

SPR 2014 Neuroradiology Session
May 17, 2014
SAM Questionnaire

Epilepsy in Childhood

Amy Kao, MD

1. **A 7-year-old girl with right hemiplegic cerebral palsy presents the Emergency Room with first seizure, described as right body jerking for 3 minutes. She is afebrile and back to her baseline mental status and function. Which of the following would be the MOST APPROPRIATE evaluation?**
 - A. Head CT with contrast in the ER
 - B. EEG in the ER
 - C. Physical exam, cbc and electrolytes, lumbar puncture
 - D. Reassurance only, as this is likely an isolated event which will not recur
 - E. Outpatient EEG, nonurgent brain MRI

Correct Answer: E

References

1. Harden CL, Huff JS, Schwartz TH, et al. Reassessment: neuroimaging in the emergency patient presenting with seizure (an evidence-based review). *Neurology* 2007; 69: 1772-1780.
2. Hirtz D, Ashwal S, Berg A et al. Practice parameter Evaluating a first nonfebrile seizure in children. *Neurology* 2000; 55:616-623.

Rationales

Option A is not correct. A noncontrast CT may be considered for emergency patients presenting with seizure, especially if there is an abnormal neurologic examination, predisposing history, or focal seizure onset. Patients less than 6 months are very likely to have significant abnormality. In an evidence-based review, 3 to 8% of pediatric patients had a CT abnormality which changed acute management, including hemorrhage, tumor, cysticercosis, and obstructive hydrocephalus.

Option B is not correct. Immediate EEG is not recommended, and findings in the first 24 to 48 hours after seizure may be transient.

Option C is not correct. Bloodwork and spinal tap are unlikely to be abnormal in a child older than 6 months old and without suggestive findings on history or examination.

Option D is not correct. Option E is correct. Practice parameter recommends EEG to assist with determination of epilepsy syndrome and prognosis regarding recurrence of seizures, as well as MRI on a nonurgent basis if cognitive/motor impairment, exam abnormality, seizure of partial onset, under 1 year of age, or focal EEG findings not suggestive of a “benign” syndrome.

2. A 7-year-old developmentally-normal boy with past history of a prolonged febrile seizure now has complex partial seizures which have not responded to 3 antiseizure medications. A 3-Tesla brain MRI is performed. Which of the following would be the epilepsy syndrome MOST LIKELY associated with a focal structural abnormality?
- A. Childhood absence epilepsy
 - B. Lennox-Gastaut syndrome
 - C. Benign rolandic epilepsy
 - D. Temporal lobe epilepsy
 - E. Dravet syndrome

Correct Answer: D

References

1. Epstein LG, Shinnar S, Hesdorffer DC et al. Human herpesvirus 6 and 7 in febrile status epilepticus: the FEBSTAT study. *Epilepsia* 2012; 53:1481-1488.
2. Shinnar S, Bello J, Chan S et al. MRI abnormalities following febrile status epilepticus in children The FEBSTAT study. *Neurology* 2012; 79:871-877

Rationales

Option A is not correct. Childhood absence epilepsy is characterized by seizures which are considered to be primary generalized in onset. Although there is evidence from functional MRI and PET studies which support involvement/origination of absence seizures in the corticothalamic circuits, MRI of the brain is expected to be normal.

Option B is not correct. Lennox-Gastaut syndrome is an epilepsy syndrome with varied etiologies, which by definition is characterized by mental retardation, multiple seizure types (including absence, drop seizures, generalized-tonic-clonic, complex partial), and slow spike-wave activity on EEG.

Option C is not correct. Benign rolandic epilepsy is characterized by independent bilateral central/temporal spikes on EEG and a normal brain MRI. Recently discovered in some patients is a mutation in GRIN2A, encoding an NMDA receptor subunit, making this a channelopathy.

Option D is correct. Febrile status epilepticus is associated with increased risk of epilepsy, namely temporal lobe epilepsy. A large multicenter prospective study has shown that children with febrile status epilepticus are at risk for acute hippocampal injury and also have greater frequency of developmental abnormalities in the hippocampus.

Option E is not correct. Dravet syndrome is the clinical syndrome most often associated with mutation in sodium channel SCN1A. Focal abnormalities have been reported, however seizures are often primary generalized in this diffuse channelopathy.

3. You review images from a brain MRI performed in an “open” scanner on a 7-year-old girl with anxiety and seizures which have persisted despite 3 antiseizure medications. EEG has shown right temporal epileptiform discharges. There is possible “fuzziness” in the right lateral temporal cortex. Of the following, which is the MOST REASONABLE recommendation?
- A. Fluorodeoxyglucose-PET
 - B. Higher-resolution MRI and evaluation at a multidisciplinary epilepsy center
 - C. Additional medication trials while awaiting maturation and improvement of her anxiety
 - D. Referral to neurosurgery

Correct Answer: B

References

1. Berg AT, Shinnar S, Levy SR et al. Early development of intractable epilepsy in children. *Neurology* 2001; 56:1445-1452.
2. Engel J Jr. Surgery for seizures. *New Engl J Med* 1996; 334:647-652.
3. Kwan P and Brodie MJ. Early identification of refractory epilepsy. *N Engl J Med* 2000; 342:314-319.

Rationales

A generally-accepted definition of medically refractory (intractable) epilepsy is epilepsy characterized by persistent seizures despite trials of more than 2 antiepileptic medications, either alone or in combination. A sentinel study found that 47% of patients diagnosed with epilepsy, became seizure-free during treatment with their first antiseizure drug. Fourteen percent became seizure-free during treatment with a second or third drug. Only 3 additional percent were controlled with combination of 2 drugs. Due to the decreasing likelihood of seizure control with subsequent medication trials, it is encouraged that patients with medically refractory epilepsy be referred to an epilepsy center, to be evaluated for candidacy for non-pharmacologic treatment options. These may offer increased likelihood of benefit.

FDG-PET can assist the non-invasive identification of a seizure focus in patients with cortical dysplasia, in particular for patients with nonconcordant test findings or with normal MRI scans, however clarification of lesion by higher-resolution MRI would be the most reasonable next step.

MR Imaging in Pediatric Epilepsy

Gilbert Vézina, MD

4. In pediatric epilepsy, the most common structural lesion identified at pathology is:
- A. Tumor
 - B. Hippocampal sclerosis
 - C. Focal cortical dysplasia
 - D. Polymicrogyria
 - E. Encephalomalacia

Correct Answer: C

References

1. Harvey AS, Cross JH, Shinnar S, Mathern GW; ILAE Pediatric Epilepsy Surgery Survey Taskforce. Defining the spectrum of international practice in pediatric epilepsy surgery patients. *Epilepsia*. 2008 Jan;49(1):146-55. PubMed PMID: 18042232
2. Lerner JT, Salamon N, Hauptman JS, Velasco TR, Hemb M, Wu JY, Sankar R, Donald Shields W, Engel J Jr, Fried I, Cepeda C, Andre VM, Levine MS, Miyata H, Yong WH, Vinters HV, Mathern GW. Assessment and surgical outcomes for mild type I and severe type II cortical dysplasia: a critical review and the UCLA experience. *Epilepsia*. 2009 Jun;50(6):1310-35. PubMed PMID: 19175385

Rationales

In children and adolescents, cortical dysplasia is the most frequent etiology (42%) followed by tumor (19%), atrophy/stroke (infections and other forms of brain, damage; 10%), and hippocampal sclerosis (6%).

5. **The transmantle sign is characteristic of:**
 - A. Polymicrogyria
 - B. Ganglioglioma
 - C. Dysembryoplastic neuroepithelial tumor (DNET)
 - D. Focal cortical dysplasia type 1
 - E. Focal cortical dysplasia type 2(B)

Correct Answer: E

References

1. Mellerio C, Labeyrie MA, Chassoux F, Roca P, Alami O, Plat M, Naggara O, Devaux B, Meder JF, Oppenheim C. 3T MRI improves the detection of transmantle sign in type 2 focal cortical dysplasia. *Epilepsia*. 2014 Jan;55(1):117-22. PubMed PMID: 24237393
2. Mühlebner A, Coras R, Kobow K, Feucht M, Czech T, Stefan H, Weigel D, Buchfelder M, Holthausen H, Pieper T, Kudernatsch M, Blümcke I. Neuropathologic measurements in focal cortical dysplasias: validation of the ILAE 2011 classification system and diagnostic implications for MRI. *Acta Neuropathol*. 2012 Feb;123(2):259-72. PubMed PMID: 22120580

Rationales

Type 2(B) focal cortical dysplasia is one of the main causes of extratemporal drug-resistant partial epilepsy that is surgically curable. It is characterized by the transmantle sign, defined as a subcortical white matter signal intensity change, tapering toward the ventricle. The transmantle sign has not been described in other developmental or acquired cortical lesions (except for tuberous sclerosis).

6. **Magnetization transfer T1 weighted images show a decrease in signal of water molecules that are:**
 - A. Interacting with adjacent “free” (mobile) protons
 - B. Interacting with adjacent “bound” (less mobile protons)
 - C. Intracellular in location
 - D. Extracellular in location
 - E. Influenced by susceptibility gradients

Correct Answer: B

References

1. Widdess-Walsh P, Diehl B, Najm I. Neuroimaging of focal cortical dysplasia. *J Neuroimaging*. 2006 Jul;16(3):185-96. Review. PubMed PMID: 16808819
2. Kadom N, Trofimova A, Vezina GL. Utility of magnetization transfer T1 imaging in children with seizures. *AJNR Am J Neuroradiol*. 2013 Apr;34(4):895-8. doi: 10.3174/ajnr.A3396. Epub 2012 Nov 15. PubMed PMID: 23153867

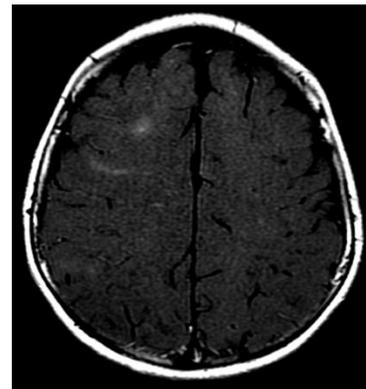
Rationales

Magnetization transfer (MT) is based on the interaction between mobile free (mobile) water protons and macromolecular bound (less mobile) protons. With MT imaging, an off resonance RF pulse is applied to saturate protons bound to macromolecules, mainly the myelin sheath covering axons. Due to spin spin interactions, there is a transfer of the saturation effect from the macromolecular bound hydrogen molecules to the nearby free protons. This results in a decrease in signal from the mobile proton and suppression of signal from background brain tissue. In the case of a lesion that contains abnormal myelination (e.g. as seen in cortical dysplasia), the signal suppression will be lessened compared to that observed in the healthy white matter; the lesion is revealed as a T1 bright focus of abnormal signal.

Challenging Cases in Epilepsy

Jason Murnick, MD, PhD

7. **This is a T1 magnetization transfer image of a patient with epilepsy. What is the most likely diagnosis?**
- A. Neurofibromatosis type I
 - B. Tuberous sclerosis
 - C. Neurocysticercosis
 - D. Rasmussen's encephalitis



Correct Answer: B

Rationales

Correct Answer: B. Tuberous sclerosis. Magnetization transfer imaging is among the most sensitive sequences for detecting the cortical tubers of tuberous sclerosis.

Other answers:

- A. Neurofibromatosis type I. NF1 is characterized by T2 hyperintense hamartomas in the deep gray structures, brainstem, and cerebellum.
- C. Neurocysticercosis. Most common cause of epilepsy in the developing world. T2-hyperintense cysts and/or enhancing nodules at the gray-white junction.
- D. Rasmussen's encephalitis. Unilateral hemispheric atrophy with multifocal T2 hyperintensities in the affected hemisphere.

References

1. Kadom, et al. Utility of magnetization transfer T1 imaging in children with seizures. *AJNR* (2013) 34: 895-898.
2. Pinto Gama, et al. Comparative analysis of MR sequences to detect structural brain lesions in tuberous sclerosis. *Pediatr Radiol* (2006) 36: 119-125.

8. Which patient would be most likely to benefit from an interictal 18FDG-PET exam for presurgical evaluation?
- A. 2-year-old with intractable epilepsy and known SCN1A sodium channel mutation.
 - B. 8-year-old with epilepsy of L frontal onset and L frontal cavernous malformation on MRI.
 - C. 5-year-old with intractable epilepsy of L frontal onset and a normal MRI.
 - D. 10-year-old with L frontal epilepsy, well-controlled on one medication.

Correct Answer: C

Rationales

Correct Answer: C. Focal epilepsy is likely to be caused by an anatomic lesion, and PET may help to localize it for surgery if it is not apparent on MRI.

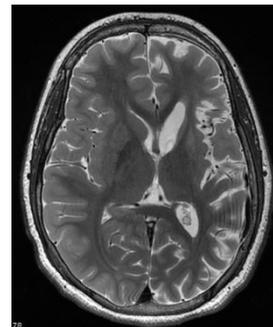
Other answers:

- A. Patient has a sodium channel mutation causing epilepsy, not a focal anatomic lesion, so is unlikely to be helped by surgery
- B. Patient with focal epilepsy corresponding to epileptogenic lesion on MRI (cavernoma) can undergo surgery without further imaging studies
- D. Seizures are well-controlled on one medication, so the patient is not a good candidate for surgery

References

1. Sood & Chugani. Functional neuroimaging in the preoperative evaluation of children with drug-resistant epilepsy. *Childs Nerv Syst* (2006) 22:810-820.
2. Jayakar et al. Diagnostic test utilization in evaluation for resective epilepsy surgery in children. *Epilepsia* (2014) e-pub ahead of print.

9. An 11-year-old boy with intractable epilepsy has this T2-weighted image. Which of the following is the most likely diagnosis?
- A. Hemimegalencephaly
 - B. Dysembryoplastic neuroepithelial tumor (DNET)
 - C. Focal cortical dysplasia, type II
 - D. Benign rolandic epilepsy
 - E. Rasmussen encephalitis



Correct Answer: E

Rationales

Correct answer: E. Rasmussen encephalitis is characterized by unilateral cortical atrophy, preferentially involving the insula. Caudate head atrophy may also be present.

Other answers:

- A. Hemimegalencephaly also has findings of hemispheric asymmetry, but the abnormal hemisphere is the larger one. Widened gyri, cortical thickening, and gray-white blurring are often seen in the abnormal hemisphere.
- B. DNET is a cortically based tumor characterized by T2 hyperintensity and often a multicystic “bubbly” appearance.
- C. Focal cortical dysplasia, type II. Typical findings are subtle cortical thickening with T2 FLAIR hyperintensity in the underlying white matter
- D. Benign rolandic epilepsy is not characteristically associated with any abnormal MRI findings.

References

1. Granata et al. Rasmussen's encephalitis: Early characteristics allow diagnosis. *Neurology* 60(3): 422-425.
2. Faingold & Onyekwelu. MRI appearance of Rasmussen encephalitis. *Pediatr Radiol* (2009) 39:756.
3. Guerrini & Pellacani. Benign childhood focal epilepsies. *Epilepsia* (2012) 53(S4):9-18.

Childhood Stroke

Gabrielle deVeber, MD

10. What is the incidence of stroke in children (hemorrhagic and ischemic)?

- A. 1 to 10 per 100,000 children per year
- B. 1 to 10 per 1,000,000 children per year
- C. 1 to 10 per 10,000 children per year
- D. None of the above

Rationales

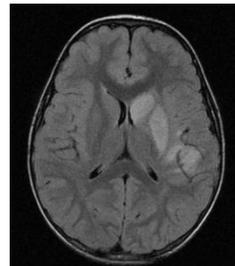
The correct answer is a) 1 to 10 per 100,000 per year. One estimate is 2.3 per 100,000 children per year with approximately half hemorrhagic and half ischemic. In neonates arterial ischemic stroke affects 1 in 4000 live births.

References

1. Fullerton HJ, Wu YW, Zhao S, Johnston SC. Risk of stroke in children: ethnic and gender disparities. *Neurology*. 2003; 61:189 –194.

11. What is the condition represented by the Figures below in this child?

- A. arterial dissection
- B. atherosclerosis due to hyperlipidemia
- C. fibromuscular dysplasia
- D. transient cerebral arteriopathy / post-varicella vasculopathy
- E. moyamoya



Correct Answer: D

Rationales

The correct answer is d) transient cerebral arteriopathy, also termed post-varicella angiopathy when chicken pox in the preceding year. This entity combines a basal ganglia stroke with an irregular narrowing of the distal ICA/proximal MCA and / or proximal ACA due to presumed inflammation although intracranial dissection can be the underlying cause in some children. The course is self-resolving over 3-6 months with a residual static mild stenosis over many years.

References

1. Sébire G. Transient cerebral arteriopathy in childhood. *Lancet*. 2006;
2. Askalan R, Laughlin S, Mayank S et al. Chickenpox and stroke in childhood: a study of frequency and causation. *Stroke*. 2001;32:1257–1262

12. The most common presentation for ischemic stroke in newborn infants is:

- A. increased irritability, inconsolability
- B. headache and confusion
- C. seizures
- D. focal neurologic deficit e.g. hemiparesis
- E. all of the above

Correct Answer: C

Rationale

The correct answer is c). Seizures alone are characteristic of neonates with arterial or venous ischemic stroke. The neonatal brain is immature and is less likely to show a focal deficit e.g. hemiparesis than older infants and children.

References

1. Nelson KB, Lynch JK. Stroke in newborn infants. *Lancet Neurol*. 2004;3:150–158.42.
2. deVeber G, Andrew M, Adams C, et al. Cerebral sinovenous thrombosis in children. *N Engl J Med*. 2001; 345:417– 423.

Stroke Imaging in Childhood

Manohar Shroff, MD, FRCPC

13. Regarding Childhood Arterial Ischemic Stroke (AIS) recurrence, which of the following statements is true?

- A. Risk of stroke recurrence is high even if vascular imaging is normal.
- B. In later childhood AIS, recurrence occurs within five years in 66 % of children when vascular imaging studies identified abnormalities.
- C. Recurrence is common after perinatal stroke
- D. Risk of stroke recurrence is similar in early childhood (perinatal) AIS and later childhood AIS.

Correct Answer: B

Rationale

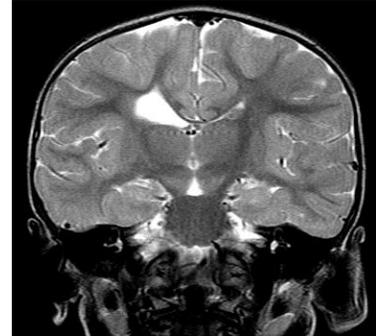
The correct answer is b) In later childhood AIS, recurrence occurs within five years in 66 % of children when vascular imaging studies identified abnormalities. As per reference mentioned below: Strokes recur in one-fifth of later childhood AIS and recurrence is rare after perinatal stroke. In later childhood AIS recurrence occurred within five years in 66 % of children whose vascular imaging studies identified abnormalities. None of the children with normal vascular imaging had a recurrent stroke.

References

1. Risk of recurrent childhood arterial ischemic stroke in a population-based cohort: the importance of cerebrovascular imaging. Fullerton HJ, Wu YW, Sidney S, Johnston SC. *Pediatrics*. 2007 Mar;119(3):495-501.

14. What is the most likely diagnosis, in the Figure below in this child? Please be specific.

- A. Presumed Perinatal Ischemic Stroke
- B. Right MCA Arterial Ischemic Stroke
- C. Sequelae of TORCH infection
- D. Periventricular Venous Infarct



Correct Answer: D

Rationale

The correct answer is d) Periventricular Venous Infarct. Note the classic location at superolateral edge of the lateral ventricle, along the course and territory of medullary veins.

References

1. Risk factors and presentations of periventricular venous infarction vs arterial presumed perinatal ischemic stroke. Kirton A, Shroff M, Pontigon AM, deVeber G. *Arch Neurol*. 2010 Jul;67(7):842-8.
2. Presumed perinatal ischemic stroke: vascular classification predicts outcomes. Kirton A, Deveber G, Pontigon AM, Macgregor D, Shroff M. *Ann Neurol*. 2008 Apr;63(4):436-43

15. What is true regarding anterior circulation dissection in children:

- A. it occurs more commonly in the cervical portion of the carotid arteries
- B. it occurs more often commonly in the intracranial anterior circulation
- C. neck pain is a common presentation
- D. stroke is not a common complication of anterior circulation dissection in children.

Correct Answer: B

Rationale

The correct answer is b). Arterial Dissections are an important cause of AIS in children. Anterior circulation dissections occur more commonly intracranially in children. Children often present with deficit and adults present with neck pain.

References

1. Craniocervical arterial dissection in children: clinical and radiographic presentation and outcome. Rafay MF, Armstrong D, Deveber G, Domi T, Chan A, MacGregor DL. *J Child Neurol*. 2006 Jan;21(1):8-16
2. Low detection rate of craniocervical arterial dissection in children using time-of-flight magnetic resonance angiography: causes and strategies to improve diagnosis. Tan MA, DeVeber G, Kirton A, Vidarsson L, MacGregor D, Shroff M. *J Child Neurol*. 2009 Oct;24(10):1250-7.

Case Presentations

Sumit Pruthi, MD

16. As opposed to adults where hypertension, diabetes and other chronic diseases are well-known stroke risk factors, no definite underlying predisposing factor is identifiable in the majority of cases of pediatric arterial ischemic stroke (AIS).
- A. True
 - B. False

Correct Answer: B

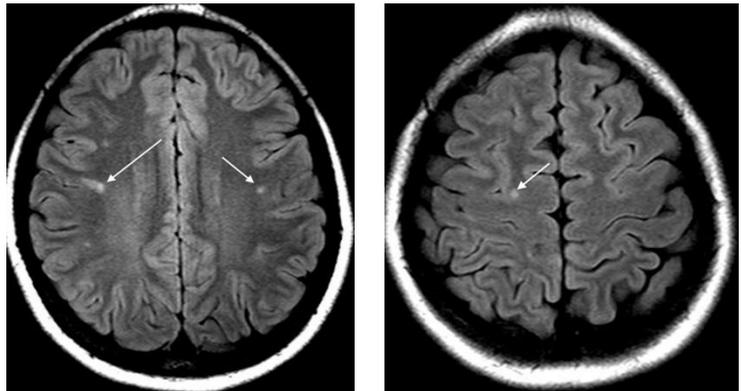
Rationale

The correct answer is b) False. Approximately 50% of children presenting with AIS have at least one identifiable predisposing cause. Childhood stroke in which no risk factors are identified represent only 10–30% of cases. On the contrary, multiple risk factors are recognizable in the majority of stroke in children; thus, a comprehensive diagnostic evaluation is crucial.

Reference

1. Friedman N. Pediatric Stroke: Past, Present and Future. *Advances in Pediatrics* 2009; 56: 271–299

17. A 17-year old female with sickle cell disease without crisis undergoes a routine annual surveillance brain MRI for detection of stroke. Axial FLAIR images from the scan reveal multiple punctate hyperintense foci (arrows). What is the significance of this finding?



- A. Usually unrelated to sickle cell disease
- B. Usually benign and of uncertain significance
- C. Usually related to multiple blood transfusions
- D. Associated with increased risk of new stroke

Correct Answer: D

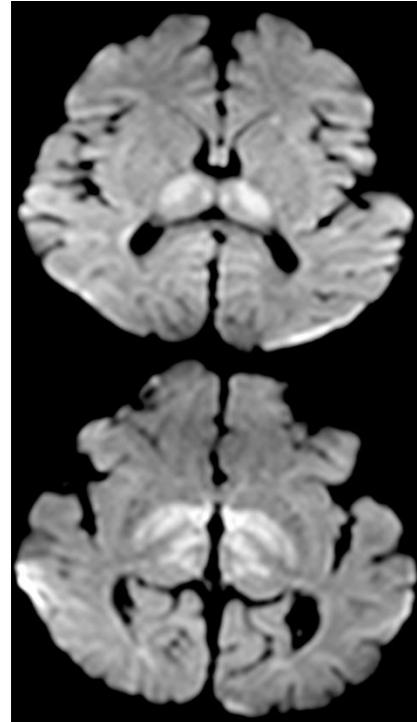
Rationale

The correct answer is d) Associated with increased risk of new stroke. The hyperintense foci represent silent infarcts and have important clinical sequelae including impaired cognitive functions and increased risk for future classic/overt strokes.

Reference

1. Pegelow CH, Macklin EA, Moser FG, et al. Longitudinal changes in brain magnetic resonance imaging findings in children with sickle cell disease. *Blood* 2002; 99: 3014–8.

18. A 3-year-old male with history of infantile spasms fairly controlled with Vigabatrin, otherwise asymptomatic, undergoes an elective brain MRI to evaluate for a possible underlying seizure focus. Based on the history and diffusion-weighted images provided, what is the most likely etiology of the finding?
- A. Venous ischemia
 - B. Arterial ischemia
 - C. Drug related changes
 - D. Encephalitis



Correct Answer: C

Rationale

The correct answer is c): Drug related changes. This is a great imaging example of a stroke mimic. Vigabatrin is a very common drug used to treat infantile spasm and is commonly associated with asymptomatic MRI abnormalities as shown in the example above. The key here is that despite dramatic imaging findings, apart from known infantile spasm, the patient is asymptomatic.

References:

1. Magnetic resonance imaging abnormalities associated with vigabatrin in patients with epilepsy. *Epilepsia* 2009; 50(2): 195–205
2. Iyer RS, Chaturvedi A, Pruthi S, et al. Medication neurotoxicity in children. *Pediatric Radiology* 2011; 41:1455-1464