Anoxic Brain Injury

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General Radiology elective / RAD 3030

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Clinical History

64 Y male with PMH of STEMI and ventricular fibrillation associated cardiac arrest that required RCA stent (about 6 months ago)

Presents on 05/18/21 with Vfib arrest x3 shocked with patient downtime of 10 minutes.

Patient is comatose. Both pupils are sluggish and course sounds heard from lungs bilaterally.

Troponin is 1 (normal: 0-0.4 ng/mL)

Potassium is 2.9 (normal: 3.5-5.0 mEq/L)

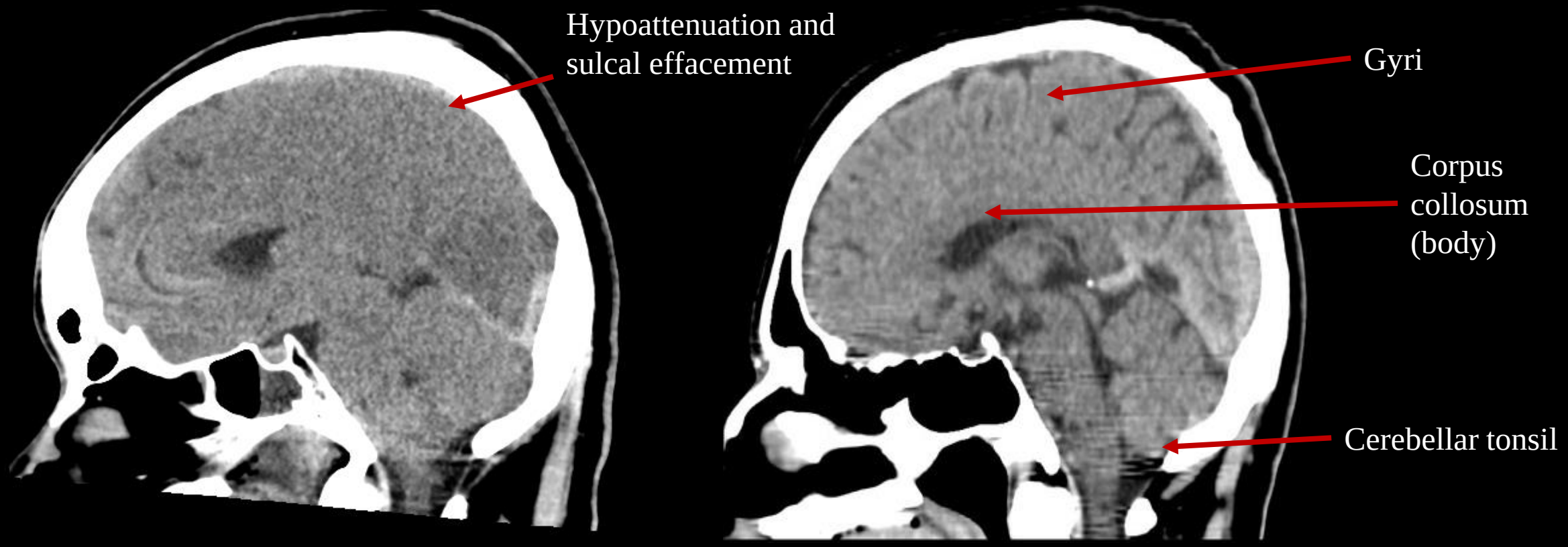
Diagnosis at presentation

This 64 Y male presents with ventricular fibrillation induced cardiac arrest and is comatose. Noncontrast head CT is expected to show evidence of ischemia.

Imaging is needed to evaluate the extent of ischemia and to note any hemorrhages if present.

Noncontrast head CT (sagittal plane) on admission (05/18)

64 Y male patient (left) vs 60 Y M with normal[1] head CT (right)



1) https://radiopaedia.org/cases/41030/studies/43776?lang=us

Noncontrast head CT (sagittal plane) on admission (05/18)

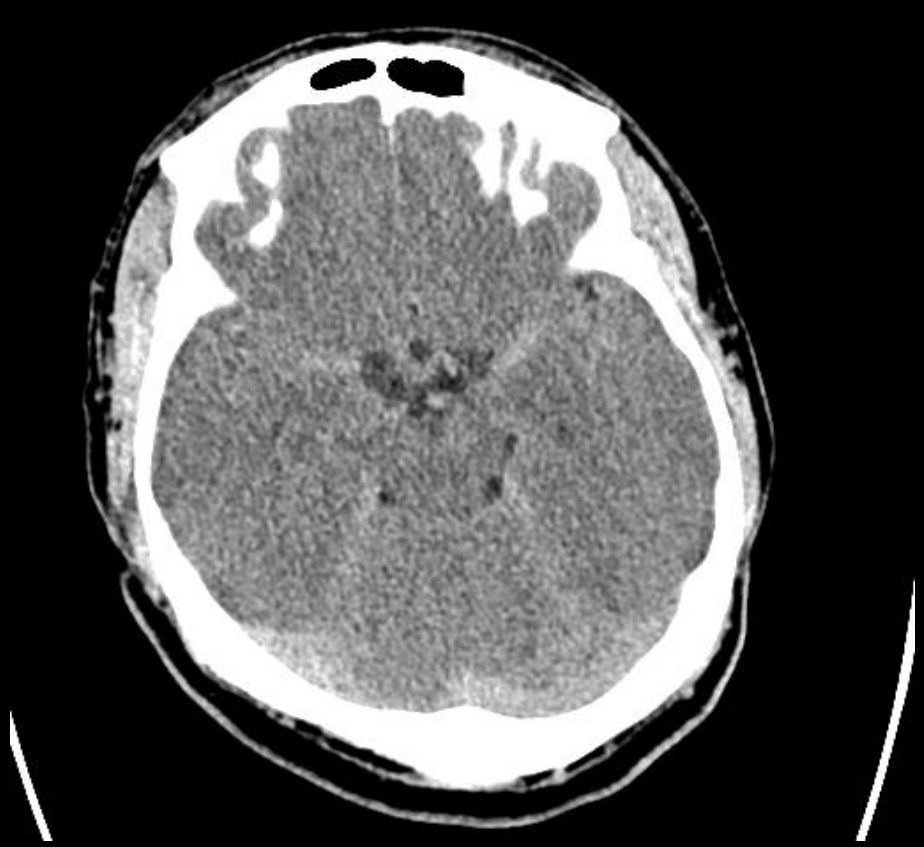
- Diffuse cerebral edema and hypoattenuation
- Sulcal effacement
- Hard to make out gyri

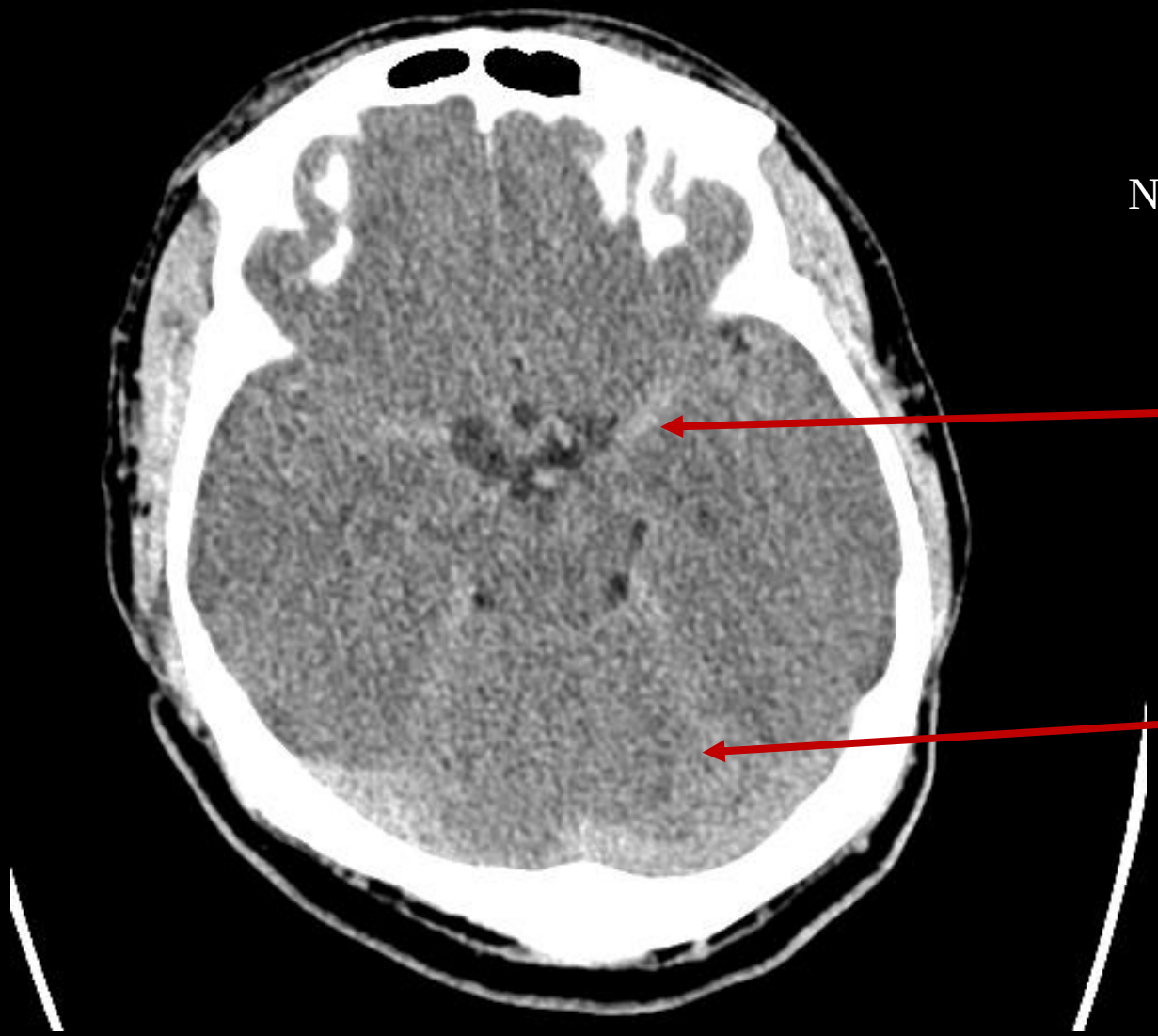
No cerebellar tonsil herniation

Noncontrast head CT (sagittal plane) on admission (05/18) [scrollable]

Noncontrast head CT (axial plane) on admission (05/18)

64 Y male patient (left) vs 60 Y M with normal head CT (right)





Noncontrast head CT (axial plane) on admission (05/18)

Increased attenuation in the basal cisterns due to cerebral edema

- Not subarachnoid hemorrhage (SAH)
- Pseudo-SAH[2]

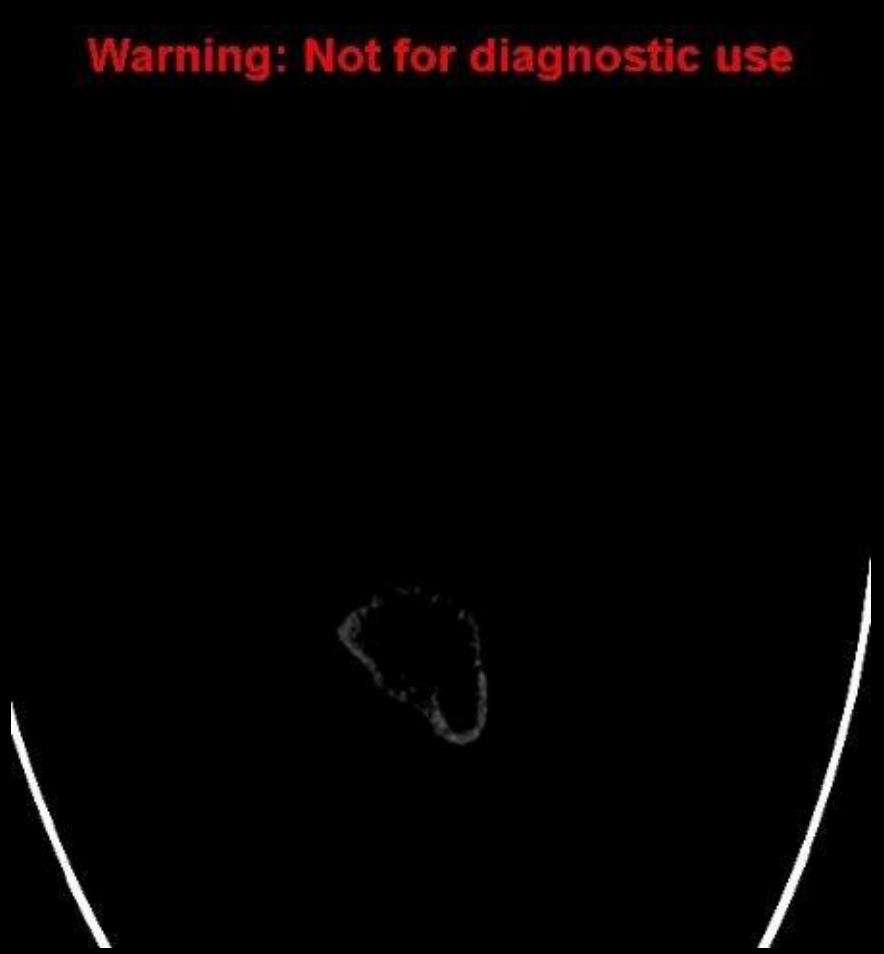
Hyperdensity in cerebellum relative to supratentorial brain parenchyma

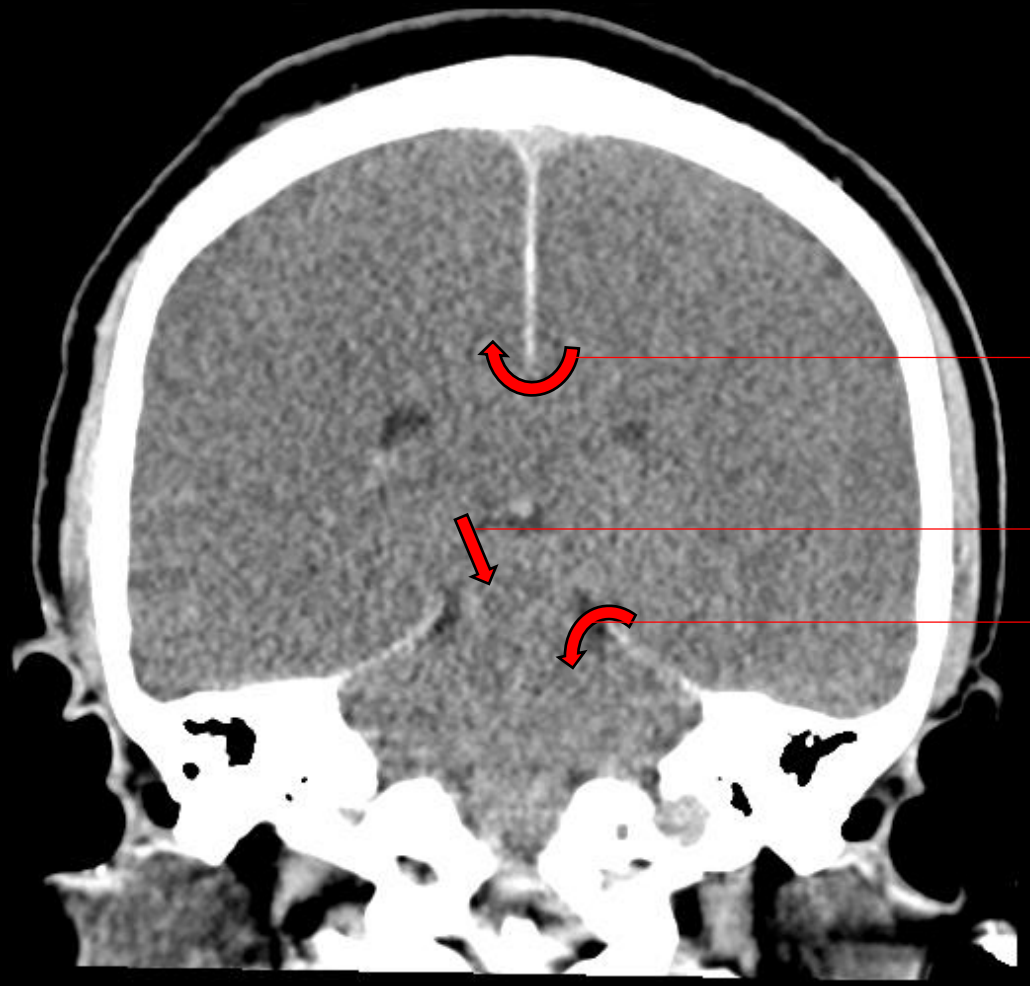
- Possible white cerebellum sign[3]

2) Lewis O, Afreen S, Folaranmi S, Fidelia-Lambert M, Poddar V, Thomas A. Anoxic Brain Injury Presenting as Pseudosubarachnoid Hemorrhage in the Medical Intensive Care Unit. *Case Rep Crit Care*. 2017;2017:9071482. doi:10.1155/2017/9071482

3) Krishnan P, Chowdhury SR. "White cerebellum" sign - A dark prognosticator. *J Neurosci Rural Pract*. 2014;5(4):433. doi:10.4103/0976-3147.140015

Noncontrast head CT (axial plane) on admission (05/18) [scrollable]





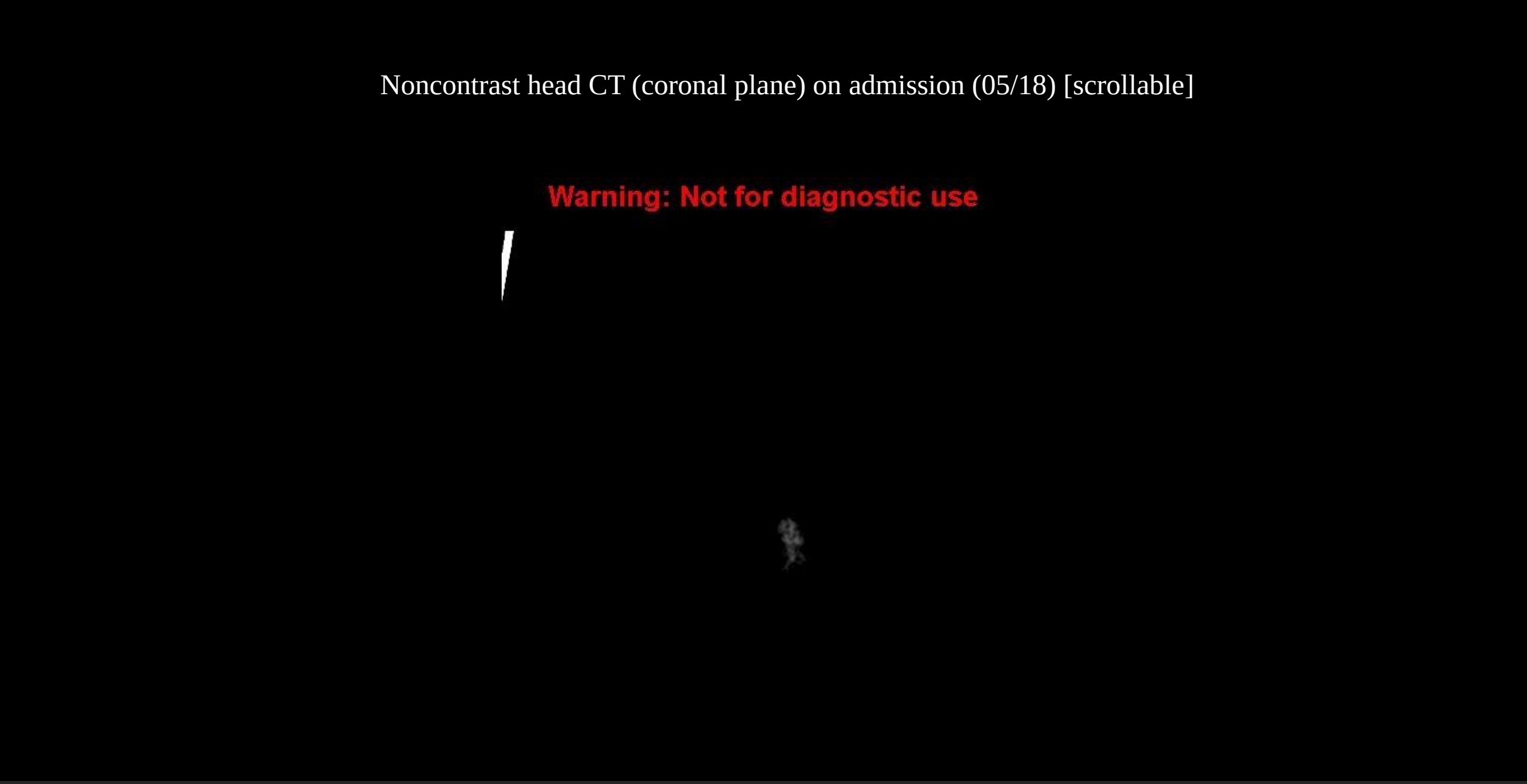
Noncontrast head CT (coronal plane) on admission (05/18)

No cingulate (subfalcine) herniation

No central (trans-tentorial) herniation

No uncal herniation

Noncontrast head CT (coronal plane) on admission (05/18) [scrollable]



Differential Diagnosis

Presentation: 64 Y male comatose after Vfib associated cardiac arrest

Diagnosis with imaging: Diffuse hypoxic-anoxic brain injury

- Global cerebral ischemia

Other possibilities:

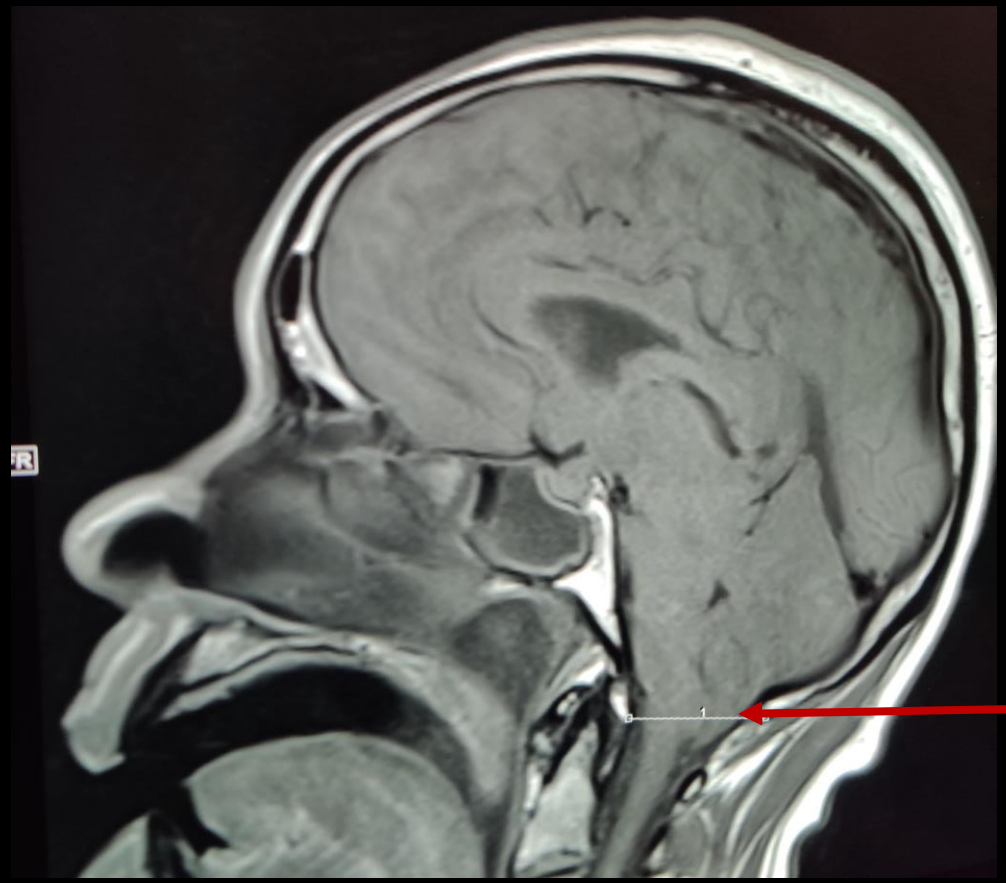
- Embolic stroke
- SAH due to basal cistern enhancement
- Traumatic brain injury (hemorrhage) if patient had fallen and hadn’t been imaged yet

Final diagnosis and Summary

Patient with previous history of ventricular fibrillation presented comatose after cardiac arrest with evidence of anoxic brain injury. Potassium was repleted and targeted temperature management was ordered.

Final diagnosis: Anoxic brain injury secondary to ventricular fibrillation. Noncontrast head CT showed diffuse cerebral edema, loss of grey-white matter differentiation and sulcal effacement.

Patient later developed tonsillar herniation and was pronounced dead 13 days after admission.



13 days later

Patient pronounced dead 05/31

Tonsillar herniation

Discussion

- Anoxic brain injury results from decreased oxygen delivery to the brain. Anaerobic respiration is stimulated and there is reduced ATP production. Lactate levels increase and the sodium-potassium pumps fail leading to increased intracellular sodium and calcium. As a result, there is mitochondrial injury generating reactive oxygen species, activation of caspases, and disruption of protein synthesis[4]. Overall, there is cytotoxic edema and a loss of grey-white matter differentiation due to the ischemia.

- Noncontrast head CT helps to diagnose the anoxic brain injury
  - Diffuse cerebral edema, sulcal effacement, increased attenuation in the basal cisterns, white cerebellum sign

4) Messina Z, Hays Shapshak A, Mills R. Anoxic Encephalopathy. [Updated 2020 Jul 6]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK539833/

Discussion

- Hyperthermia is a potential factor for unfavorable functional neurologic recovery[5]
  - Targeted temperature management to limit brain damage

- Goals of targeted temperature management for acute brain injuries[6]
  - Decrease excitotoxicity
  - Limit inflammation
  - Prevent ATP depletion
  - Reduce free radical production

5) Zeiner A, Holzer M, Sterz F, Schörkhuber W, Eisenburger P, Havel C, Kliegel A, Laggner AN. Hyperthermia after cardiac arrest is associated with an unfavorable neurologic outcome. Arch Intern Med. 2001 Sep 10;161(16):2007-12. doi: 10.1001/archinte.161.16.2007. PMID: 11525703.

6) Andresen M, Gazmuri JT, Marín A, Regueira T, Rovegno M. Therapeutic hypothermia for acute brain injuries. *Scand J Trauma Resusc Emerg Med*. 2015;23:42. Published 2015 Jun 5. doi:10.1186/s13049-015-0121-3

ACR appropriateness Criteria

- Case was in accordance with the ACR appropriateness guidelines[7]

Variant 2: **Acute or progressively worsening mental status change in patient with a known intracranial process (mass, recent hemorrhage, recent infarct, central nervous system infection, etc). Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
CT head without IV contrast	Usually Appropriate	☢☢☢
MRI head without and with IV contrast	Usually Appropriate	O
MRI head without IV contrast	Usually Appropriate	O
CT head without and with IV contrast	May Be Appropriate	☢☢☢
CT head with IV contrast	May Be Appropriate	☢☢☢

- Average price[8] of noncontrast head CT for upper-tier academic hospitals: $1390.12 ± $686.13

7) American College of Radiology. ACR Appropriateness Criteria®. Available at https://acsearch.acr.org/list
8) Paul AB, Oklu R, Saini S, Prabhakar AM. How Much Is That Head CT? Price Transparency and Variability in Radiology. *Journal of the American College of Radiology*. 2015;12(5):453-457. doi:10.1016/j.jacr.2014.12.016.

Take Home Points / Teaching points

- On CT, anoxic brain injury can result in attenuation in the basal cisterns and subarachnoid space referred to as pseudosubarachnoid hemorrhage (pseudo-SAH)
- On CT, sulcal effacement may be noted after CSF is displaced due to cerebral edema
- Targeted temperature management is important for acute brain injuries to limit damage

References

1) https://radiopaedia.org/cases/41030/studies/43776?lang=us

2) Lewis O, Afreen S, Folaranmi S, Fidelia-Lambert M, Poddar V, Thomas A. Anoxic Brain Injury Presenting as Pseudosubarachnoid Hemorrhage in the Medical Intensive Care Unit. *Case Rep Crit Care*. 2017;2017:9071482. doi:10.1155/2017/9071482

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Questions?