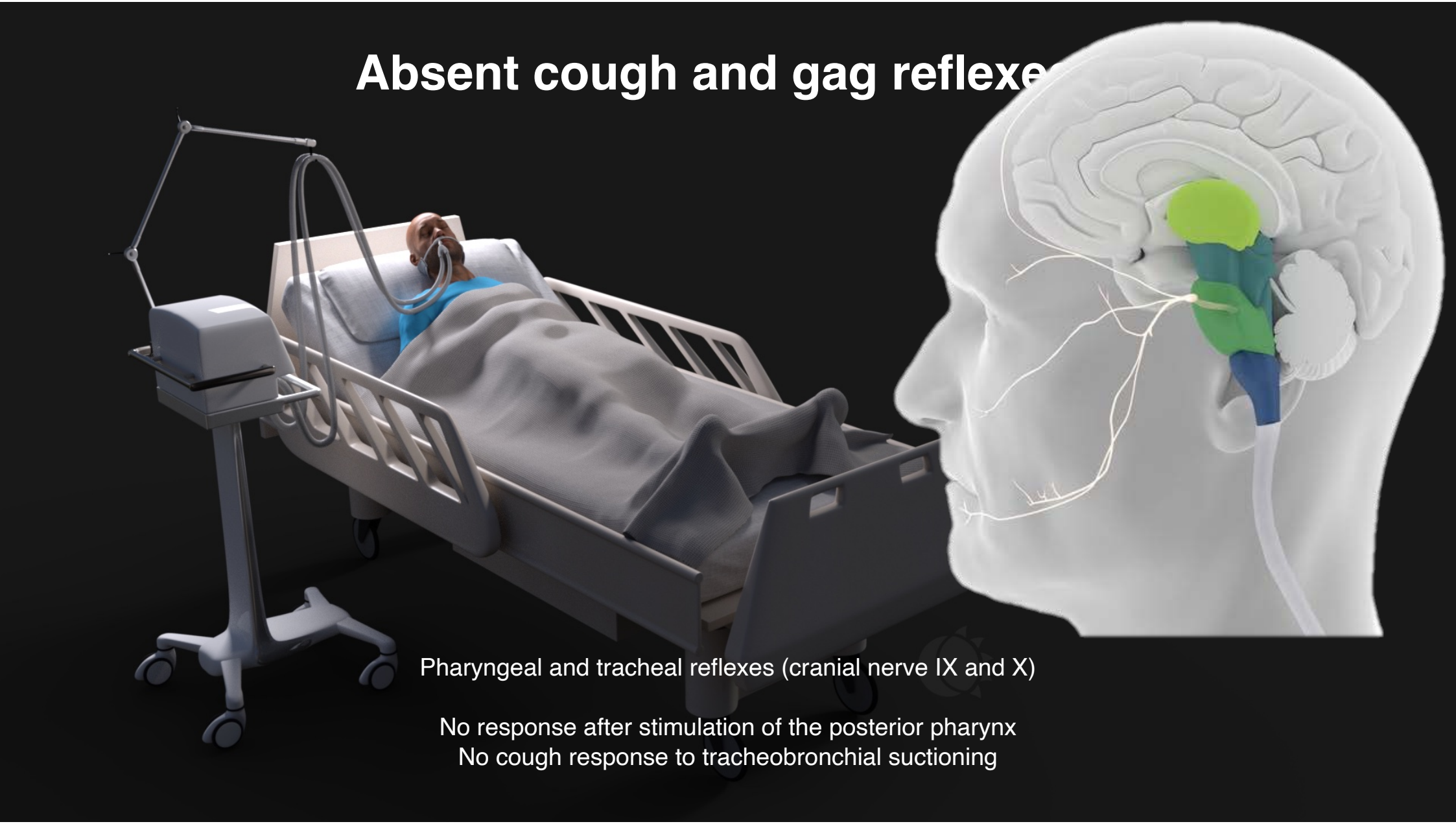

II N. opticus
III N. oculomotorius


V N. trigeminus
VII N. facialis


V N. trigeminus
VII N. facialis

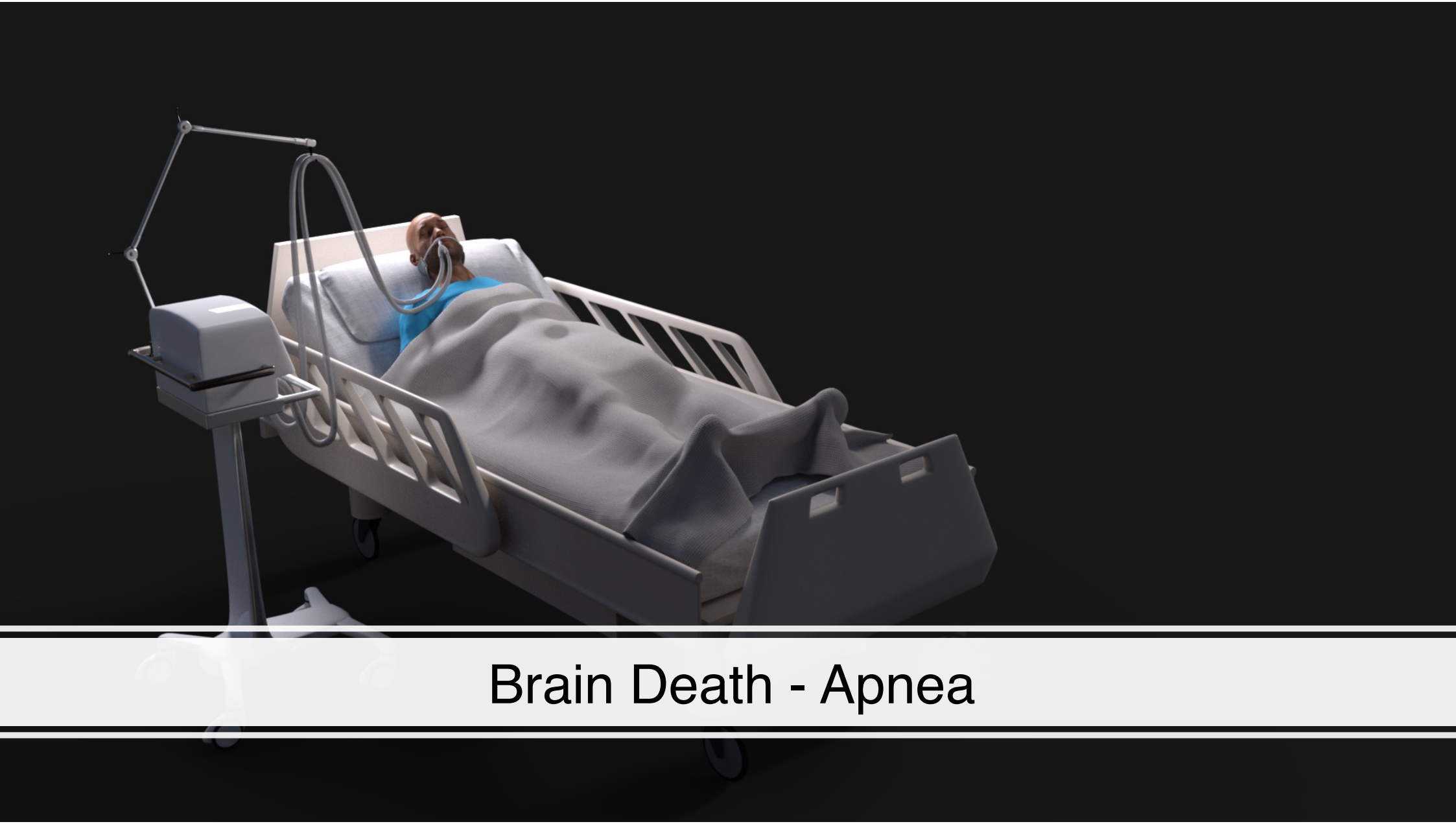

VIII N. vestibulocochlearis
III N. oculomotorius
VI N. abducens

# Absent cough and gag reflexe



Pharyngeal and tracheal reflexes (cranial nerve IX and X)

No response after stimulation of the posterior pharynx
No cough response to tracheobronchial suctioning



# Brain Death - Apnea

## The Apnea Test

### Prerequisites

- $PaCO_2$ between 35 mm Hg and 45 mm Hg
- Systolic blood pressure ≥100 mm Hg with or without vasopressors
- Administer 100% oxygen for at least 10 minutes (ideal $PaO_2$ >200 mm Hg with positive end-expiratory pressure ≤5 cm $H_2O$)
- Absence of clinical signs of intravascular volume contraction

### Steps

- Disconnect the patient from the ventilator
- Deliver oxygen at 6 L/min through a catheter advanced through the tracheal tube until close to the carina
- Look carefully for any respiratory movements while monitoring pulse oximetry and blood pressure
- Abort and reconnect to the ventilator if evidence of respiratory movements, refractory hypotension (systolic blood pressure <90 mm Hg) or worsening hypoxemia (pulse oximetry <85%)
- If no respiratory movements after approximately 8 minutes, obtain arterial blood gases
- Apnea is established if $PaCO_2$ ≥60 mm Hg (or 20 mm Hg greater than baseline)

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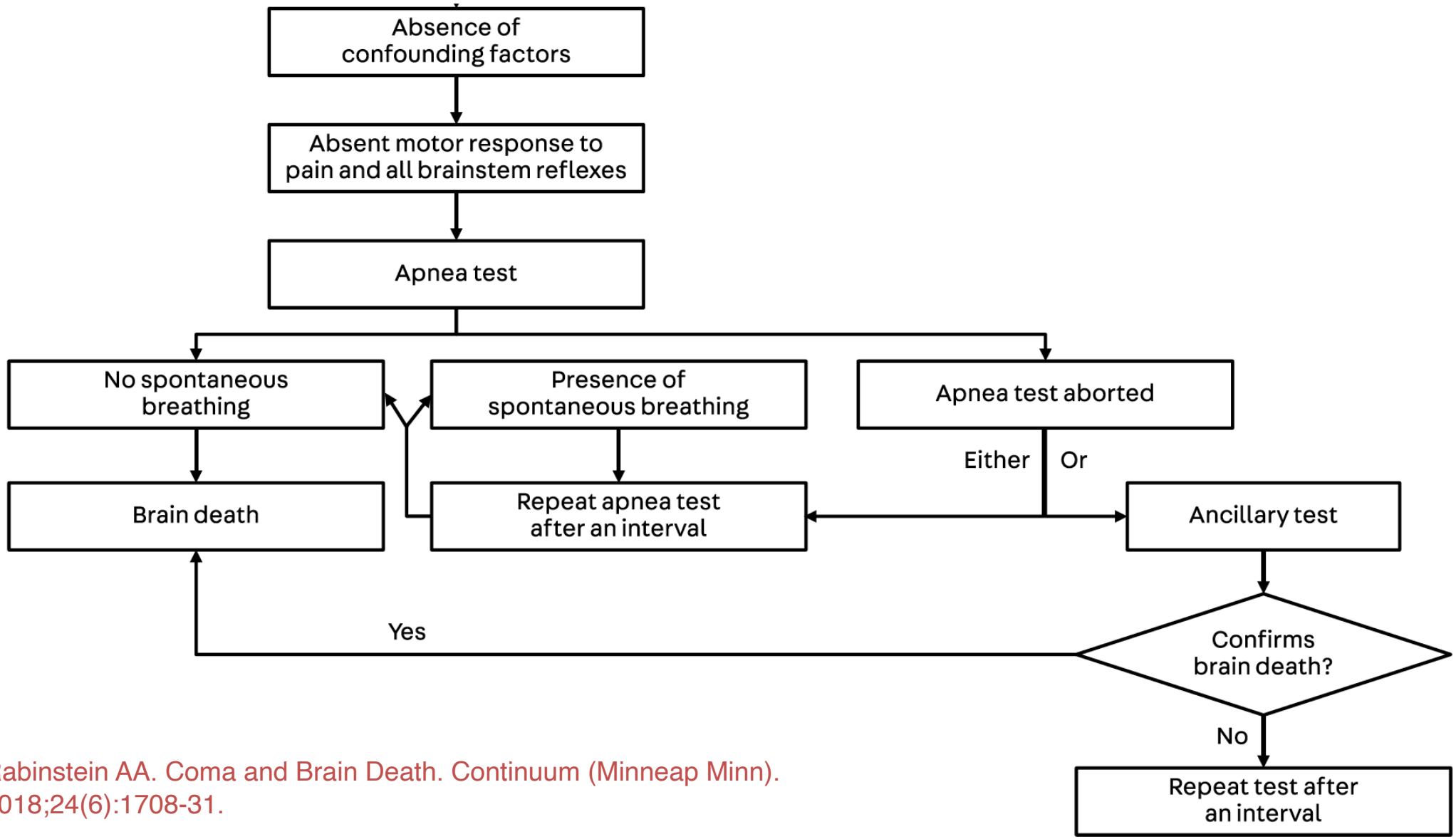
$PaCO_2$ = partial pressure of carbon dioxide, arterial; $PaO_2$ = partial pressure of oxygen, arterial.

Rabinstein AA. Coma and Brain Death. Continuum (Minneap Minn).2018;24(6):1708-31.

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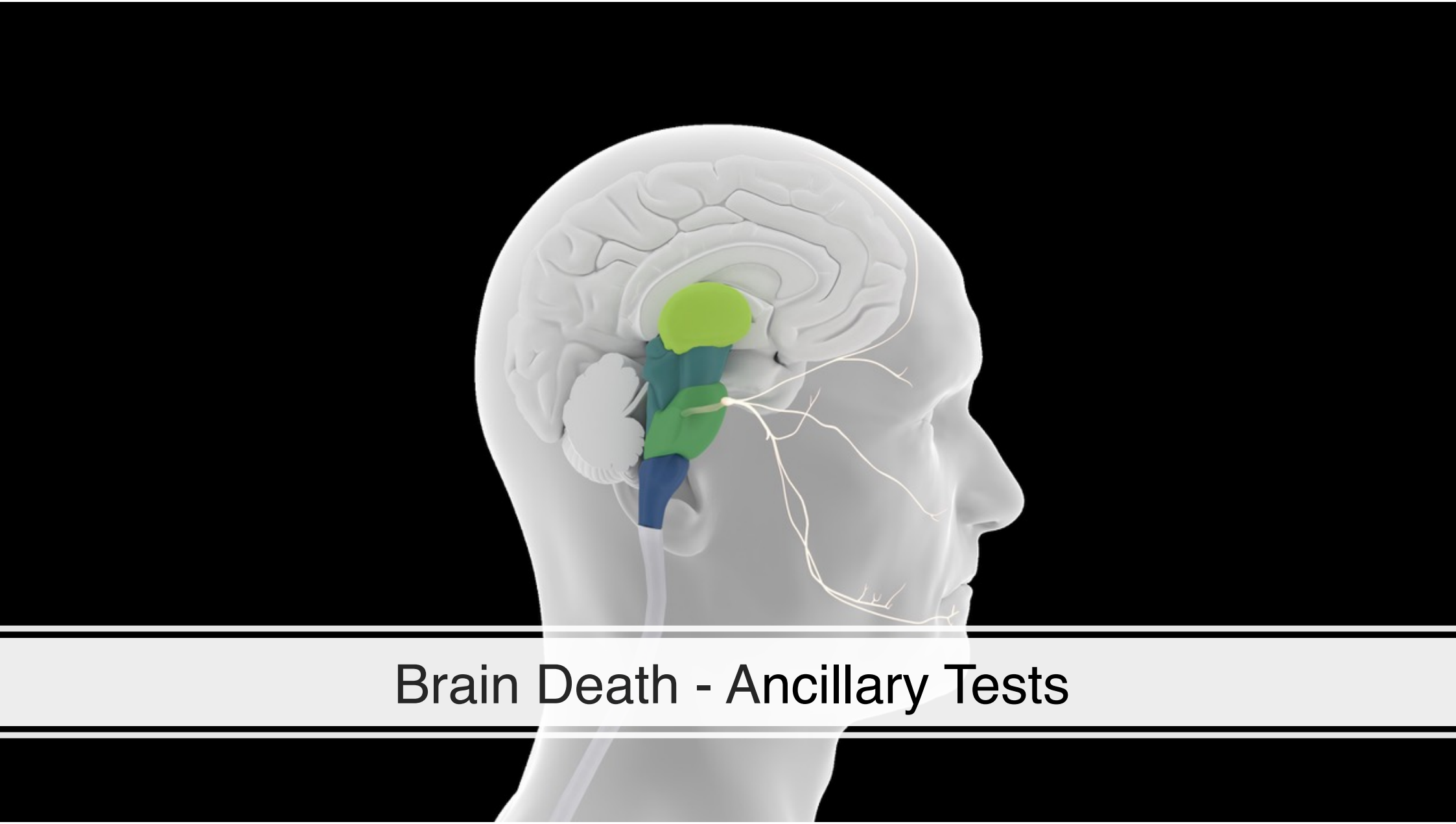

# Brain Death - Ancillary Tests

**Table 3** Comparative Findings, Accuracies and Pitfalls of the Electrophysiology and Neuroimaging Ancillary Tests for the diagnosis of Brain Death

| Test | Findings | Sensitivity/ Specificity | Advantages | Disadvantages | Pitfalls |
|---|---|---|---|---|---|
| *Electrophysiological tests* | | | | | |
| Electroencephalography (EEG) | Flat EEG—no activity over 2 μV, for a period of 30 minutes | 83%; 97% | • Can be performed bedside<br>• Noninvasive<br>• Cheaper | • Limited in evaluation of subcortical structures like thalami and brainstem<br>• Interference<br>• Diagnostic uncertainty in up to 20% | False positives from hypothermia (brain death evaluation should never be done when temperature <36°C), CNS depressants or metabolic factors |
| Somatosensory evoked potential (SSEP) | No parietal sensory cortical activity after median nerve stimulation | 100%; 78% | • Can be performed bedside<br>• Noninvasive | • Interrogates only a discrete region of brain<br>• Poor specificity | • False positive from hypothermia or CNS depressants<br>• Can be normal in early phase of brain death<br>• Upper cervical cord/ medullary lesions can mimic BD |
| Brainstem evoked activation potential (BAEP) | No brainstem response after auditory stimulus | 100%; 73.7% | • Can be performed bedside<br>• Noninvasive | • Interrogates only a discrete region of brain<br>• Poor specificity | |

Rizvi T, Batchala P, Mukherjee S. Brain Death: Diagnosis and Imaging Techniques. Semin Ultrasound CT MR. 2018;39(5):515-29.

| | | | | | |
|---|---|---|---|---|---|
| *Neuroimaging tests* | | | | | |
| *Catheter angiography* | Absence of contrast opacification of the intracranial segments and branches of carotid and vertebral arteries; absence of contrast in the deep veins; visualization of the external carotid arteries | NA | Regarded as "gold standard" among the neuroimaging tests | • Invasive<br>• Expertise needed<br>• Expensive and time consuming<br>• Limited availability<br>• Risk of contrast induced renal damage in potential donors | • Stasis filling (can be misinterpreted/false negative)<br>• False negative in postdecompressive craniectomy too.<br>• False positive in hypotensive patients |
| CT angiography | • Absence of contrast opacification of the intracranial segments and branches of carotid and vertebral arteries<br>• Absence of contrast in the deep veins (overall this seems to be the most reliable sign in multiple series) | 69.7%-100%; NA | • Noninvasive<br>• Availability<br>• Simultaneous donor organ imaging | • Contrast induced renal damage in potential donors<br>• Lack of technique standardization precludes adequate comparison of results in multiple series. | • Variable criteria<br>• Stasis filling particularly in the major arteries close to base of skull. (false negative)<br>• False negative in postdecompressive craniectomy<br>• Potentially false positive in hypotensive patients |

Rizvi T, Batchala P, Mukherjee S. Brain Death: Diagnosis and Imaging Techniques. Semin Ultrasound CT MR. 2018;39(5):515-29.

| Test | Findings | Sensitivity/ Specificity | Advantages | Disadvantages | Pitfalls |
|---|---|---|---|---|---|
| MR angiography | Absence of flow related enhancement in the intracranial arteries | 100%; 100% | • Gadolinium contrast requirement is only optional<br>• MR imaging alongside reveal extent of hypoxic brain injury<br>• Time-of-flight imaging appears to be immune to "stasis filling" phenomenon | • Technical difficulties in placing patient on advanced life support in the scanner<br>• Presence of susceptibilities can degrade image | MR artefacts |
| CT perfusion | Absence of intracranial perfusion in both supratentorial and infratentorial compartments | 100%; NA | • Availability<br>• Can be performed along CT angiography | • Risk of contrast induced renal damage in potential donors | Considered investigational |
| MR perfusion | • Absence of intracranial perfusion in both supratentorial and infratentorial compartments<br>• MR equivalent of "hot nose sign" | NA | Can be performed along with the initial work up | Technical difficulties in placing patient on advanced life support in the scanner | Considered investigational |

Rizvi T, Batchala P, Mukherjee S. Brain Death: Diagnosis and Imaging Techniques. Semin Ultrasound CT MR. 2018;39(5):515-29.

| Test | Findings | Sensitivity/ Specificity | Advantages | Disadvantages | Pitfalls |
|---|---|---|---|---|---|
| Transcranial Doppler | Small systolic peaks without diastolic flow or reverberating flow pattern | 70%-100%; 97%-100% [d] | • Safe, inexpensive<br>• Can be done bedside<br>• No contrast administration<br>• Anterior and posterior circulation can be evaluated | • Expertise needed<br>• Operator dependent<br>• Getting reliable signal with limited window | False negative in postdecompressive craniectomy |
| HMPAO/ECD planar or SPECT imaging | • "Hollow skull" or "light bulb sign" in static images due to lack of cerebral perfusion<br>• "Hot nose sign" due to increased activity around the nose from ECA perfusion | 100%; 100% | No iodinated contrast administration | • Limited availability<br>• Time consuming<br>• Limited evaluation of posterior fossa and brainstem especially by planar imaging | False negative in postdecompressive craniectomy |

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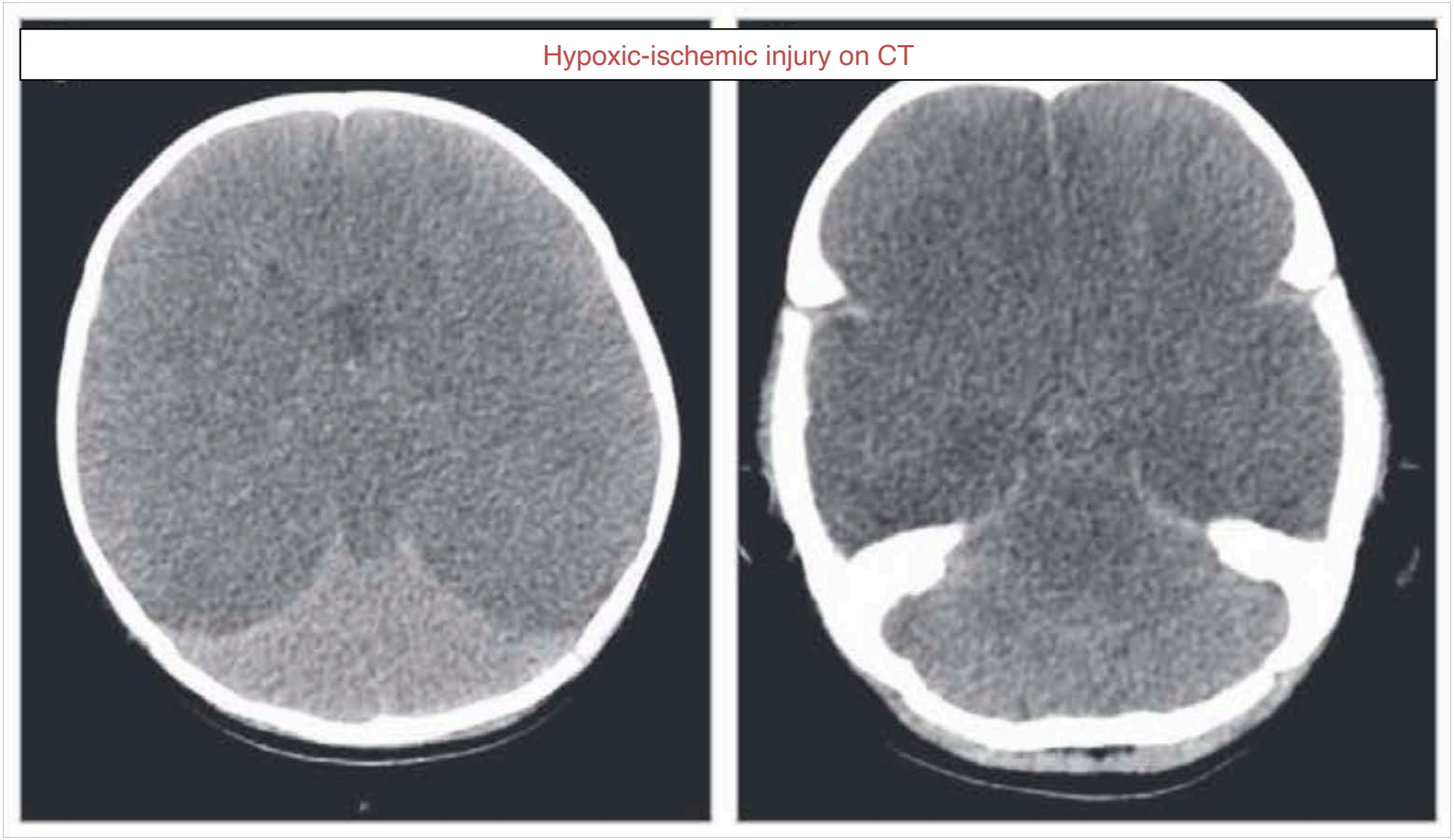


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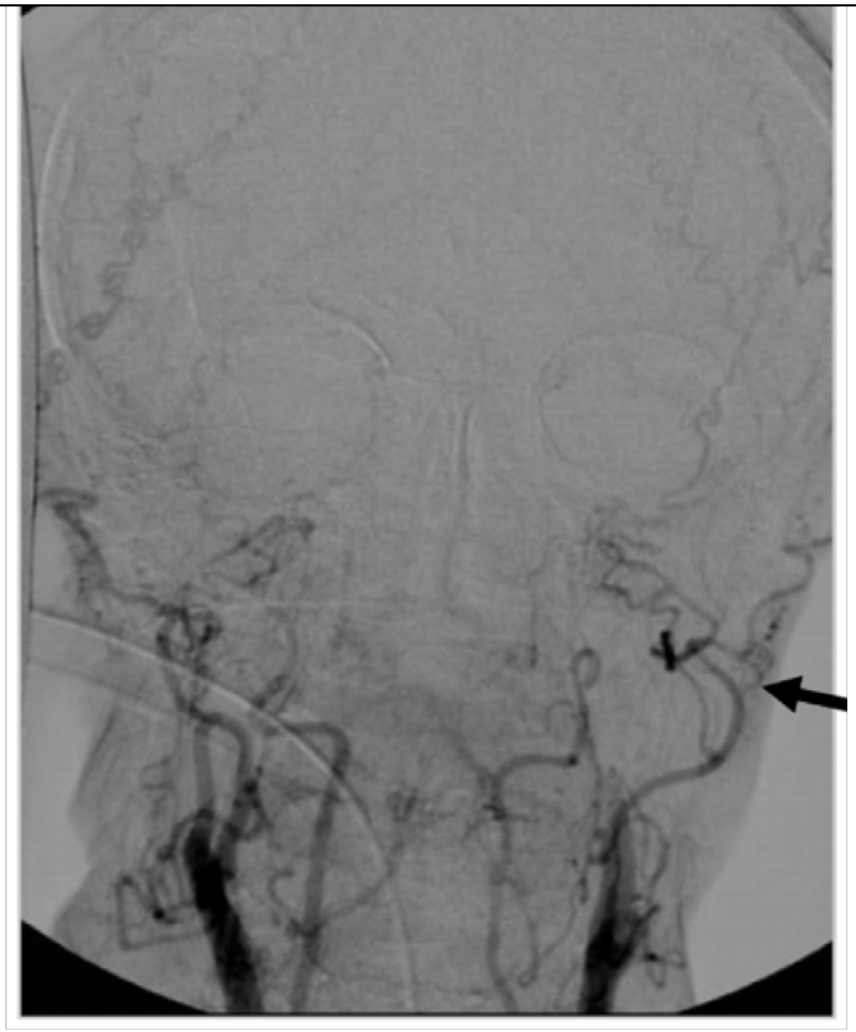
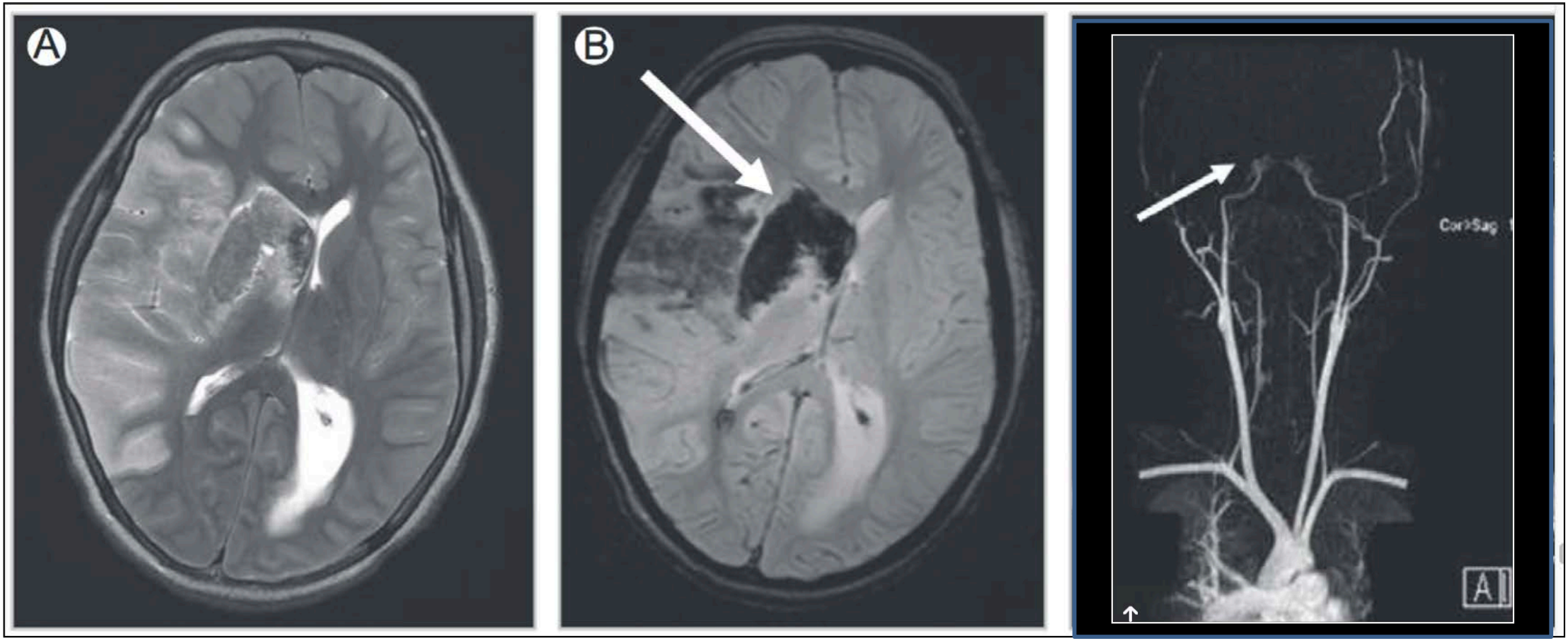
Catheter cerebral angiogram in brain death



CT-angiogram in brain death

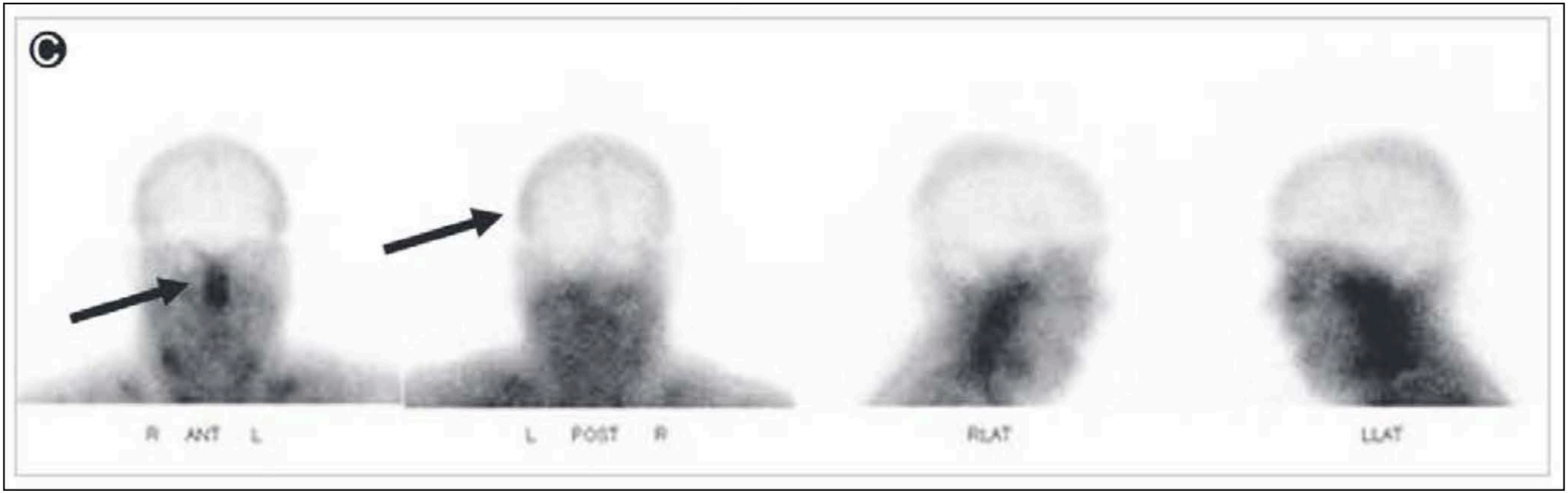
Rizvi T, Batchala P, Mukherjee S. Brain Death: Diagnosis and Imaging Techniques. Semin Ultrasound CT MR. 2018;39(5):515-29.

# MRI and MRA in brain death




Rizvi T, Batchala P, Mukherjee S. Brain Death: Diagnosis and Imaging Techniques. Semin Ultrasound CT MR. 2018;39(5):515-29.

# HMPAO nuclear scintigraphy in brain death

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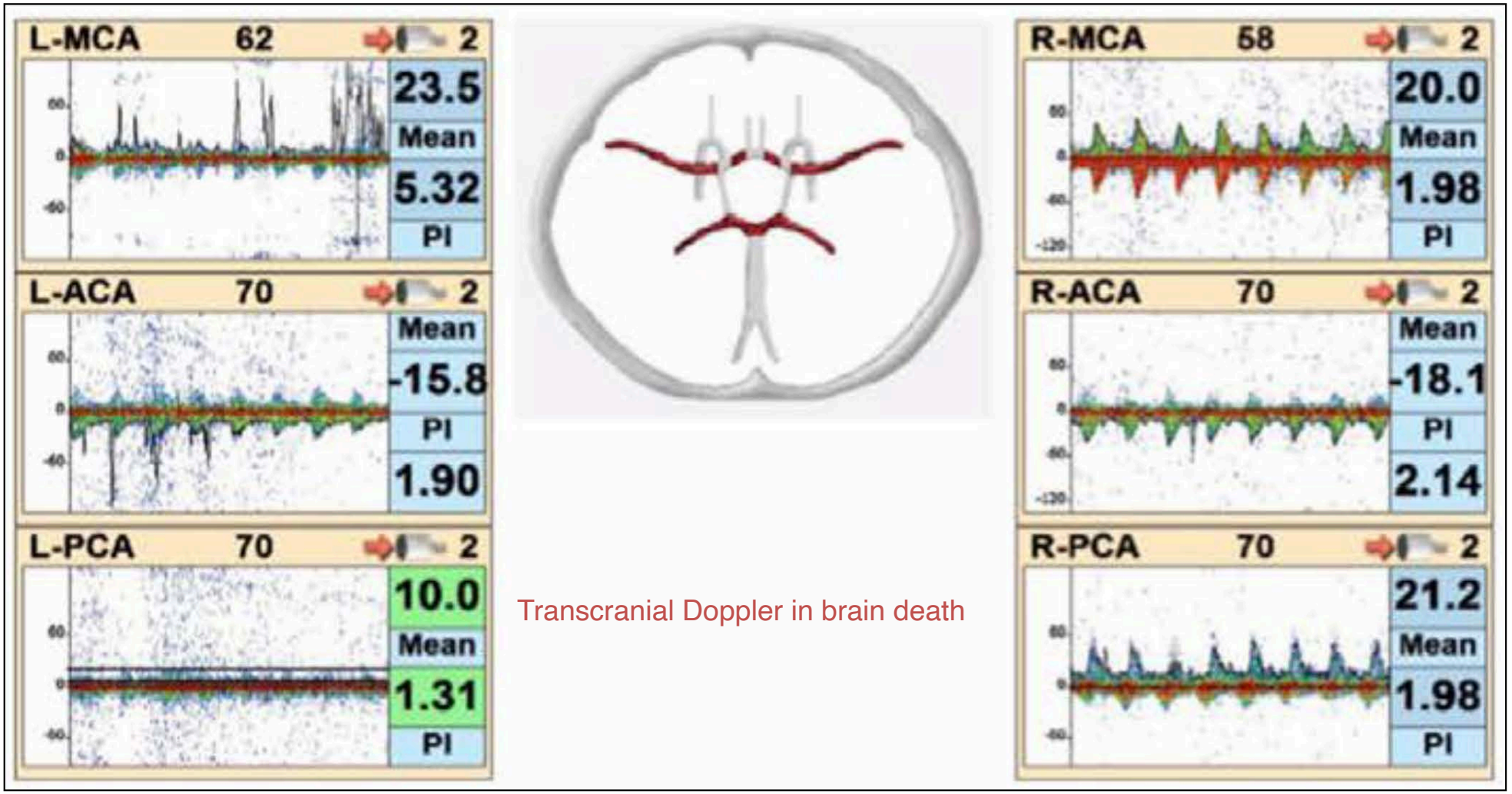


Transcranial Doppler in brain death

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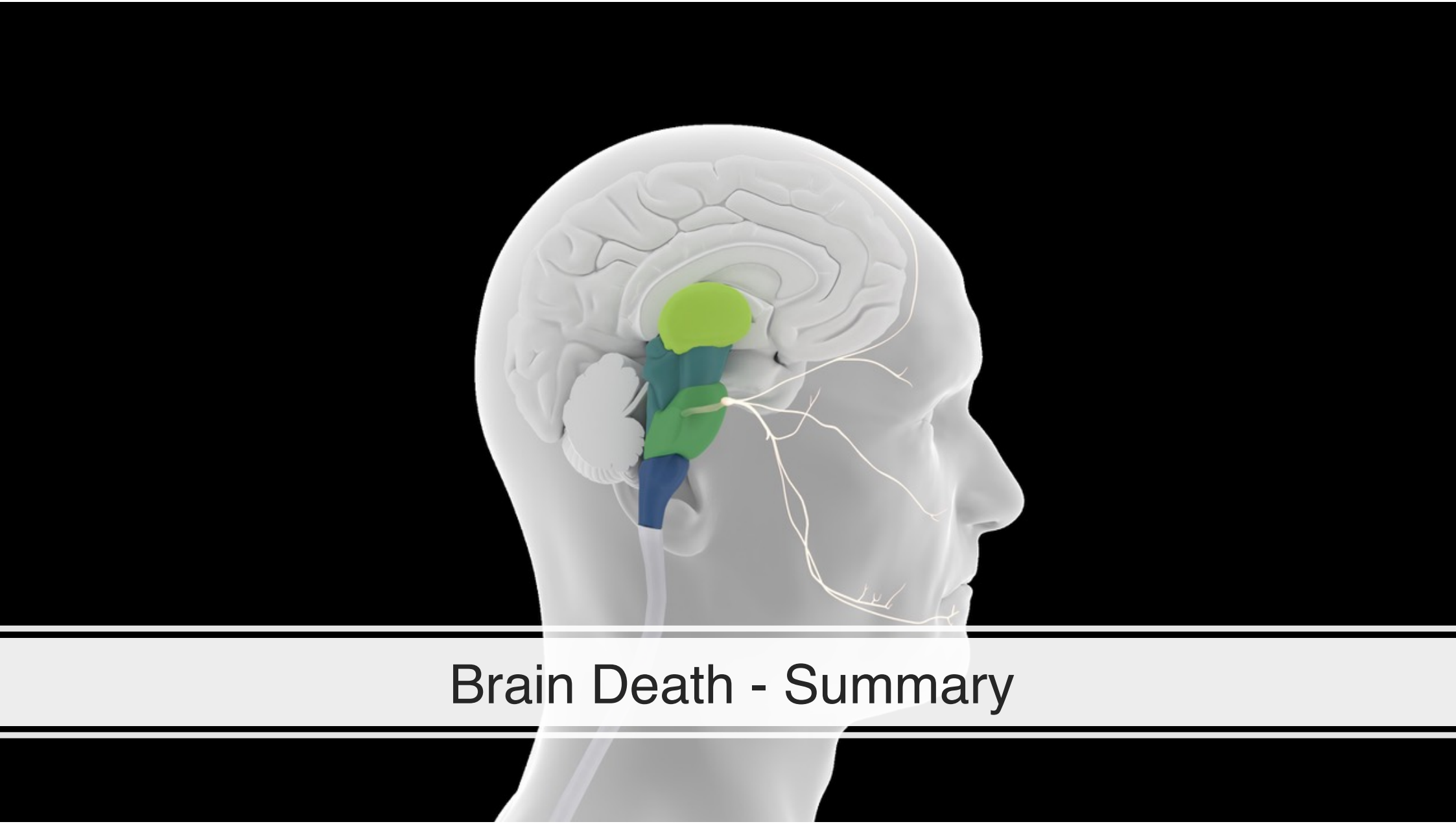

# Brain Death - Summary

**TABLE 9-1** 25 Assessments to Declare a Patient Brain Dead[a]

▶ **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 of 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 ≥36°C [96.8°F])
7. ☐ Systolic blood pressure >100 mm Hg
8. ☐ No spontaneous respirations

▶ **Examination (All Must Be Checked)**

9. ☐ Pupils nonreactive to bright light
10. ☐ Corneal reflexes absent
11. ☐ Eyes immobile, oculocephalic reflexes absent (tested only if cervical-spine integrity ensured)
12. ☐ Oculovestibular reflexes absent
13. ☐ No facial movement to noxious stimuli at supraorbital nerve or temporomandibular joint or absent snout and rooting reflexes (neonates)
14. ☐ Gag reflex absent
15. ☐ Cough reflex absent to tracheal suctioning
16. ☐ No motor response to noxious stimuli in all four limbs (Spinally mediated reflexes are permissible and triple flexion response is most common.)

▶ **Apnea Testing (All Must Be Checked)**

17. ☐ Patient is hemodynamically stable (systolic blood pressure ≥100 mm Hg)
18. ☐ Ventilator adjusted to normocapnia ($Paco_2$ 35–45 mm Hg)
19. ☐ Patient preoxygenated with 100% $Fio_2$ for 10 minutes ($Pao_2$ ≥200 mm Hg)
20. ☐ Patient maintains oxygenation with a PEEP of 5 cm water
21. ☐ Disconnect ventilator
22. ☐ Provide oxygen via an insufflation catheter to the level of the carina at 6 L/min or attach T-piece with continuous positive airway pressure (CPAP) valve at 10 cm water
23. ☐ Spontaneous respirations absent
24. ☐ Arterial blood gas drawn at 8–10 minutes, patient reconnected to ventilator
25. ☐ $Paco_2$ ≥60 mm Hg, or 20 mm Hg rise from normal baseline value

OR

Apnea test aborted and ancillary test (EEG or cerebral blood flow study) confirmatory

*Continued on page 1420*

Wijdicks EF. Determining Brain Death. Continuum (Minneap Minn). 2015;21(5 Neurocritical Care):1411-24.

| Test | Testing Conditions | Diagnostic Finding Compatible With Brain Death | Possible Pitfalls |
|---|---|---|---|
| **EEG** | Minimum of eight electrodes:<br>Interelectrode distance ≤10 cm<br>Interelectrode impedance between 100 and 10,000 Ω<br>Sensitivity ≥2 μV<br>High-frequency filter <30 Hz and low-frequency filter >1 Hz<br>Duration ≥30 minutes | Complete absence of cerebral electric activity, including lack of reactivity to intense, painful, visual, and auditory stimulation | Electric artifacts (common in the intensive care unit); mostly evaluates the cortex |
| **Nuclear medicine scan**[a] | Isotope injection within 30 minutes of reconstitution; anterior and bilateral planar image counts upon injection and after 30 minutes, 1 hour, and 2 hours | No brain perfusion (hollow skull) | Incorrect injection (can be avoided by confirming uptake in the liver) |
| **Transcranial Doppler** | Bilateral transtemporal and transforaminal insonation; transorbital window insonation can be considered | Reverberating arterial flow or small peaks in early systole | Lack of reliable signal because of poor temporal bone window; highly dependent on skill of operator; absence of flow is not reliable because it may be due to poor windows or poor technique |
| **Catheter angiography** | Contrast injection in the arch and under high pressure | Absence of flow in intracranial arteries | Inadequate pressure upon injection; partial filling of intracranial arteries without reaching perfusing branches |
| **CT angiography** | Contrast injection from a peripheral vein with a pressure injector; arterial and venous phases should be imaged | Absence of flow in distal middle cerebral arteries | May be unreliable in low-flow states (delayed perfusion may be missed by usual timing of image acquisition); sensitivity is limited when only using arterial filling as diagnostic criterion; absent flow in internal cerebral veins may increase sensitivity |

Rabinstein AA. Coma and Brain Death. Continuum (Minneap Minn). 2018;24(6):1708-31.