





# Rhythmic mid-Temporal Theta of Drowsiness Activated by Hyperventilation- Uncommon Trigger of a Rare Benign EEG Variant in Pediatrics. An Educational Review

Brooke Asemota, MD<sup>1,2</sup> , Jacob M. Dohmeier, BS<sup>2</sup> ,  
 Nupur Singh, BA<sup>2</sup>, Andrew J. Gienapp, MS<sup>3,4</sup> ,  
 Marianna Rivas-Coppola, MD<sup>1,2</sup>, and Nitish Chourasia, MD<sup>1,2</sup> 

## Abstract

Distinguishing abnormal electroencephalogram (EEG) waveforms from benign variants is critical for accurate interpretation of EEG. Hyperventilation (HV) is one of the basic procedures during EEG to enable activation of epileptiform activity. Rarely, HV can activate benign EEG rhythms. Herein, we illustrate two pediatric cases with bursts of rhythmic mid-temporal theta of drowsiness (RMTD), activated by hyperventilation. Continued awareness of this EEG phenomenology and its variations in pediatrics is important in avoiding misdiagnosis of epilepsy.

## Keywords

hyperventilation, psychomotor variant, rhythmic mid-temporal theta of drowsiness, theta rhythm

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## Introduction

Electroencephalography (EEG) serves as a vital tool in the assessment, diagnosis, and management of patients with epilepsy. Based on ILAE criteria,<sup>1</sup> epilepsy can be diagnosed following two unprovoked seizures or a single unprovoked epileptic seizure and an abnormality on EEG or magnetic resonance imaging (MRI) with a high probability that seizures could recur. Due to this emphasis on EEG as part of routine diagnostic work up for seizures, an erroneous diagnosis of epilepsy can result from a combination of inadequate history along with overreading of EEG.<sup>2</sup> Specifically, benign EEG variations, such as wicket spikes, hypnagogic hypersynchrony, hyperventilation-induced slowing, fragmented alpha activity, or fluctuations of sharply contoured background rhythms, can be misinterpreted as epileptiform.<sup>3</sup> One such variant, rhythmic mid-temporal theta of drowsiness (RMTD), seen more commonly in adults, is described as abrupt theta frequency (4-7 Hz) rhythmic bursts maximal over the mid-temporal region. This well described variant can be mistaken for a pathologic discharge due to sharply contoured rhythmic waveforms associated with it. Herein, we illustrate two pediatric cases with the uncommon phenomenon of hyperventilation

activated RMTD on EEG and discuss established characteristics differentiating benign variants from abnormal epileptiform complexes.

## Cases

### Case 1

A 5-year-old boy presented for an outpatient EEG and evaluation in the neurology clinic following a self-limited,

<sup>1</sup>Neuroscience Institute, Le Bonheur Children's Hospital, Memphis, TN, USA

<sup>2</sup>Division of Pediatric Neurology, The University of Tennessee Health Science Center, Memphis, TN, USA

<sup>3</sup>Children's Foundation Research Institute, Le Bonheur Children's Hospital, Memphis, TN, USA

<sup>4</sup>Department of Neurosurgery, The University of Tennessee Health Science Center, Memphis, TN, USA

### Corresponding Author:

Nitish Chourasia, Neuroscience Institute, Le Bonheur Children's Hospital, 848 Adams Ave., 3rd floor Neurology, Memphis, TN 38103, USA.

Email: [nchouras@uthsc.edu](mailto:nchouras@uthsc.edu)



generalized, tonic-clonic seizure out of sleep. Routine EEG showed bursts of notched and sharply contoured 4–7 Hz theta, independently in the left and right temporal regions, which were activated with hyperventilation, which persisted in drowsiness and light sleep (Fig. 1), consistent with RMTD. The bursts of RMTD lasted between 6–120 s and occurred independently as well as simultaneously in bilateral temporal regions with variable asynchrony. No further seizures were reported on follow up over the past year and patient was not on any anti-seizure prophylaxis.

## Case II

A 12-year-old girl presented to the neurology clinic following an episode of loss of consciousness suspicious for new onset seizures. She had a history of a single febrile seizure at 2 years of age. Routine EEG showed 4–10 s bursts of notched and sharply contoured 5–7 Hz theta activated with hyperventilation which persisted in drowsiness and light sleep. These bursts occurred independently as well as simultaneously in bilateral temporal regions, with a relative left temporal predominance. There was no associated clinical change, and the rhythm was consistent with RMTD, without any epileptiform features. No further seizures were reported on subsequent follow up over the past 6 months and patient was referred to Cardiology for evaluation of syncope.

## Discussion

Our cases highlight the importance of identification of rare benign variants like RMTD in Pediatrics and their uncommon triggers such as hyperventilation, to enable accurate identification on EEG. The bursts of RMTD while activated during

hyperventilation persisted into drowsiness with stereotypical notched sharply contoured morphology in the unilateral/bilateral temporal regions without evolution, confirming the well-described pattern of this benign variant. While previous reports have described HV activated RMTD in a young adult and an adolescent (15-year-old girl),<sup>4,5</sup> we illustrate that this rare EEG phenomenology can occur in younger children.

## History and Prevalence

This rhythm first described by Gibbs et al in 1963 was first labelled “the psychomotor variant” because this was first observed in patients with “psychomotor” (temporal lobe) seizures.<sup>6,7</sup> Lipman and Hughes renamed the pattern Rhythmic Mid-Temporal Discharges (RMTD), according to its electrographic characteristics.<sup>8</sup> In 1985, Klass and Westmoreland included this pattern among those that were “nonepileptogenic and epileptiform” or “patterns of uncertain significance” or “normal variants.”<sup>9</sup> Previous reports have described patients with RMTD and concurrent diagnoses of epilepsy, psychiatric co-morbidities, as well as mild alterations in neurocognitive function,<sup>4,6</sup> although, no causal association with RMTD has been established. RMTD is more commonly seen in the adult population, occurring in approximately 10% of the adult population versus only 0.4–1% of the pediatric population.<sup>3</sup> When seen in children, RMTD is known to occur during the late teenage years with rare reports documenting rhythm in children as young as 4 years old.<sup>4,6,10</sup>

## Characteristics and Localization

The morphology and frequency of RMTD is characterized by notched, sharply contoured 4–7 Hz theta frequency waveforms

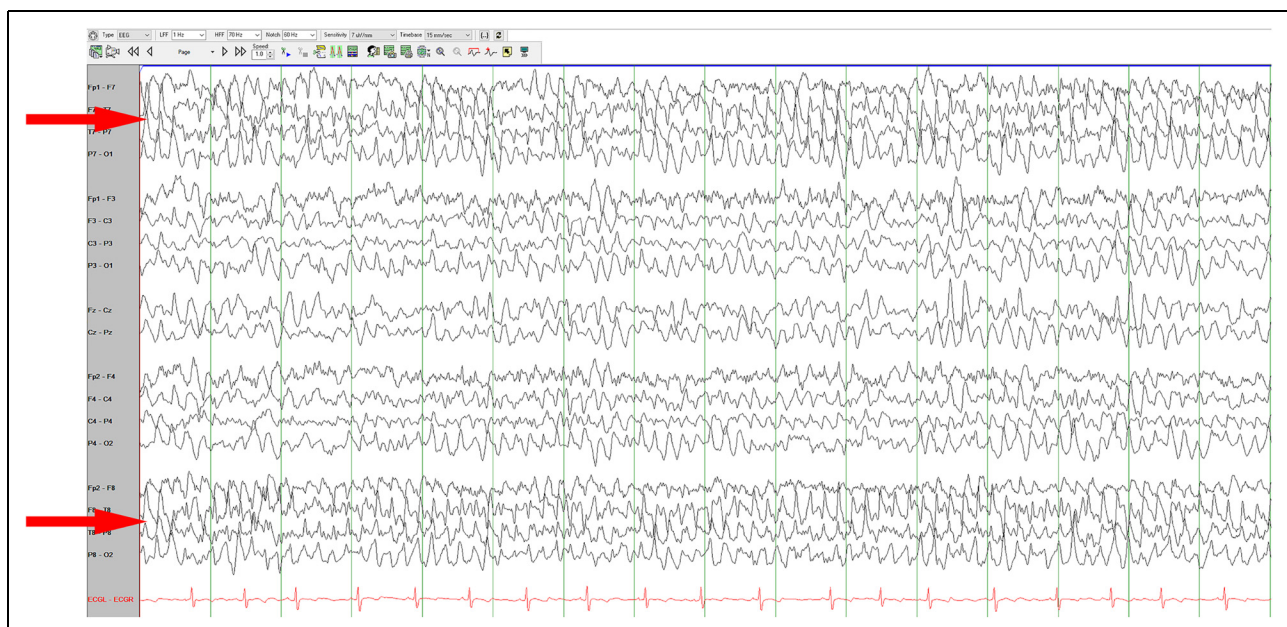
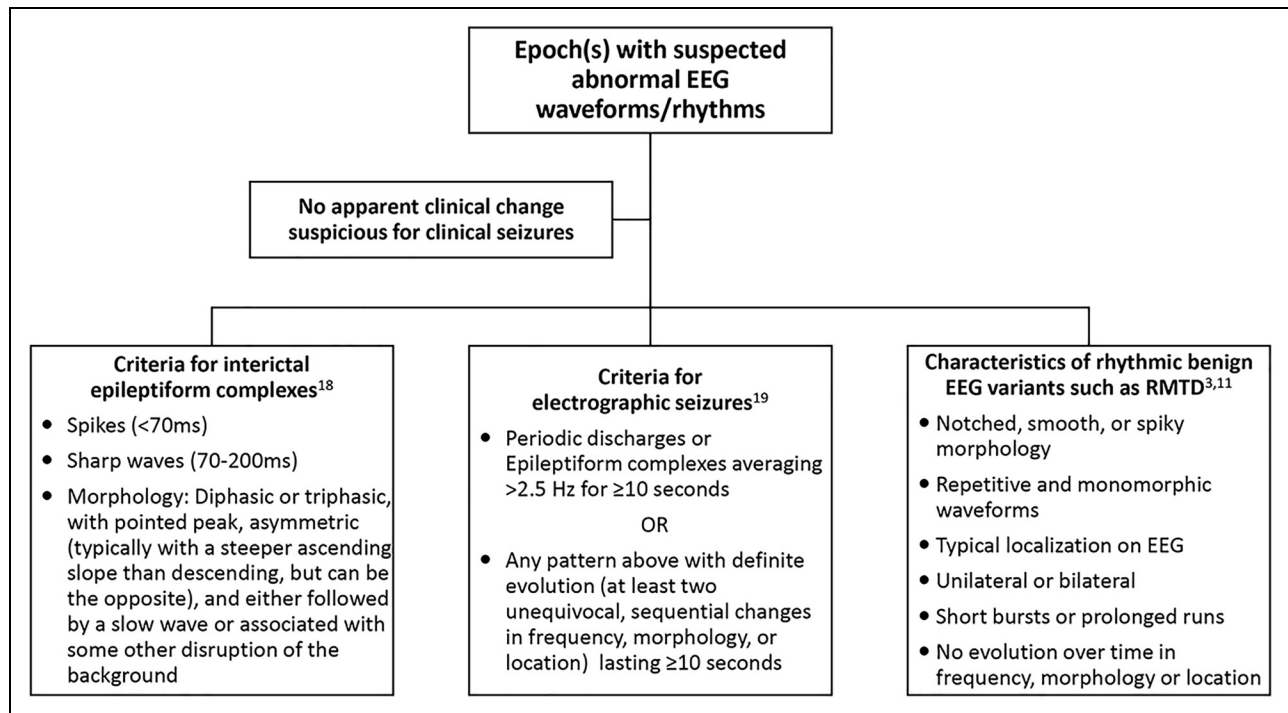


Figure 1. EEG of the patient in case I showing RMTD in bilateral temporal regions.



**Figure 2.** Characteristic features on EEG to help differentiate interictal epileptiform complexes, electrographic seizures and benign rhythmic variants such as RMTD.<sup>3,11,15,16</sup>

seen in the mid-temporal regions which can spread parasagittally.<sup>11</sup> Corroborating this localization with magnetoencephalography source modeling, RMTD has been shown to originate in the fissural cortex of the posterior inferior temporal region.<sup>12</sup> RMTD can also occur bilaterally, sometimes with a unilateral predominance similar to our cases.<sup>4,6,13</sup> RMTD is mostly seen in drowsiness or light sleep, although it has also been reported in relaxed wakefulness,<sup>6,10</sup> as noted in our patients. During bursts of RMTD seen in relaxed wakefulness or drowsiness, our patients continued to maintain awareness with purposeful activities. These clinical observations further favor benign variants like RMTD and are consistent with previous reports that have shown no associated clinical change or impaired function despite prolonged continuous runs.<sup>3,12,14</sup> RMTD is also usually monomorphic, does not evolve significantly in frequency or amplitude, differentiating it from most ictal patterns. Figure 2 summarizes EEG characteristics that can help differentiate benign EEG variants from abnormal epileptiform complexes and electrographic seizures.

### Knowledge gap and Need for Awareness

Currently, educational requirements for child neurology residency require competency in neurodiagnostics, but there are no specific competency requirements related to EEG.<sup>17</sup> Recognizing benign variants is therefore limited by education and exposure. This limitation is supported by a survey of US adult neurology residency program directors, which noted significant variation in EEG reading exposure, lack of consistency

in teaching, and evaluating EEG reading milestones for neurology trainees.<sup>18</sup> Neurologists and epileptologists would continue to benefit from recurring discussions of EEG variants in continuing medical education programs, online/social media platforms, and reports in the literature.<sup>19</sup> Increasing knowledge and discussion of benign variants, such as RMTD, would greatly help in reducing the likelihood of erroneous diagnosis of epilepsy resulting from overinterpretation of EEG.

### Conclusion

RMTD is a rare rhythm in pediatrics and has the potential to be misdiagnosed for pathologic epileptiform complexes or electrographic seizures. Knowledge of fundamental features of RMTD should aid in its recognition and differentiation from pathologic spikes.

### Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.




### Ethics Statement

Our institution does not require ethical approval for reporting individual cases or case series less than 5 cases. Verbal informed consent was obtained from a legally authorized representative(s) for anonymized patient information to be published in this article.

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## ORCID iDs

Brooke Asemota  <https://orcid.org/0000-0002-4940-0932>  
 Jacob M. Dohmeier  <https://orcid.org/0000-0003-0625-432X>  
 Andrew J. Gienapp  <https://orcid.org/0000-0002-6847-3387>  
 Nitish Chourasia  <https://orcid.org/0000-0002-9204-4849>

## References

1. Fisher RS, Acevedo C, Arzimanoglou A, et al. ILAE Official report: A practical clinical definition of epilepsy. *Epilepsia*. 2014;55(4):475-482. doi:10.1111/epi.12550
2. Benbadis SR, Lin K. Errors in EEG interpretation and misdiagnosis of epilepsy. Which EEG patterns are overread? *Eur Neurol*. 2008;59(5):267-271. doi:10.1159/000115641
3. Kang JY, Krauss GL. Normal variants are commonly overread as interictal epileptiform abnormalities. *J Clin Neurophysiol*. 2019;36(4):257-263. doi:10.1097/WNP.0000000000000613
4. Hughes JR. The continuous rhythmic mid-temporal discharge. *Clin Electroencephalogr*. 2001;32(1):10-13. doi:10.1177/155005940103200104
5. Koutroumanidis M, Hennessy MJ, Sparkes M, Binnie CD. Continuous bitemporal rhythmic subclinical epileptiform activity in an adult without epileptic seizures. *Clin Neurophysiol*. 2000;111(4):600-603. doi:10.1016/s1388-2457(99)00311-9
6. Gibbs FA, Rich CL, Gibbs EL. Psychomotor variant type of seizure discharge. *Neurology*. 1963;13:991-998. doi:10.1212/wnl.13.12.991
7. Pedley TA. EEG Patterns that mimic epileptiform discharges but have no association with seizures. In: Henry CE, ed. *Current clinical neurophysiology : update on EEG and evoked potentials*. Elsevier; 1980:307-336.
8. Lipman IJ, Hughes JR. Rhythmic mid-temporal discharges. An electro-clinical study. *Electroencephalogr Clin Neurophysiol*. 1969;27(1):43-47. doi:10.1016/0013-4694(69)90107-2
9. Klass DW, Westmoreland BF. Nonepileptogenic epileptiform electroencephalographic activity. *Ann Neurol*. 1985;18(6):627-635. doi:10.1002/ana.410180602
10. Fawaz A, Nasreddine W, Bustros S, Kayed DM, Beydoun A. A prolonged rhythmic midtemporal discharge in a child without seizures. *Clin EEG Neurosci*. 2015;46(2):126-129. doi:10.1177/1550059414522230
11. Asadi-Pooya AA, Sperling MR. Normal awake, drowsy, and sleep EEG patterns that might be overinterpreted as abnormal. *J Clin Neurophysiol*. 2019;36(4):250-256. doi:10.1097/WNP.0000000000000585
12. Lin YY, Wu ZA, Hsieh JC, et al. Magnetoencephalographic study of rhythmic mid-temporal discharges in non-epileptic and epileptic patients. *Seizure*. 2003;12(4):220-225. doi:10.1016/s1059-1311(02)00264-9
13. Hughes JR, Cayaffa JJ. Is the “psychomotor variant” — “rhythmic mid-temporal discharge” an ictal pattern? *Clin Electroencephalogr*. 1973;4(1):42-49. <https://doi.org/10.1177/155005947300400106>
14. Tatum WO, Husain AM, Benbadis SR, Kaplan PW. Normal adult EEG and patterns of uncertain significance. *J Clin Neurophysiol*. 2006;23(3):194-207. doi:10.1097/01.wnp.0000220110.92126.a6
15. Kane N, Acharya J, Beniczky S, et al. A revised glossary of terms most commonly used by clinical electroencephalographers and updated proposal for the report format of the EEG findings. Revision 2017. *Clin Neurophysiol Pract*. 2017;2:170-185. doi:10.1016/j.cnp.2017.07.002
16. Hirsch LJ, Fong MWK, Leitinger M, et al. American Clinical neurophysiology society’s standardized critical care EEG terminology: 2021 version. *J Clin Neurophysiol*. 2021;38(1):1-29. doi:10.1097/WNP.0000000000000806
17. Accreditation Council for Graduate Medical Education. ACGME program requirements for graduate medical education in child neurology. Accreditation Council for Graduate Medical Education. Accessed Aug 25, 2022. [https://www.acgme.org/globalassets/pfassets/programrequirements/185\\_childneurology\\_2022v2.pdf](https://www.acgme.org/globalassets/pfassets/programrequirements/185_childneurology_2022v2.pdf)
18. Nascimento FA, Gavvala JR. Education research: Neurology resident EEG education: A survey of US neurology residency program directors. *Neurology*. 2021;96(17):821-824. doi:10.1212/WNL.00000000000011354
19. Amin U, Benbadis SR. The role of EEG in the erroneous diagnosis of epilepsy. *J Clin Neurophysiol*. 2019;36(4):294-297. doi:10.1097/WNP.0000000000000572