

# Roadmap to EEGs: video-based e-learning modules addressing clinical EEG reading

Irfan S. Sheikh<sup>1</sup>, Roohi Katyal<sup>2</sup>, Aris Hadjinicolaou<sup>3</sup>, Fábio A. Nascimento<sup>1,4</sup>, Sandor Beniczky<sup>5</sup>

<sup>1</sup> Department of Neurology, Massachusetts General Hospital, Harvard Medical School, Boston, MA, USA

<sup>2</sup> Department of Neurology, University of Maryland Medical Center, Baltimore, MD, USA

<sup>3</sup> Department of Clinical Neurophysiology/Epilepsy, Harvard Medical School, Boston Children's Hospital, USA

<sup>4</sup> Department of Neurology, Washington University School of Medicine, St. Louis, MO, USA

<sup>5</sup> Department of Clinical Neurophysiology, Danish Epilepsy Centre, Dianalund and Aarhus University Hospital; Department of Clinical Medicine, Aarhus University, Aarhus, Denmark

Received July 16, 2022; Accepted August 16, 2022



VIDEOS ONLINE



• **Correspondence:**  
Irfan Sheikh  
55 Fruit St., Wang 7<sup>th</sup> floor,  
Boston, MA 02114, USA  
<isheikh@mgh.harvard.edu>  
<irfansheikh2561@yahoo.com>

In 2019, the International League Against Epilepsy (ILAE) Education Task Force published a competency-based curriculum for epileptology [1]. The *Epileptic Disorders Internship Program* team has developed a series of online, video-based learning modules (“Roadmap to EEGs”) addressing competencies related to interpreting EEG and describing common adults and pediatric EEG patterns (1.4) and diagnosing and classifying epilepsies and epilepsy syndromes using the most recent ILAE classifications (1.7). This series covers seven major topics in electroencephalography and epileptology (*table 1*), and all videos are publicly available and readily accessible via the *Epileptic Disorders* website (see accompanying *supplementary material*) and the *Epileptic Disorders Internship Program* YouTube<sup>®</sup> channel. In alignment with principles of adult learning theory [2] and prior ILAE e-learning experience [3], we ensured that each video is relatively short (duration ranging from 9 to 16 minutes) and focuses on high-yield information. Moreover, all educational content is based on the most recent guidelines and ILAE position statements [4-7]. Additionally, we would encourage all learners to complete a pre-test (<https://www.surveymonkey.com/r/RoadmapPre-Test>) and post-test (<https://www.surveymonkey.com/r/RoadmapPost-test>) because this data will help us estimate learning outcomes and modify the modules accordingly in future revisions. We believe this e-learning series will allow junior trainees to acquire foundational knowledge in EEG/epilepsy, and senior

trainees to review previously learned EEG/epilepsy information. We hope that our Roadmap to EEGs will help innumerable trainees across the globe achieve competency in EEG and epileptology. ■

## Supplementary material.

Supplementary data and summary slides accompanying the manuscript are available at [www.epilepticdisorders.com](http://www.epilepticdisorders.com).

## Disclosures.

The authors would like to disclose the following: I. Sheikh, R. Katyal, and A. Hadjinicolaou are Interns of the Epileptic Disorders Internship Program. S. Beniczky is Editor-in-Chief of *Epileptic Disorders*, and F. Nascimento is Associate Editor of *Epileptic Disorders*.

## References

- Blümcke I, Arzimanoglou A, Beniczky S, Wiebe S. Roadmap for a competency-based educational curriculum in epileptology: report of the Epilepsy Education Task Force of the International League Against Epilepsy. *Epileptic Disord* 2019; 21(2): 129-40.
- Cooper AZ, Richards JB. Lectures for adult learners: breaking old habits in graduate medical education. *Am J Med* 2017; 130(3): 376-81.
- Nascimento FA, Kural MA, Beniczky S. Learning about e-learning – the 34<sup>th</sup> International Epilepsy Congress experience. *Epileptic Disord* 2022; 24(3): 623-5.
- Kural MA, Duez L, Sejer Hansen V, Larsson PG. Criteria for defining interictal epileptiform discharges in EEG: a clinical validation study. *Neurology* 2020; 94(20): e2139-47.

▼ **Table 1.** Roadmap to EEG e-learning modules: characteristics of the e-learning modules including topics, content, and learning objectives.

Module	Topic	Content	Learning objectives [1]
1	Normal EEG	Wakefulness Drowsiness NREM sleep: K-complexes and sleep spindles REM sleep: REM and saw-tooth waves	1.4.7
2A	Normal variants: Part 1	POSTS RMTD SSS Lambda waves Photic driving Wicket spikes Mu rhythm Ciganek rhythm	1.4.8
2B	Normal variants: Part 2	Non-epileptiform sharp transients/spiky fluctuation of the background activity Posterior slow waves of youth Temporal slow of the elderly Slow-fused transients Slow (notched) alpha variant 6Hz SWs 14 and 6Hz positive bursts	1.4.8
3	EEG artifacts	Sweat EKG Eye blink Horizontal (lateral) eye movement Eye flutter Glossokinetic artifact Secretion artifact Myogenic Patting	1.4.8
4	Interictal epileptiform discharges	6 IFCN criteria for defining an interictal epileptiform discharge [4] with examples of both IED and non-epileptiform discharges	1.4.9
5A	Focal seizures: Part 1	Basic principles of focal seizures Brief pattern qualifying as ictal Low voltage fast activity with evolving rhythm Focal electrodecrement seizure Left frontal seizure	1.4.10 1.7.3
5B	Focal seizures: Part 2	Right occipital evolving seizure >2.5 Hz SW Right temporal seizure	1.4.10 1.7.3
6	Idiopathic generalized epilepsies [5]	IGE EEG and clinical hallmarks Childhood absence epilepsy Juvenile absence epilepsy Juvenile myoclonic epilepsy Epilepsy with generalized tonic-clonic activity	1.4.10 1.7.4
7A	Developmental and epileptic encephalopathies: Part 1 [6]	EEG and clinical hallmarks Early infantile onset (<3 months of age) EIDEE Infantile/neonatal onset	1.4.9 1.4.10 1.7.5

▼ **Table 1.** Roadmap to EEG e-learning modules: characteristics of the e-learning modules including topics, content, and learning objectives (*continued*).

Module	Topic	Content	Learning objectives [1]
		IESS (West syndrome) Dravet Syndrome	
7B	Developmental and epileptic encephalopathies: Part 2 [7]	Childhood onset (2-12 years of age) Lennox-Gastaut syndrome Landau-Kleffner syndrome (subtype of EE-SWAS)	1.4.9 1.4.10 1.7.5

POSTS: positive occipital sharp transients of sleep

RMTD: rhythmic mid-temporal theta of drowsiness

SSS: small sharp spikes

IED: interictal epileptiform discharge

IFCN: International Federation of Clinical Neurophysiology

IGE: idiopathic generalized epilepsy

IESS: infantile epileptic spasms syndrome

EIDEE: early infantile developmental and epileptic encephalopathy

EE-SWAS: epileptic encephalopathy with spike-wave activation in sleep

SW: spike-wave

5. Hirsch E, French J, Scheffer IE, Bogacz A, Alsaadi T, Sperling MR, et al. ILAE definition of the idiopathic generalized epilepsy syndromes: position statement by the ILAE Task Force on Nosology and Definitions. *Epilepsia* 2022; 63(6): 1475-99.

6. Zuberi SM, Wirrell E, Yozawitz E, Wilmshurst JM, Specchio N, Riney K, et al. ILAE classification and definition of epilepsy syndromes with onset in neonates

and infants: position statement by the ILAE Task Force on Nosology and Definitions. *Epilepsia* 2022; 63(6): 1349-97.

7. Specchio N, Wirrell EC, Scheffer IE, Nabbout R, Riney K, Samia P, et al. ILAE classification and definition of epilepsy syndromes with onset in childhood: position paper by the ILAE Task Force on Nosology and Definitions. *Epilepsia* 2022; 63(6): 1398-442.

## Legends for video sequences

### Module 1. Normal EEG Teaching Module

This module covers topics regarding normal EEG. Learners will be able to recognize and describe background activity and sleep. Learners will be able to recognize key features of an awake EEG background including background frequencies, eye blink artifacts, posterior dominant rhythm (including PDR by age), and anterior to posterior organization. Learners will be able to identify features of drowsiness and stage 2 sleep structures including vertex waves, roving eye movements, sleep spindles and K-complexes, as well as REM sleep features.

#### Key words for video research on [www.epilepticdisorders.com](http://www.epilepticdisorders.com)

*Phenomenology:* multiple

- K-complex
- Sleep spindles
- Vertex waves
- Saw-tooth waves
- Normal awake EEG
- Drowsiness EEG
- NREM sleep
- REM sleep

*Localization:* not applicable

*Syndrome:* not applicable

*Aetiology:* not applicable

**Module 2A. Normal Variants Part 1**

This module covers the most common normal variants seen on EEGs. Learners will be able to recognize normal variants including positive occipital sharp transients of sleep (POSTS), rhythmic mid-temporal theta of drowsiness (RMTD), small sharp spikes (SSS), lambda waves, photic driving, wicket spikes, Mu rhythm and Ciganek rhythm.

**Key words for video research on [www.epilepticdisorders.com](http://www.epilepticdisorders.com)**

*Phenomenology:* multiple

- POSTS (positive occipital sharp transients of sleep)
- RMTD (rhythmic mid-temporal theta of drowsiness)
- SSS (small sharp spikes)
- Lambda waves
- Photic driving
- Wicket spikes
- Mu rhythm
- Ciganek rhythm

*Localization:* not applicable

*Syndrome:* not applicable

*Aetiology:* multiple

- Normal Variants
- Drowsiness EEG

**Module 2B. Normal Variants Part 2**

This module covers part 2 of normal variants that are most commonly seen on EEGs. Learners will be able to identify non-epileptiform sharp transients, posterior slow waves of youth, temporal slow of the elderly, slow-fused transients, slow (notched) alpha variant, 14 and 6Hz positive bursts, and 6 Hz SWs (spike-waves).

**Key words for video research on [www.epilepticdisorders.com](http://www.epilepticdisorders.com)**

*Phenomenology:* multiple

- Non-epileptiform sharp transients
- Posterior slow waves of youth
- Temporal slow of the elderly
- Slow-fused transients
- Slow (notched) alpha variant
- 6Hz SWs (spike-waves)
- 14 and 6 Hz Positive bursts

*Localization:* not applicable

*Syndrome:* not applicable

*Aetiology:* multiple

- Normal variants
- Drowsiness EEG

**Module 3. EEG Artifacts**

In this teaching module learners will be able to recognize artifacts frequently seen on EEG and take actions necessary for eliminating artifacts. Learners will be able to identify the following artifacts: sweat, EKG, eye blink, horizontal (lateral) eye movements, eye flutter, glossokinetic, secretion, myogenic, and patting.

**Key words for video research on [www.epilepticdisorders.com](http://www.epilepticdisorders.com)**

*Phenomenology:* multiple

- Sweat artifact
- EKG artifact
- Eye blink artifact
- Horizontal (lateral) eye movement artifact
- Eye flutter artifact
- Glossokinetic artifact
- Secretion artifact
- Myogenic artifact
- Patting artifact.

*Localization:* not applicable

*Syndrome:* not applicable

*Aetiology:* EEG artifacts

#### Module 4. Interictal Epileptiform Discharges

In this teaching module learners will be able to identify an interictal epileptiform discharge (IED) based on the 6 International Federation of Clinical Neurophysiology (IFCN) criteria with examples of both IED and non-epileptiform sharp transients.

##### Key words for video research on [www.epilepticdisorders.com](http://www.epilepticdisorders.com)

*Phenomenology:* multiple

- Interictal epileptiform discharges
- Non-epileptiform sharp transients

*Localization:* multiple

- Right temporal interictal epileptiform discharge
- Right frontal interictal epileptiform discharge
- Left parietotemporal interictal epileptiform discharge

*Syndrome:* not applicable

*Aetiology:* interictal discharges

#### Module 5A. Focal Seizures Part 1

In this module we will cover the basic principles of focal seizures including the definition of an electroclinical and electrographic seizure. By the end of this teaching module learners will be able to recognize and describe ictal patterns and to correctly diagnose and classify focal epilepsies. The seizure types discussed in this module include brief pattern qualifying as ictal, low voltage fast activity, an evolving rhythm and focal electrodecrement seizure. Multiple seizure localizations will be covered including left frontal seizure, right frontal seizure and right temporal seizure.

##### Key words for video research on [www.epilepticdisorders.com](http://www.epilepticdisorders.com)

*Phenomenology:* multiple

- Brief pattern qualifying as ictal
- Low voltage fast activity
- Evolving rhythm
- Focal electrodecrement seizure

*Localization:* multiple

- Left frontal seizure
- Right frontal seizure
- Right temporal seizure

*Syndrome:* not applicable

*Aetiology:* multiple

- Focal seizures
- Myoclonic seizure
- Clinical seizure
- Electrographic seizure

#### Module 5B. Focal Seizures Part 2

This module covers part 2 of focal seizures. By the end of the end of the module learners will be able to recognize and describe ictal patterns and correctly diagnose and classify focal epilepsies. Learners will be able to identify a right occipital seizure, a right temporal seizure and an ictal pattern with greater >2.5Hz spike-wave activity. Multiple seizure localizations will be covered including right occipital seizure and right temporal seizure.

##### Key words for video research on [www.epilepticdisorders.com](http://www.epilepticdisorders.com)

*Phenomenology:* ictal pattern with >2.5Hz spike-wave

*Localization:* multiple

- Right occipital seizure
- Right temporal seizure

*Syndrome:* mesial temporal lobe sclerosis

*Aetiology:* multiple

- Focal seizures
- Electrographic seizures
- Temporal lobe epilepsy

### Module 6. Idiopathic Generalized Epilepsy

In this teaching module learners will be able to recognize and identify idiopathic generalized epilepsy (IGE) syndromes in accordance with the 2022 ILAE position statement. EEG hallmarks of IGE and basic principles including both EEG findings and diagnostic criteria will be covered. The following syndromes that will be discussed include childhood absence epilepsy, juvenile absence epilepsy, juvenile myoclonic epilepsy, and epilepsy with generalized tonic-clonic activity.

#### Key words for video research on [www.epilepticdisorders.com](http://www.epilepticdisorders.com)

*Phenomenology:* multiple

- 3 Hz generalized spike-and-wave discharges
- 4-6 Hz generalized spike-and-wave discharges

*Localization:* generalized

*Syndrome:* multiple

- Childhood absence epilepsy (CAE)
- Juvenile absence epilepsy (JAE)
- Juvenile myoclonic epilepsy (JME)
- Epilepsy with generalized tonic-clonic activity

*Aetiology:* Idiopathic Generalized Epilepsy (IGE)

### Module 7A. Developmental and Epileptic Encephalopathy Part 1

This teaching module covers part 1 of developmental and epileptic encephalopathies (DEEs) with discussion that is in accordance with the most recent ILAE guidelines. Learners will be able to identify interictal abnormalities, ictal patterns and correctly diagnose and classify DEEs. The syndromes discussed in part 1 of this module include early infantile developmental and epileptic encephalopathy (EIDEE), Ohtahara syndrome, early myoclonic epilepsy, infantile epileptic spasms syndrome (IESS), West syndrome and Dravet syndrome.

#### Key words for video research on [www.epilepticdisorders.com](http://www.epilepticdisorders.com)

*Phenomenology:* multiple

- Developmental and epileptic encephalopathy

*Localization:* not applicable

*Syndrome:* multiple

- Early infantile developmental and epileptic encephalopathy (EIDEE)
- Ohtahara syndrome
- Early myoclonic encephalopathy
- Infantile epileptic spasms syndrome (IESS)
- West syndrome
- Dravet syndrome

*Aetiology:* developmental and epileptic encephalopathy

### Module 7B. Developmental and Epileptic Encephalopathies Part 2

This teaching module covers part 2 of developmental and epileptic encephalopathies (DEEs) with discussion that is in accordance with the most recent ILAE guidelines. Learners will be able to identify interictal abnormalities, ictal patterns and correctly diagnose and classify DEEs. The syndromes discussed in part 2 of this module include Lennox Gastaut syndrome (LGS), Landau-Kleffner syndrome and epileptic encephalopathy with spike wave activation in sleep (EE-SWAS).

#### Key words for video research on [www.epilepticdisorders.com](http://www.epilepticdisorders.com)

*Phenomenology:* multiple

- Developmental and epileptic encephalopathy
- Epileptic encephalopathy with spike wave activation in sleep (EE-SWAS)

*Localization:* not applicable

*Syndrome:* multiple

- Lennox Gastaut syndrome (LGS)
- Landau-Kleffner syndrome

*Aetiology:* developmental and epileptic encephalopathy

## TEST YOURSELF

**(1) Which of the following is considered to be an EEG normal variant?**

- A. EKG artifact
- B. K-complex
- C. Sleep spindle
- D. Slow-fused transient
- E. Low-voltage fast activity with evolving rhythm

**(2) Which of the following is seen during stage 2 sleep (NREM sleep)?**

- A. Rhythmic mid-temporal theta of drowsiness (RMTD)
- B. Posterior dominant rhythm
- C. Sleep spindles
- D. Ciganek rhythm
- E. Mu rhythm

**(3) List all of the idiopathic generalized epilepsies in accordance with the updated ILAE 2022 position statement.**

---

*Note: Reading the manuscript provides an answer to all questions. Correct answers may be accessed on the website, [www.epilepticdisorders.com](http://www.epilepticdisorders.com).*

---