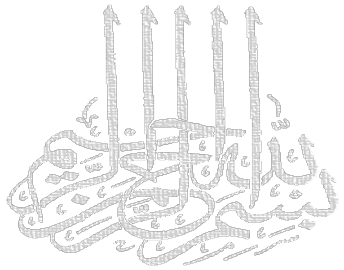


Ancillary Testing in Brain Death Diagnosis

Outline

- Indications of ancillary testing
- Choice of ancillary testing
  - Electroencephalogram: EEG
  - CT angiography: CTA
  - Cerebral Scintigraphy (Nuclear Brain scanning)
  - Transcranial Doppler: TCD

Indications of Ancillary Testing

- Severe facial or cervical spine trauma, or facial deformity confounding cranial nerve assessment.
- When neuromuscular paralysis or heavy sedation is present
- Incomplete apnea testing. (Severe chronic pulmonary disease or severe obesity resulting in chronic retention of CO2….)
- Toxic levels of CNS-depressant drugs or neuromuscular blocking agents.
- Severe electrolyte, acid-base, or endocrine disturbance (defined by severe acidosis or laboratory values markedly deviated from the norm).
- Children younger than 1 year old.
- Required by institutional policy in some protocols
- To shorten the duration of the observation period)

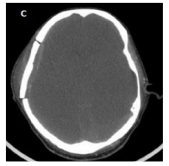
Ancillary Testing…

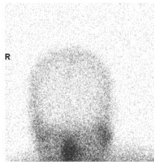
- The choice of an ancillary test is dictated in large part by practical considerations, i.e., availability, advantages, and disadvantages.
- Only 1 needs to be performed.

Ancillary Tests

Cerebral Angiography

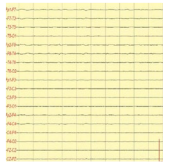
(conventional, computerized tomographic, and magnetic resonance)

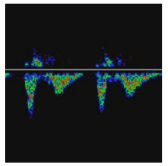




Cerebral Scintigraphy (Nuclear Brain scanning)

Electroencephalogram (EEG)



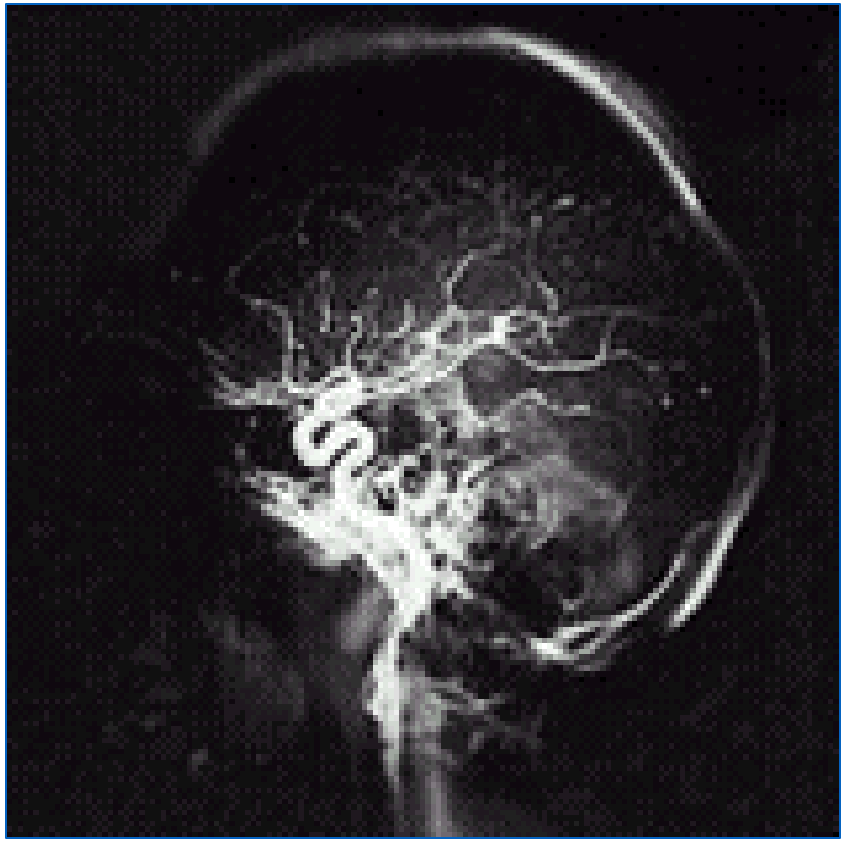


Transcranial Doppler (TCD)

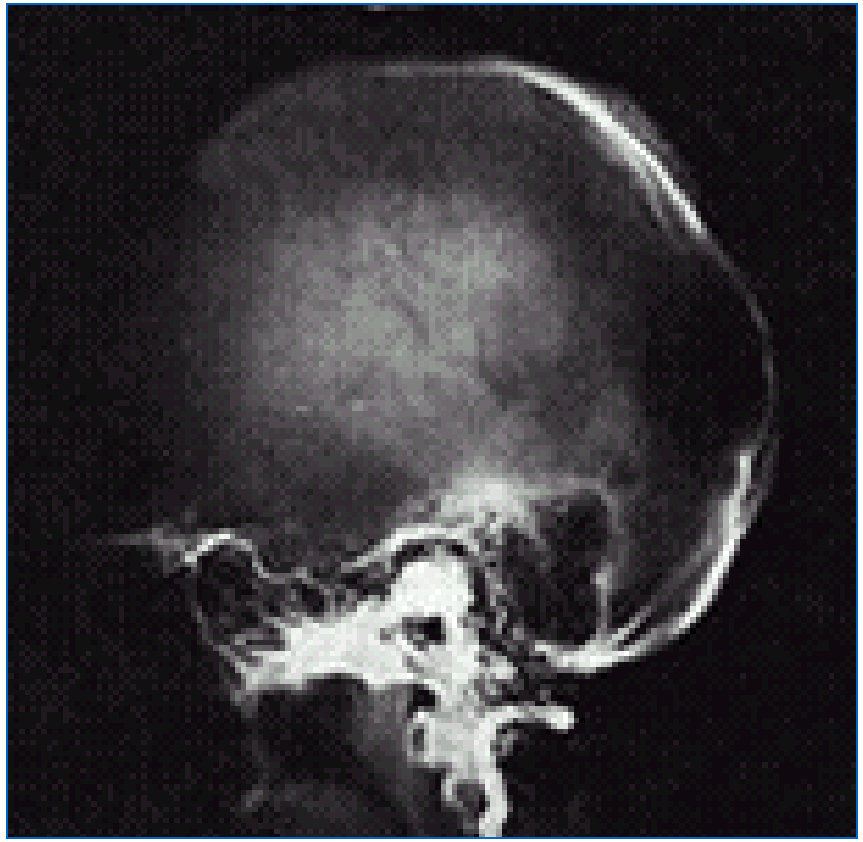
Cerebral angiography

- The contrast medium should be injected in the aortic arch under high pressure and reach both anterior and posterior circulations.
- No intracerebral filling should be detected at the level of entry of the carotid or vertebral artery to the skull.
- The external carotid circulation should be patent.
- The filling of the superior longitudinal sinus may be delayed.

Cerebral Angiography

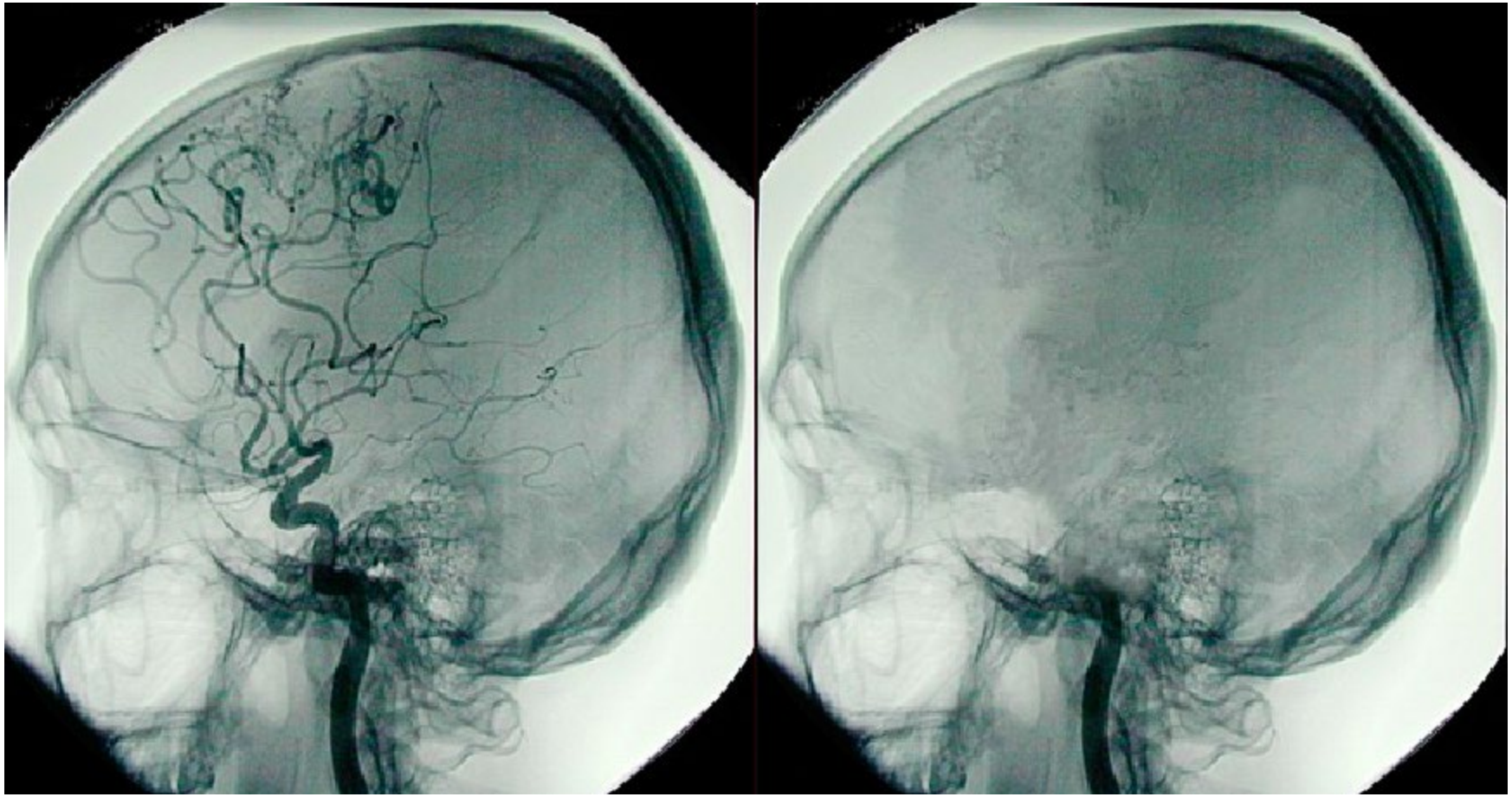


Normal Blood Flow



No Blood Flow

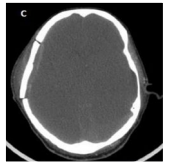
Cerebral Angiography

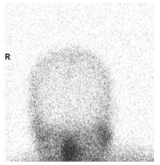


Ancillary Tests

Cerebral Angiography

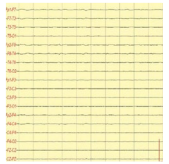
(conventional, computerized tomographic, and magnetic resonance)

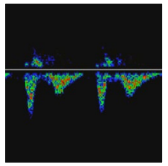




Cerebral Scintigraphy (Nuclear Brain scanning)

Electroencephalogram (EEG)





Transcranial Doppler (TCD)

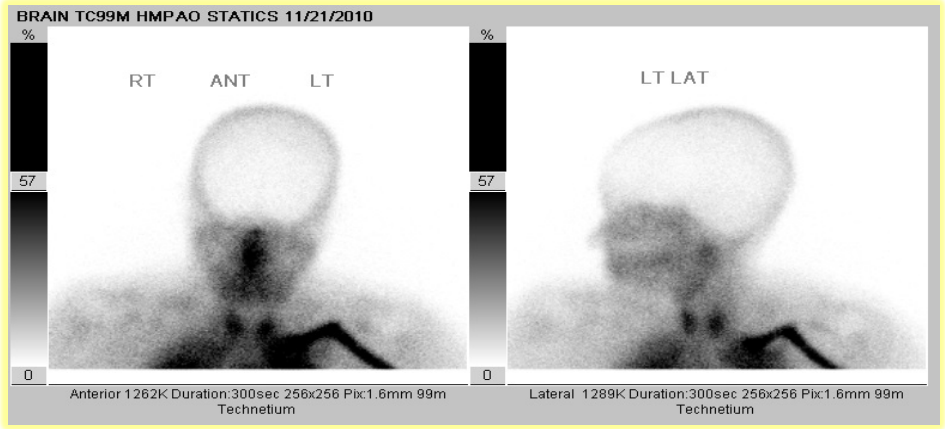
Cerebral Scintigraphy

- The isotope should be injected within 30 minutes after its Reconstitution.
- Anterior and both lateral planar image counts of the head should be obtained at several time points: immediately, between 30 and 60 minutes later, and at 2 hours.
- A correct IV injection may be confirmed with additional images of the liver demonstrating uptake (optional).
- No radionuclide localization in the middle cerebral artery, anterior cerebral artery, or basilar artery territories of the cerebral hemispheres (hollow skull phenomenon).
- No tracer in superior sagittal sinus (minimal tracer can come from the scalp).

Normal Technicium Scan

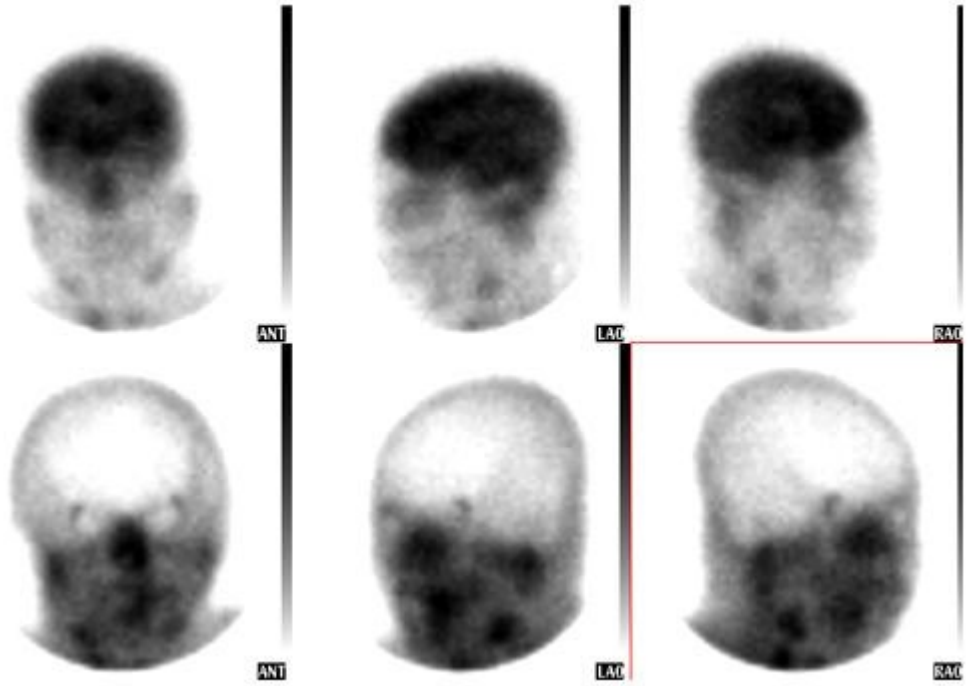
Tc-99m HMPAO scintigraphy

- Noninvasive, excellent correlation with cerebral angiogram
- Multiple flow patterns have been described
  - No intracranial flow provides straightforward confirmation of brain death; flow within cerebrum and cerebellum rules out the diagnosis
  - Preservation of cerebellar flow with absence of cerebral flow is not diagnostic, but patients will usually end up progressing to brain death
  - Lack of cerebellar flow with preservation of cerebral flow is an indeterminate finding
- Hot nose sign due to obstruction of internal carotid artery flow and subsequent increased external carotid flow into collateral and extracranial circulation through center of the face
- Disadvantages are that it is not widely available on an urgent basis



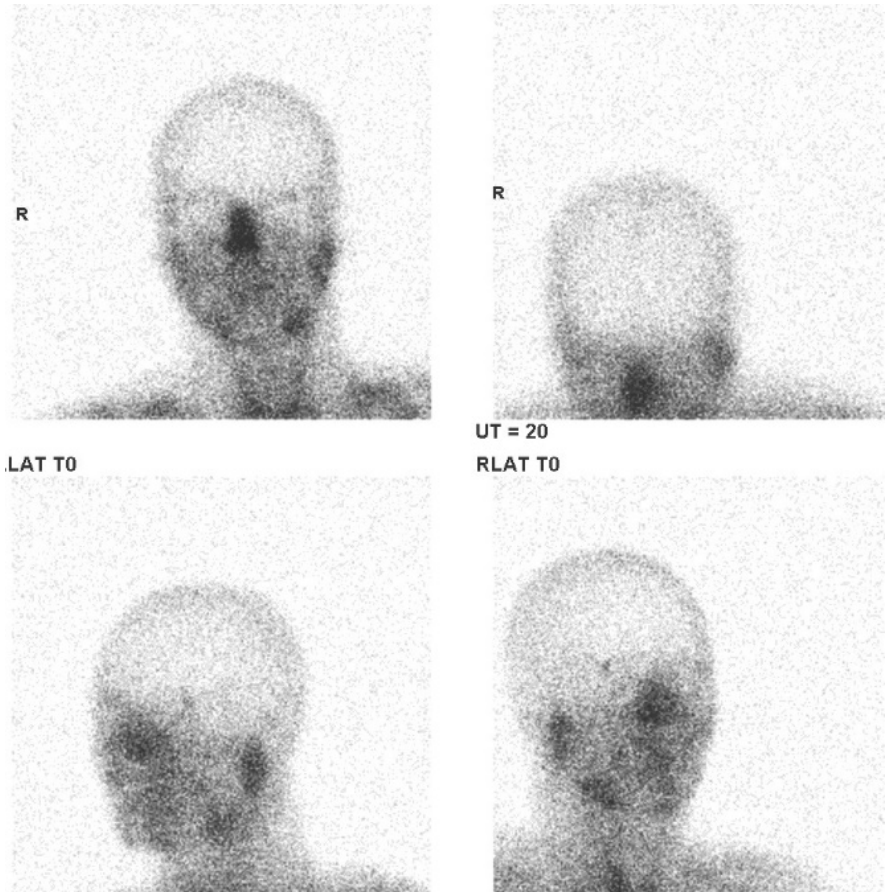
Tc-99m HMPAO scintigraphy in a patient with clinically diagnosed brain death demonstrates no intracranial vascular flow.

HMPAO-Tc99m imaging



- The top figures show anterior posterior and lateral views of a normal scan with uptake in the brain.
- The bottom figures (same sequence) show lack of brain perfusion and the "empty light bulb" and "hot nose" signs.

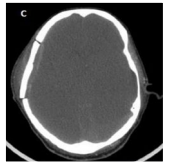
Hot Nose Sign

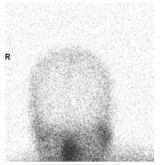


Ancillary Tests

Cerebral Angiography

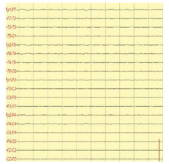
(conventional, computerized tomographic, and magnetic resonance)

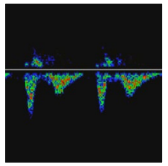




Cerebral Scintigraphy (Nuclear Brain scanning)

Electroencephalogram (EEG)





Transcranial Doppler (TCD)

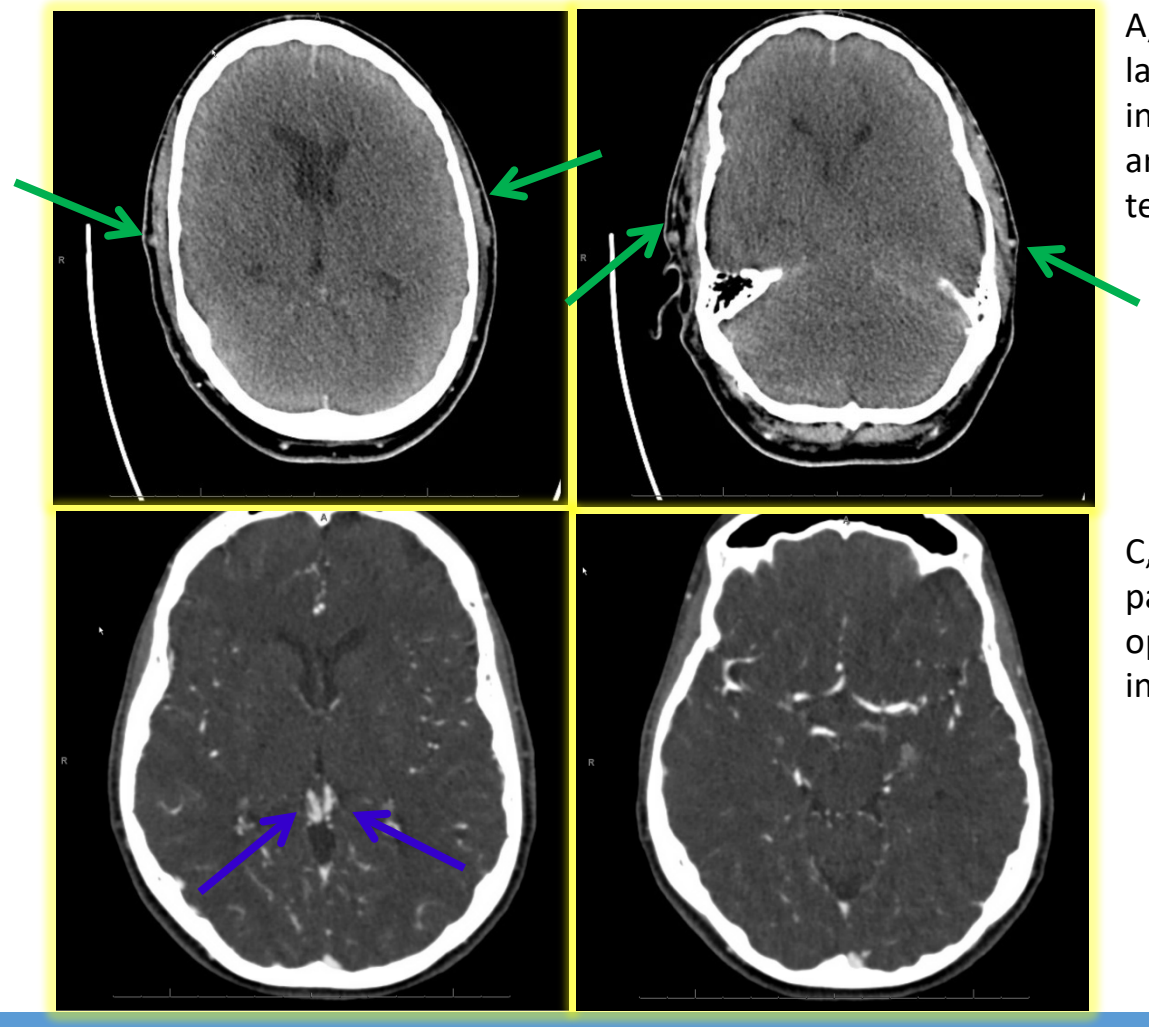
CT/CTA/CT perfusion

- Noninvasive, widely available, great rapidity, and does not require a high level of expertise to perform
- Accuracy first demonstrated by Dupas et al., who first introduced a 2-phase protocol (arterial and mixed arterial and venous phase), with a 7 point scale. This was subsequently was accepted as one of the ancillary tests for confirmation of brain death in France. Additionally Austria, Switzerland, and Canada have adopted its use in confirmation of brain death.
- Frampas et al introduced an abbreviated 4 point scale, concluding lack of opacification of MCAs and internal cerebral veins in CTA is efficient and reliable in brain death diagnosis

CT/CTA/CT perfusion

- Residual brain perfusion can occur with de-compressive craniectomy and skull defects, leading to false positive results, and Welschehold et al. have proposed using lack of opacification of the ICV as criteria, showing high sensitivity and specificity
- Shankar et al. demonstrated lack of cerebral blood flow and cerebral blood volume in the brain stem with CT perfusion is very sensitive for brain death
- Disadvantages of the use of CTA are risk of renal damage for patients in consideration for organ transplant

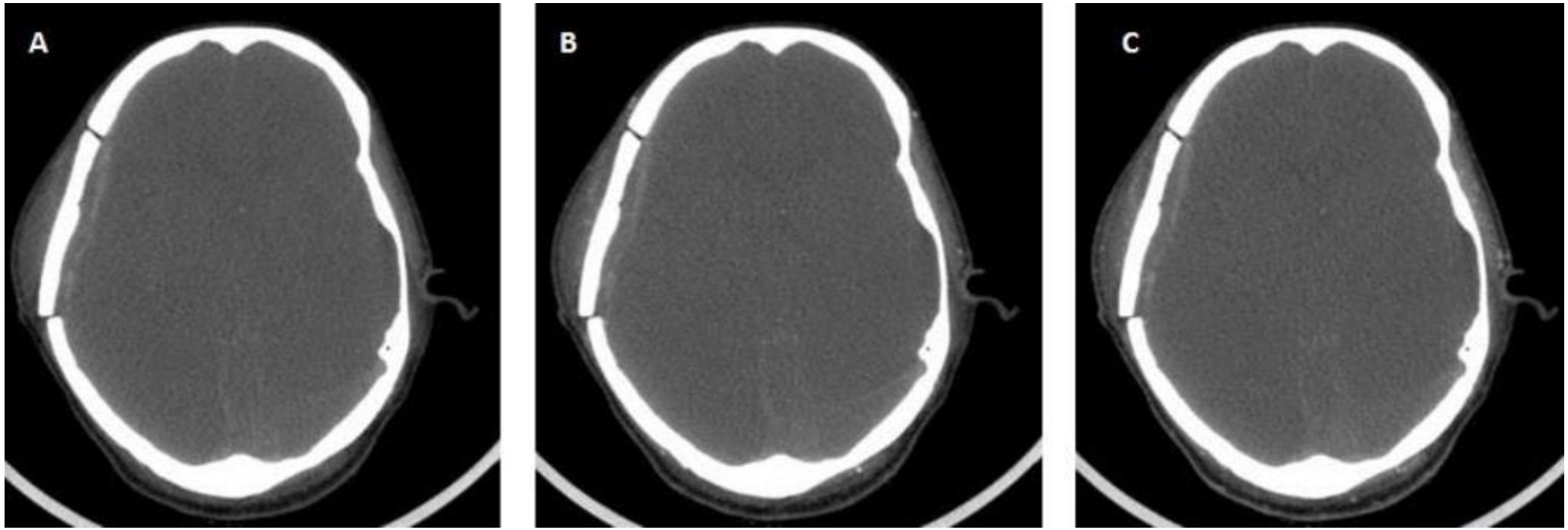
43 year old male with aortic dissection, postoperative course complicated by ischemic bowel



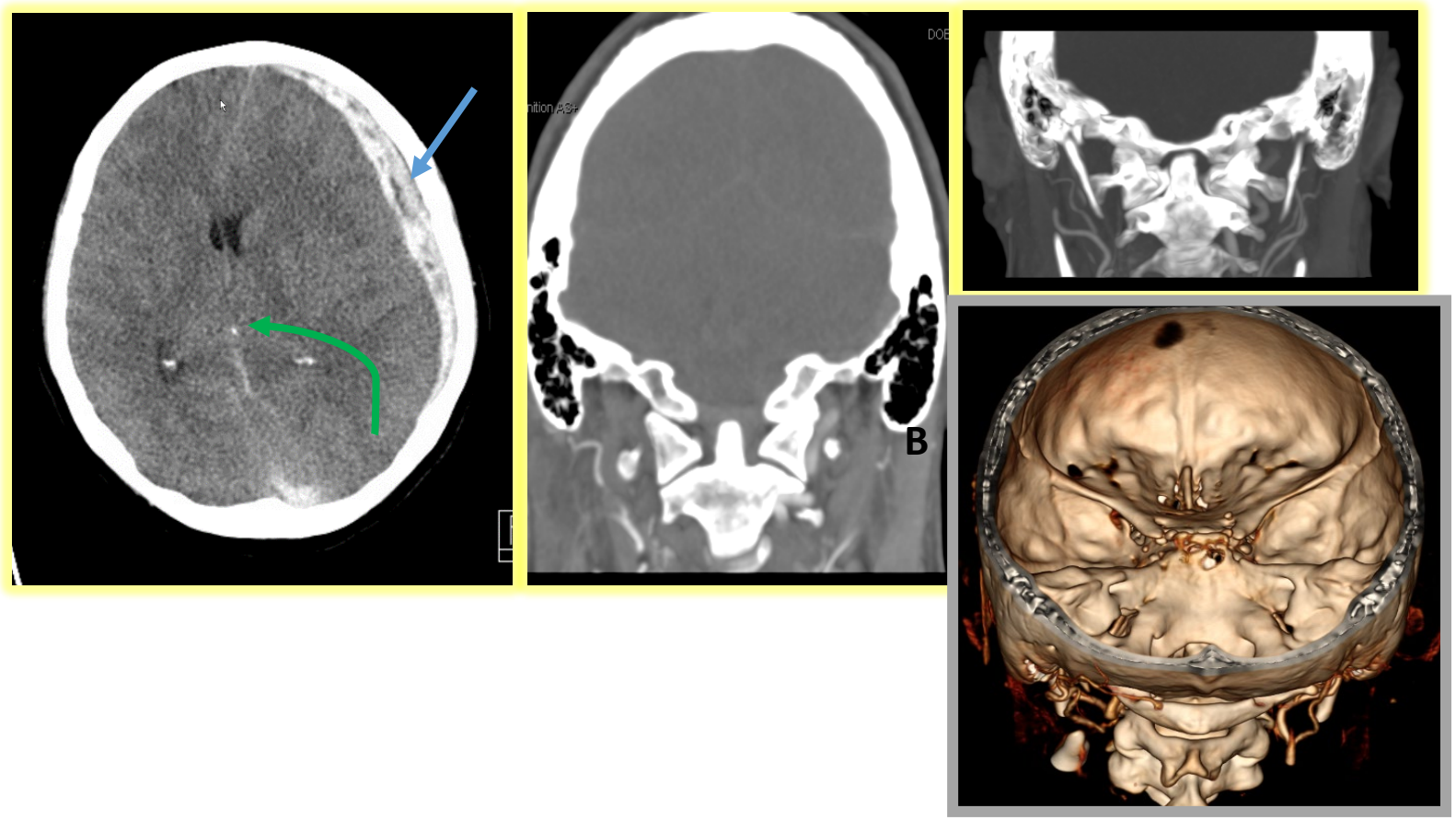
A, B) Axial slices of a CT angiogram demonstrate lack of opacification of intracranial circulation, including internal cerebral veins and midline arteries. There is opacification of the superficial temporal artery and branches (green arrows)

C, D) Normal Axial CT angiogram of a normal patient for comparison demonstrating opacification of all intracranial arteries and internal cerebral veins (blue arrows)

CT Angiography

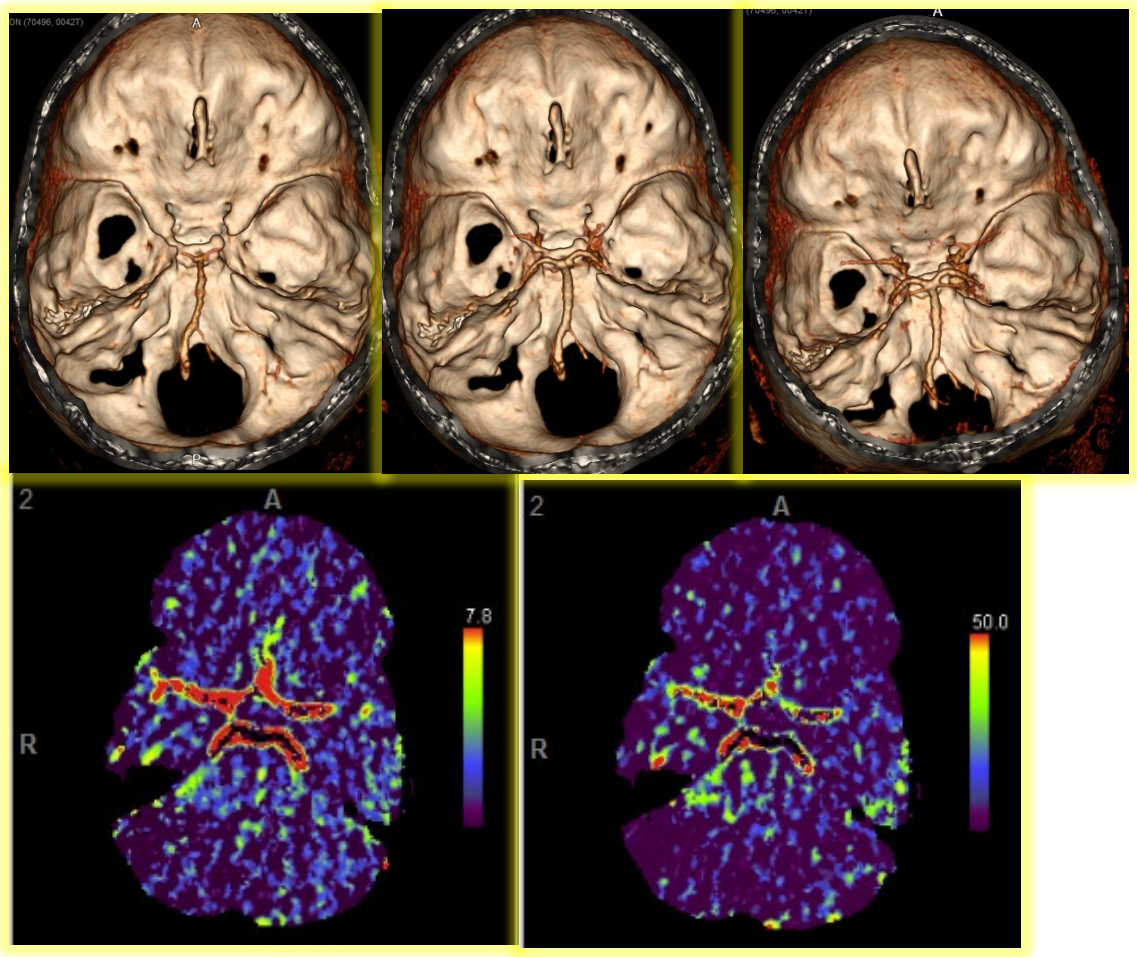


57 year old female, initially presenting with headaches, became unresponsive



A) Axial noncontrast CT demonstrates subdural hematoma (blue arrow) and midline shift (blue arrow). B, C) Coronal and D) 3D CTA reconstructions demonstrate lack of opacification of intracranial circulation

42 year old female with witnessed fall while running, found to have diffuse SAH



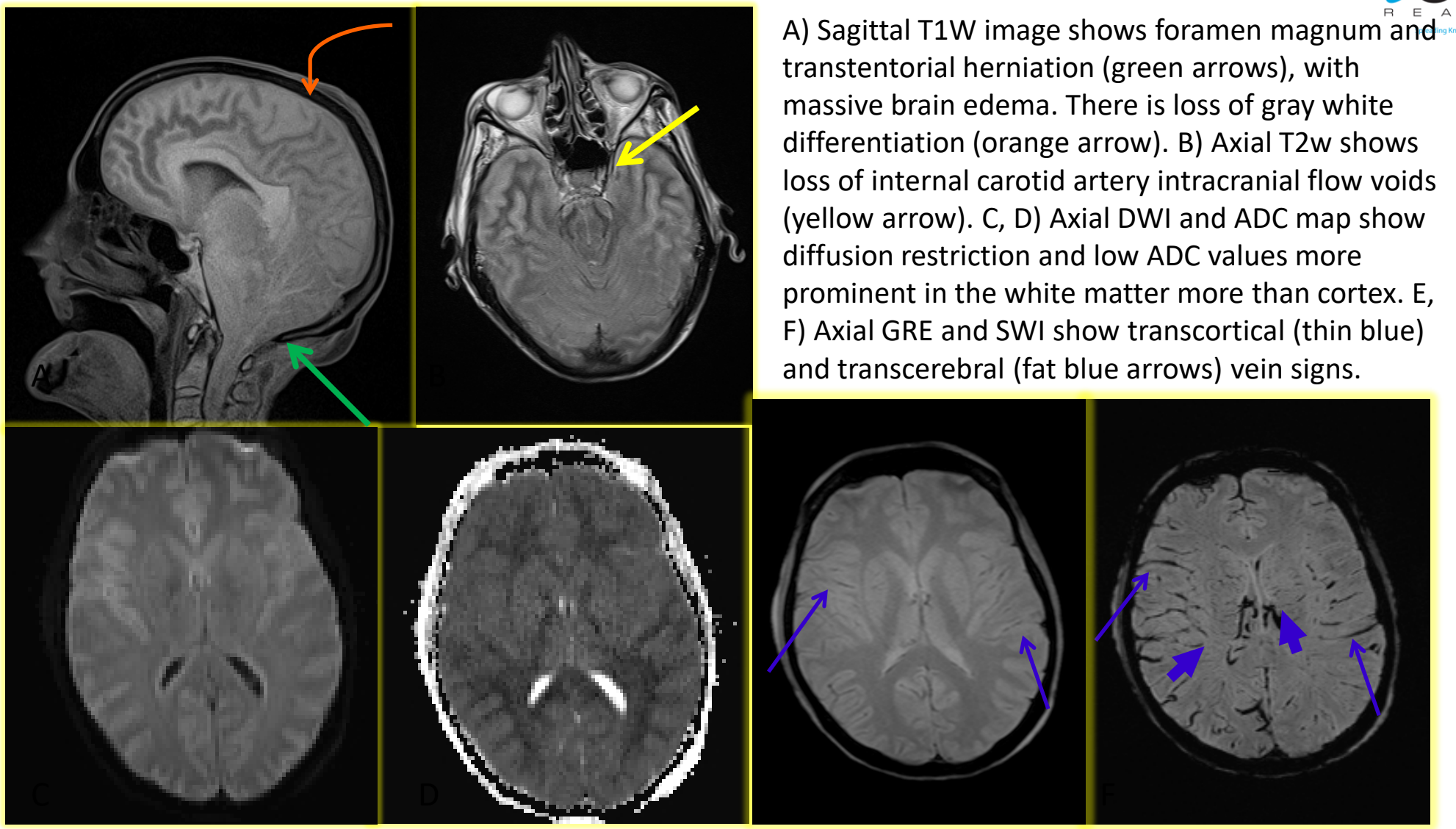
A, B, C) Axial 3D CTA reconstructions demonstrate minimal delayed opacification of intracranial circulation more likely “nearly” brain dearth.

D) Cerebral Blood Volume and E) Cerebral Blood Flow CT perfusion images demonstrate matched decreased CBV and CBF within the supratentorium and posterior fossa

MRI/MRA

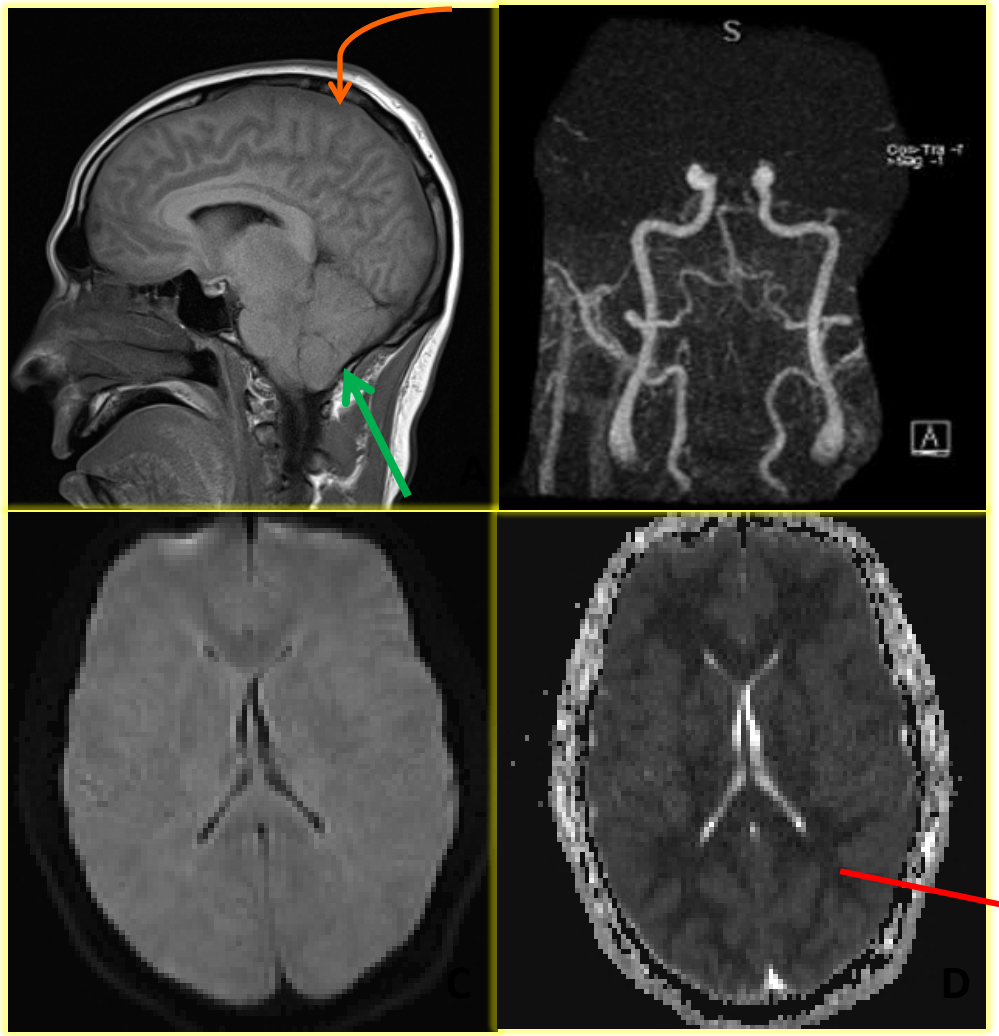
- A number of signs have been associated with the diagnosis of brain death on MRI and MRA
  - Massive brain edema leads to transtentorial and foramen magnum herniation
  - The increase in intracranial pressure and cerebral circulatory arrest leads to absence of intracranial vascular flow
  - There is poor gray matter/white matter differentiation with the brain edema on conventional MRI
  - Diffuse diffusion restriction results from diffuse cytotoxic edema, there is decreased ADC values more prominent in white matter compared to gray matter, related to differences in water accumulation in different cyto-architectures
  - Transcortical and transcerebral vein signs can be seen, which has also been described with acute stroke[35]
  - Prominent nasal and scalp enhancement
  - MRA can demonstrate non-visualization of intracranial vasculatures likely compatible with conventional angiogram.
- Disadvantages of MRI /MRA include difficulty to obtain on ventilated patients and length of time for scanning

48 yo female with perforated colon secondary to bowel impaction s/p colostomy, admitted with AMS and found to be septic



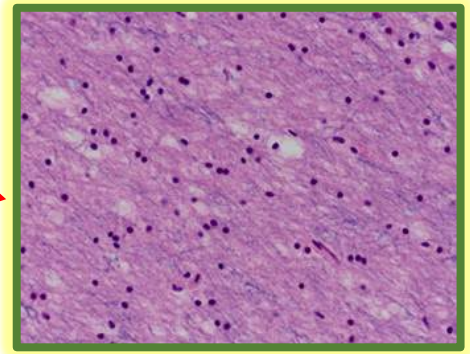
A) Sagittal T1W image shows foramen magnum and transtentorial herniation (green arrows), with massive brain edema. There is loss of gray white differentiation (orange arrow). B) Axial T2w shows loss of internal carotid artery intracranial flow voids (yellow arrow). C, D) Axial DWI and ADC map show diffusion restriction and low ADC values more prominent in the white matter more than cortex. E, F) Axial GRE and SWI show transcortical (thin blue) and transcerebral (fat blue arrows) vein signs.

32 year old man presenting with headache, lumbar puncture with CSF consistent with viral infection



A) Sagittal T1W image shows tonsillar herniation (blue arrow) and loss of cortical sulci (orange arrow). B) Intracranial MRA demonstrates loss of vascular flow within the supraclinoid internal carotid arteries.

C, D) Axial DWI and ADC map demonstrate diffuse diffusion restriction with decreased ADC values.

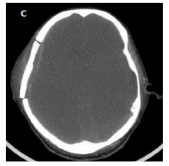


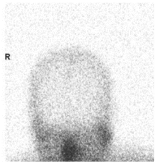
Vacuolation and decreased myelin staining in white matter

Ancillary Tests

Cerebral Angiography

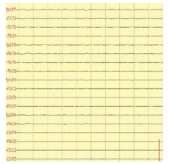
(conventional, computerized tomographic, and magnetic resonance)

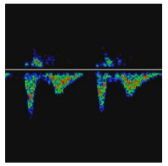




Cerebral Scintigraphy (Nuclear Brain scanning)

Electroencephalogram (EEG)





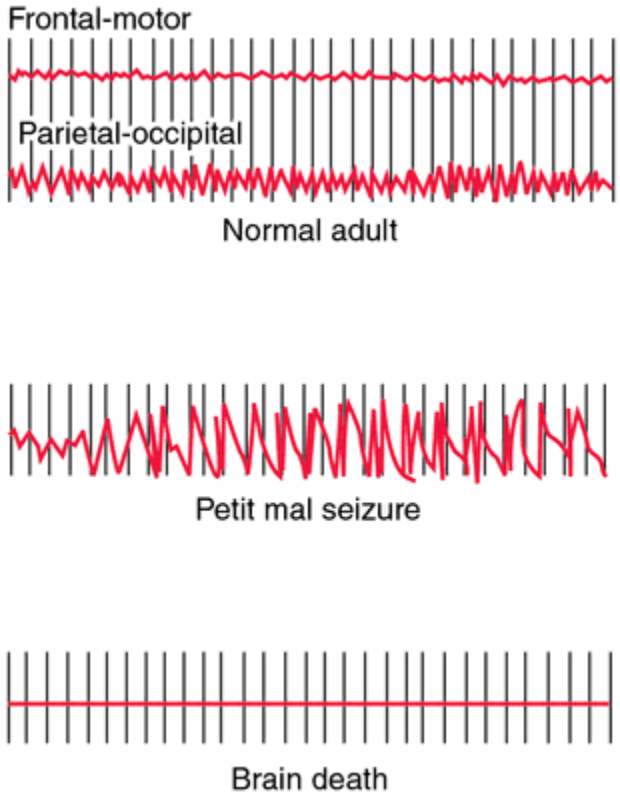
Transcranial Doppler (TCD)

Electroencephalography

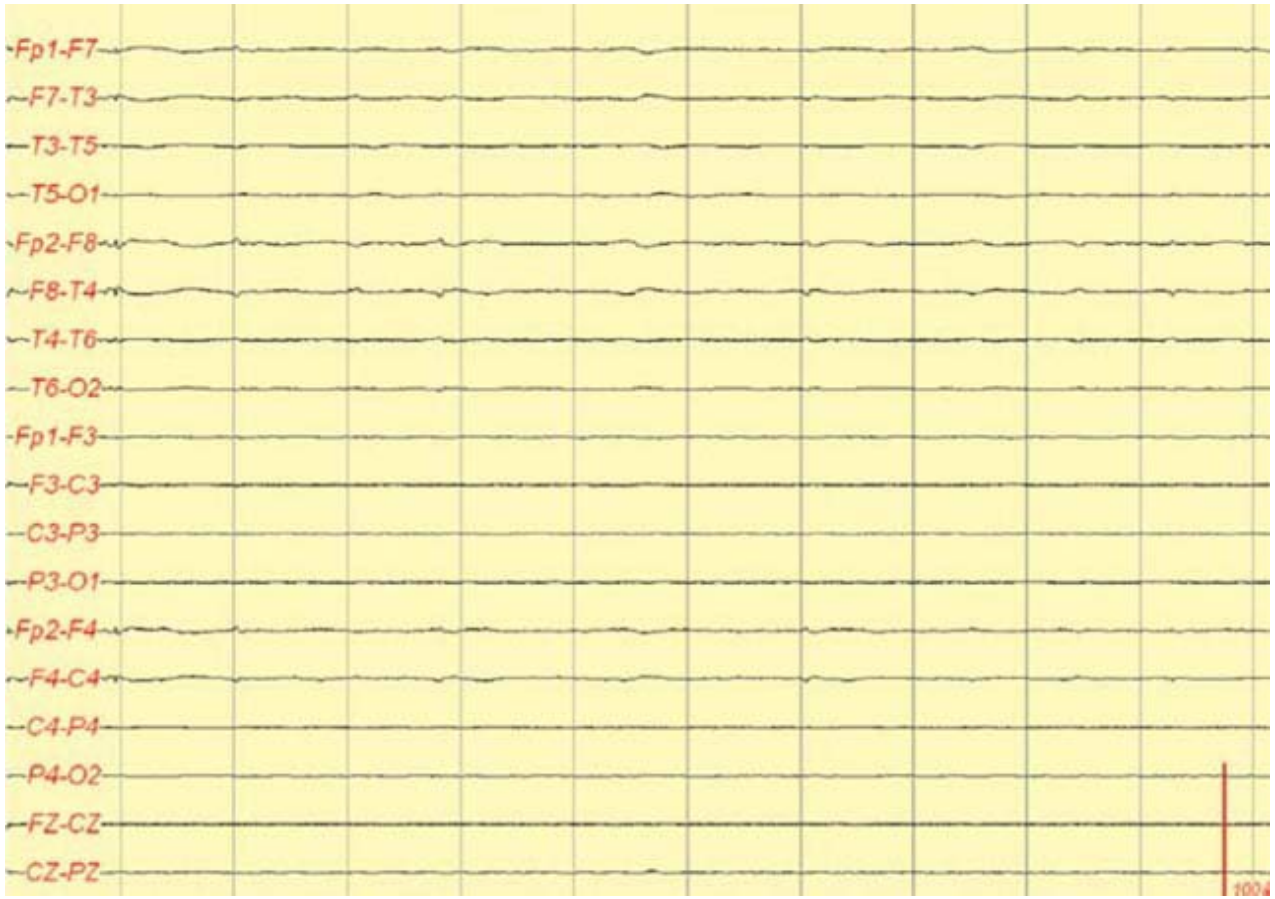
- A minimum of 8 scalp electrodes should be used.
- Interelectrode impedance should be between 100 and 10,000.
- The integrity of the entire recording system should be tested.
- The distance between electrodes should be at least 10 cm.
- The sensitivity should be increased to at least 2 V for 30 minutes with inclusion of appropriate calibrations.
- The high-frequency filter setting should not be set below 30 Hz, and the low-frequency setting should not be above 1 Hz.
- Electroencephalography should demonstrate a lack of reactivity to intense somatosensory or audiovisual stimuli.

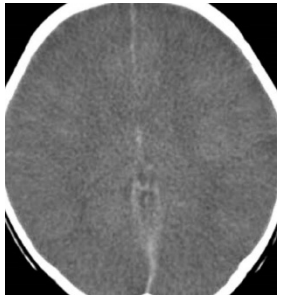
Electroencephalogram (EEG)

Normal



Electroencephalography (EEG)



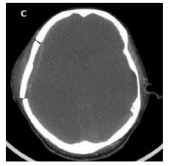


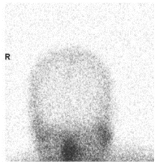
A case of fatal pneumococcal in 14 year old with 19A meningoencephalitis
Electroencephalogram at 5 days post-admission shows excessively suppressed background activity, indicating brain death.

Ancillary Tests

Cerebral Angiography

(conventional, computerized tomographic, and magnetic resonance)





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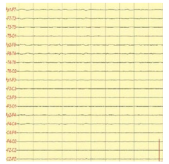
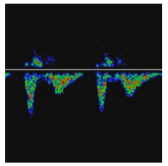
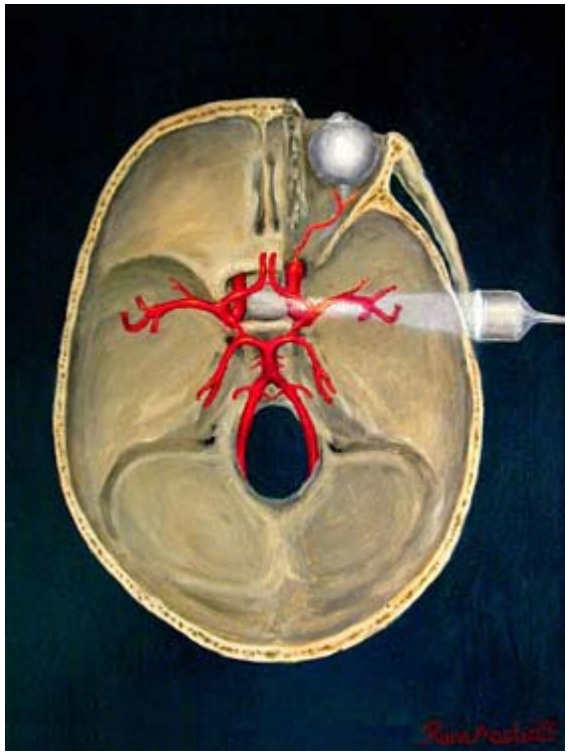


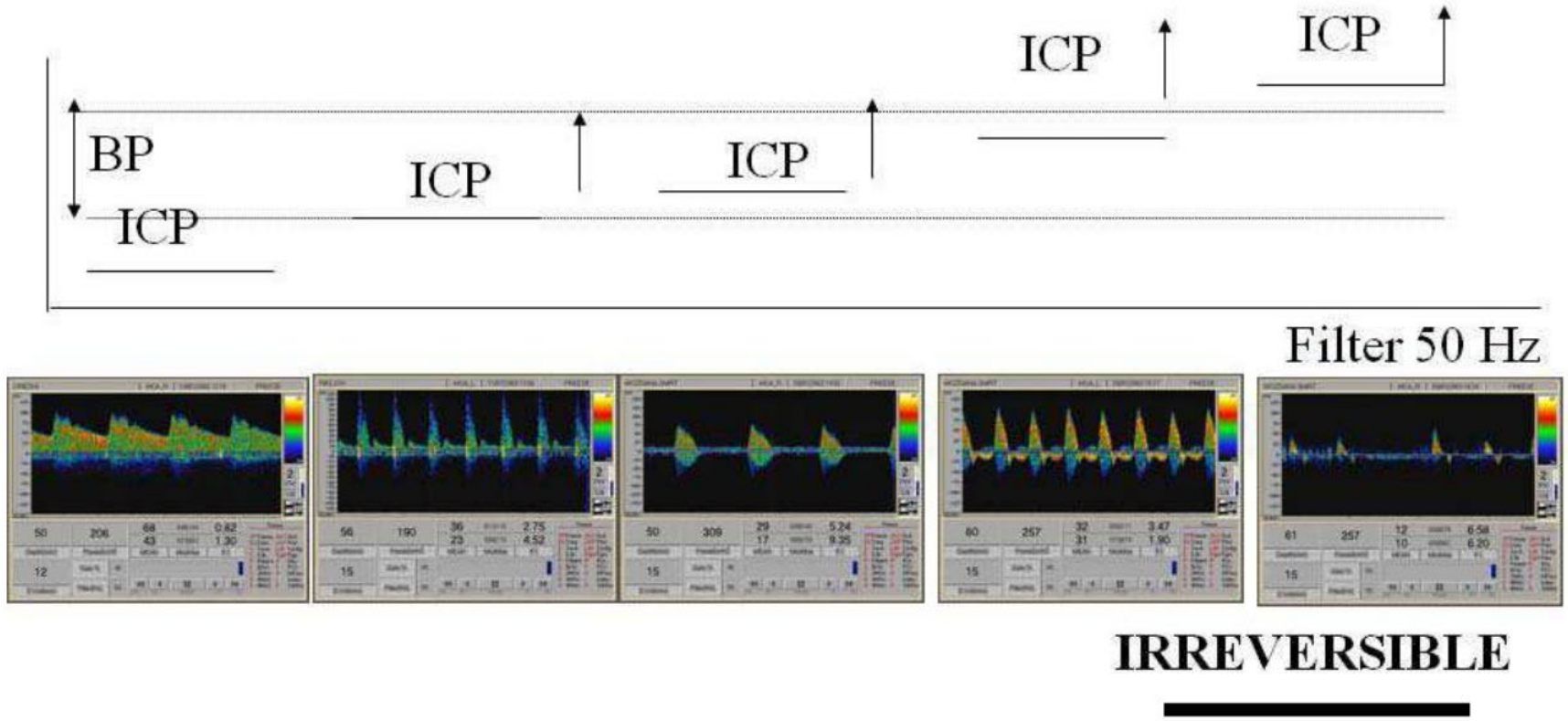


Transcranial Doppler (TCD)

Transcranial Doppler Sonography (TCD)



Transcranial Doppler Sonography



Hemodynamic changes in middle cerebral artery (MCA) during increase of intracranial pressure (ICP)

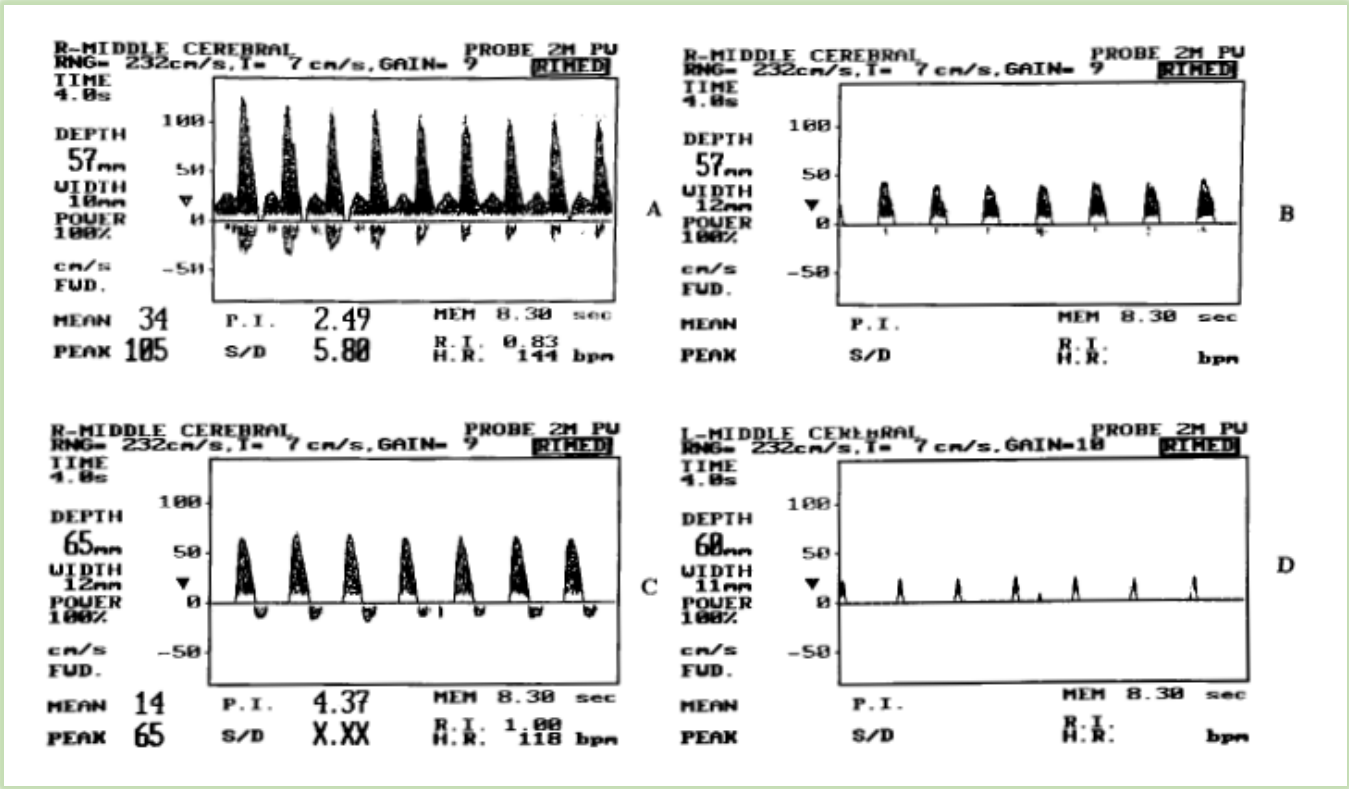
Transcranial Doppler ultrasonography

- TCD is useful only if a reliable signal is found.
- The abnormalities should include either reverberating flow or small systolic peaks in early systole.
- A finding of a complete absence of flow may not be reliable owing to inadequate transtemporal windows for insonation.
- There should be bilateral insonation and anterior and posterior insonation.
- The probe should be placed at the temporal bone, above the zygomatic arch and the vertebrobasilar arteries, through the suboccipital transcranial window.
- Insonation through the orbital window can be considered to obtain a reliable signal.
- TCD may be less reliable in patients with a prior craniotomy.

Transcranial Doppler

- Noninvasive and inexpensive, with great portability
- Cerebral circulatory arrest is indicated by flow patterns without forward flow progress, progressing from
    1) decrease in diastolic flow
    2) disappearance of diastolic flow
    3) oscillating pattern with retrograde flow in diastole
    4) short systolic spikes
    5) absence of Doppler signal
- Has been shown to correlate with four vessel angiography in intracranial circulatory arrest. Cerebral circulatory arrest in the basilar and both middle cerebral arteries correctly predicted fatal brain damage in all patients in one study
- Disadvantage of TCD is that it is highly operator dependent

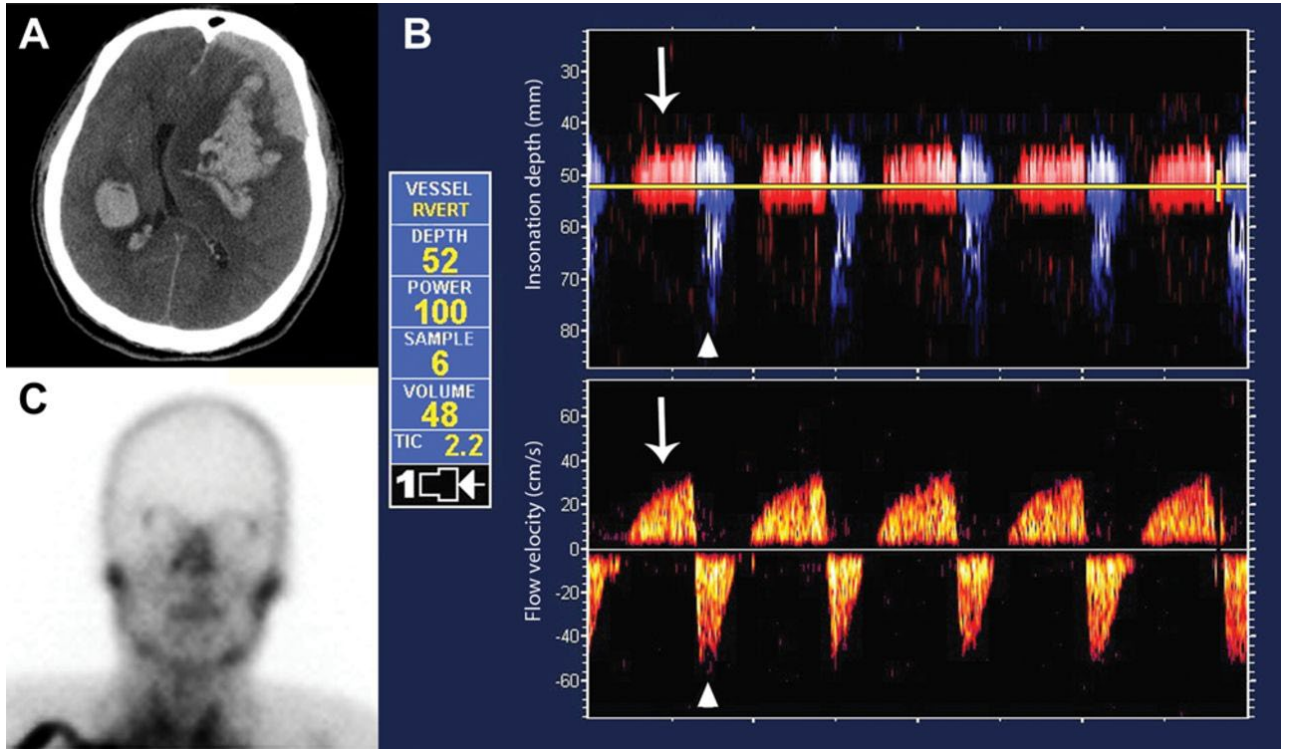
Transcranial Doppler



TCD patterns of cerebral circulatory arrest, taken from the right middle cerebral artery. A) Low diastolic velocity, B) systolic peaks with zero diastolic velocity, C) oscillating pattern with negative flow in diastole, D) short systolic spikes. Reprinted with permission from Hadani et al. [17]

Reverberating TCD Flow Pattern in Brain Death

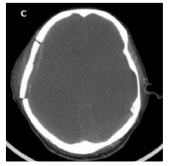
Small systolic peaks without diastolic flow

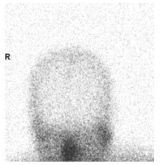


Ancillary Tests

Cerebral Angiography

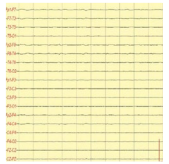
(conventional, computerized tomographic, and magnetic resonance)

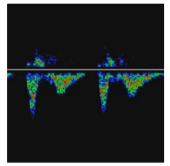




Cerebral Scintigraphy (Nuclear Brain scanning)

Electroencephalogram (EEG)





Transcranial Doppler (TCD)

Thank You