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A Video-Based Introductory EEG Curriculum for Neurology Residents and Other EEG Learners

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Abstract

Introduction: It is difficult to provide standardized formal education in EEG because of time limitations and the availability of expert teachers. Video-based miniature lectures are a useful way to standardize the foundational principles of EEG and support learning during EEG/epilepsy rotations. **Methods:** A curriculum of 10 EEG teaching videos was developed based on concepts outlined in the Accreditation Council for Graduate Medical Education Neurology Milestones. The videos were short (6-17 minutes) and made available to residents rotating through an EEG/epilepsy rotation in two neurology residency programs. Residents were instructed to review the videos and then apply their newly learned skills during EEG reading sessions. A survey about the process was completed at the end of the year. **Results:** Twenty-one residents participated in the curriculum, and 15 (71%) responded to the survey. Two-thirds of respondents (10/15) said that they watched all of the videos, and 87% (13/15) watched at least half of the videos. All of the respondents used the videos as introductions to EEG concepts, and approximately half of respondents returned to the videos as a refresher after the rotation was over. Nearly all respondents either agreed or strongly agreed that the curriculum was a useful component of the rotation and helped them to understand difficult concepts. All strongly agreed that they would recommend the curriculum to other residents. **Discussion:** A video-based approach to EEG teaching could complement existing curricula and ensure that learners have access to foundational miniature lectures when and where they need them.

Keywords

Video, Residency, Neurology, Flipped Classroom, Electroencephalography

Appendices

- A. Introduction to EEG
- B. Polarity Rules
- C. Montages
- D. Eye Movements on EEG
- E. Technical Issues
- F. Normal Awake EEG
- G. Normal Sleep on EEG
- H. Interictal Epileptiform Discharges
- I. Focal Slowing
- J. Diffuse Slow and Periodic Discharges
- K. Self-Assessment for Videos
- L. Postcurriculum Survey

All appendices are peer reviewed as integral parts of the Original Publication.

Educational Objectives

By the end of the module, learners will be able to:

1. Understand the basic technical principles of EEG and how they relate to EEG interpretation.
2. Understand simple EEG findings, including normal awake and sleep patterns, as well as common abnormalities.
3. Apply the knowledge introduced in the videos to basic interpretation of routine EEG recordings.

Introduction

Accurate interpretation of EEG recordings is essential to the care of patients with epilepsy and related disorders. However, it is generally recognized that EEG interpretation is not always done accurately, and misinterpretation of EEG findings can lead to inappropriate treatment and harm to patients.¹

The major problem in EEG interpretation is over-diagnosis of abnormalities (i.e., interpreting normal variants as abnormal or epileptiform). In a recent survey of self-identified EEG experts, over 90% of respondents (and 95% of board-certified electroencephalographers) had encountered patients who were treated for epilepsy based on a misread EEG.¹ One potential source of misinterpreted EEG is uncommon or subtle mimics of epileptiform discharges such as wicket spikes, rhythmic midtemporal theta of drowsiness,

small sharp spikes, and other rare findings that are difficult to accurately identify without intensive and prolonged EEG training.^{2,3} Further, the most common single reason for misdiagnosis on EEG is over-interpretation of normal fluctuations in the EEG background.⁴ Therefore, one could make the argument that most sources of EEG misinterpretation could be avoided by adequate training in recognizing normal EEG patterns.

There are several potential causes for inadequate EEG training during residency. Much of a resident's learning will depend on the presence of enthusiastic, well-trained EEG instructors who are given adequate time to teach. In large academic centers, such teachers may focus more on higher-level EEG teaching of epilepsy and neurophysiology clinical fellows. In smaller centers, the talented EEG teachers may be stretched too thin: they are too busy with clinical work and administrative activities that they do not have time to provide introductory education to residents.

Prober and Khan⁵ have outlined a proposal for the reimagining of medical education based on principles developed by one of the authors in K-12 educational settings.⁶ Within their educational model, they suggest that there is minimal, foundational, and evergreen (i.e., known to be true) material that can be learned online with either short videos, electronic textbooks, or other online resources. Much of this learning can be done outside of the institutional learning environment, thus opening up educational time within the institution for interactive and deeper learning activities.⁵

We developed a curriculum to standardize the teaching of foundational EEG principles using a flipped-classroom method with video-based miniature lectures. Rather than requiring lectures or one-on-one sessions with experienced EEG practitioners for dissemination of the most basic EEG principles, we introduced these principles using online videos to be viewed prior to participation in the educational activities within the institution. We hypothesized that the availability of the videos would encourage residents to acquire greater mastery of this foundational material since they could view it multiple times as needed to review and become comfortable with the content. By using this method to build a stronger foundation in EEG basics, we anticipated that residents would be freed to spend their EEG learning time focusing on developing a deeper understanding of the range of normal patterns within EEG recordings. We piloted this curriculum in two academic centers, and evaluated whether this was both acceptable and deemed a useful learning experience for residents.

There is a precedent for flipping EEG education. Residents in an anesthesiology program were provided with two 1-hour podcasts on EEG in place of in-person didactic lectures. These residents showed a similar degree of improvement in their performance on a multiple-choice question evaluation tool when compared to residents who had attended the in-person lectures.⁷ This current curriculum was designed for nonneurology trainees and focused on visual recognition of simple EEG patterns. There are other learning resources designed to serve as an introduction to EEG theory and interpretation,⁸ but we are not aware of any published video-based curricula that cover topics in appropriate depth for higher-level learners such as neurology residents.

Rather than producing 1-hour video lectures, we wanted to make videos that were conducive to the short periods of free time available to the average busy neurology resident. We also believe that there is a pedagogical advantage to focusing on a small number of learning points in each video.⁹ Many recently published modular video-based curricula designed included videos that were 8 to 15 minutes in duration,¹⁰⁻¹² and so we attempted to keep all of our videos within this time range.

Methods

An evaluation to determine the effectiveness of video-based miniature lectures was conducted with neurology residents from two separate institutions: Yale University in New Haven, CT, US and Dalhousie University in Halifax, NS, Canada. At Yale, residents spend a total of 1 month in clinical neurophysiology in

their second and third postgraduate training year (PGY2 and PGY3). A total of 16 residents completed one month of training during the evaluation period. At Dalhousie, residents complete a 3-month rotation in EEG and Epilepsy during the PGY3 or PGY4 year, and a total of five residents completed this rotation during the evaluation period. The study period at both centers was between July 1, 2014 and June 30, 2015. Because we were determining the effectiveness of an educational intervention, this evaluation was granted an exemption from the formal research ethics review by the Human Subjects Committee at Yale University.

A video curriculum of 10 video-based miniature lectures (Appendices A-J) was developed by one of the authors using Camtasia screen capture and video editing software. Each video is designed to be brief, focusing on a small number of teaching points, and easily watched by a busy resident in a single sitting. They range in duration from 6 to 17 minutes. The topics in the videos are chosen to emphasize introductory concepts of EEG terminology, technology, and interpretation. They are also blueprinted to the subcompetencies outlined in the Accreditation Council for Graduate Medical Education Neurology Milestones (Table 1).¹³

Table 1. Video Topics Mapped to the Neurology Milestones EEG Subcompetencies

Video	Title	Duration	Topics
Subcompetencies: explains EEG nontechnical terms (Level 1), uses appropriate terminology related to EEG (Level 2)			
1	The Basics of EEG	11:30	Terminology, 10-20 system, basic EEG technology, common EEG patterns, clinical utility of EEG
2	Polarity Rules in EEG	6:17	Differential amplifier, polarity in interpreting EEG
3	EEG Montages	14:20	Bipolar, common reference, average reference, weighted average reference, Laplacian, reference contamination, strengths and weaknesses of specific montages
Subcompetency: recognizes common EEG artifacts (Level 3)			
4	Eye Movements on EEG	6:47	Horizontal and vertical eye movements
5	Technical Issues in EEG Interpretation	13:54	Normal frequency bands, low- and high-frequency filters, notch filter and impedance, sensitivity, time scale
Subcompetencies: describes normal EEG features of wake and sleep states and recognizes normal EEG variants (Level 4)			
6	Normal Awake EEG	16:55	Alpha rhythm, alpha squeak, mu rhythm, lambda waves
7	Normal Sleep EEG	16:52	Stage I and II sleep, slow-wave sleep, REM sleep
Subcompetency: interprets common EEG abnormalities (Level 4)			
8	Interictal Epileptiform Discharges	11:29	Focal discharges, generalized discharges
9	Focal Slowing and Attenuation	12:16	Focal slowing and attenuation, including clinical significance
10	Generalized Slowing and Periodic Discharges	12:00	Generalized slowing; focal, multifocal, and generalized discharges

During the pilot curriculum period, residents were expected to review the teaching videos during their clinical neurophysiology/EEG rotation, outside of the time allotted for EEG review in the clinic, and outside the traditional expert-led educational environment. The videos were available through a public folder on Dropbox, and on the Yale School of Medicine instructional video website that was accessible only through the school of medicine intranet.

After watching each video, learners completed two- to-three multiple-choice questions based on the videos, and received immediate feedback on their performance. This feedback included explanations for the correct answers and references to the specific time points in each video where the answer could be found (Appendix K). We used the Qualtrics survey platform to provide immediate feedback on the multiple-choice questions, but other survey platforms may be used, or the questions may be completed on paper.

At the end of the pilot curriculum, surveys (Appendix L) were distributed to every resident using the SurveyMonkey website. Residents were asked how many of the videos they watched, in what context, and using what digital platforms (i.e., tablet, cell phone or computer). They were also asked to respond to

questions about the usefulness and acceptability of these curricular materials, and whether they would recommend them to other residents. Suggestions for changes to the curriculum were also solicited.

Results

Eleven out of 16 (69%) residents at Yale and four out of five (80%) residents at Dalhousie responded to the anonymous survey, creating a pool of 15 respondents. The baseline level of training of the residents, number of videos each resident watched, and their reasons for using the teaching videos are outlined in Table 2. There was a range of training levels: at Yale, the residents do clinical neurophysiology rotations in PGY2 and PGY3, while at Dalhousie, the residents rotate in EEG/epilepsy in either PGY3 or PGY4. Most residents (10/15, 67%) responded that they watched all of the teaching videos, while 13/15 (87%) watched at least half of the videos. Most residents responded that they used the videos as an introduction to concepts before the start of a rotation, while approximately half of the residents used the videos as a refresher after the rotation was over. One-third utilized the videos to review difficult concepts during the rotation.

Table 2. Survey Respondent Characteristics and Answers About Video Use

Respondent Characteristics/Answers	Yale	Dalhousie	Total
Level of training			
PGY2	8	0	8
PGY3	3	1	4
PGY4	0	3	3
How many videos were viewed			
<3	0	0	0
3-4	2	0	2
5-6	1	0	1
7-8	1	1	2
9-10	7	3	10
Devices used to view videos			
Cell phone	0	0	0
Tablet	1	0	1
Laptop/desktop	0	14	14
How videos were used			
As an introduction to concepts before the start of the rotation	11	3	14
To review difficult concepts during the rotation	4	1	5
As a clinical refresher after the rotation was over	6	1	7

The residents' responses to questions about the usefulness and acceptability of the video-based lecture curriculum for EEG education are shown in the Figure. Almost all residents agreed or strongly agreed that the curriculum was a useful component of the rotation, that it helped them to understand difficult concepts, and that it complemented their learning on the EEG rotation. Residents generally agreed that the curriculum met the learning objectives, and allowed for improved performance during the rotation. The majority of residents strongly agreed that they would watch the videos again, and all strongly agreed both that they would recommend the curriculum to residents in other programs and that the video-based curriculum should continue to be used. Residents did not agree as strongly that the curriculum allowed them to better understand difficult concepts or perceived that the videos introduced new concepts that were not addressed in other contexts.

Thirteen respondents said that the videos were just the right length, while one resident said that they were somewhat too short. No residents thought that the videos were either too long, or far too short. Five residents responded that there should be many more videos, five responded that there should be a few more videos, and four thought that there was just the right number of videos in the curriculum. No residents thought that there were too many videos in the curriculum.

Figure. Weighted mean response on a 5-point Likert scale to questions about the usefulness of a video-based EEG teaching curriculum, with 95% confidence intervals. Questions are grouped into three broad categories: the usefulness of the curriculum as a complement to the EEG rotation, the curriculum as a stand-alone learning tool, and the acceptability of the curriculum as a learning tool.

Discussion

In this pilot evaluation of the implementation of a video-based didactic approach to EEG education in two residency programs, residents felt strongly that the curriculum was a useful complement to their EEG rotations, and almost all residents indicated that they would continue with this curriculum and would recommend it to residents in other programs.

This model may represent a way to optimize didactic learning in an age of restrictive duty hour regulations, and strained faculty schedules.¹⁴ In one study of critical care fellows, attendance at educational lectures in the program was approximately 43%.¹⁵ This means that at any given time, over half of all trainees were not able to take advantage of the didactic curriculum which is generally considered to be a cornerstone of formal graduate medical education. In addition, there is the issue of timing of didactic sessions. Neurology programs are required to follow a schedule of daily (or weekly) sessions covering a broad range of clinical and basic science topics. At the same time, residents rotate through different services, making it virtually impossible for the didactic sessions to align with what the residents are experiencing on service. This model of didactic instruction can ensure constructive alignment during subspecialty rotations, as the didactic sessions delivered through web-based videos, can match the daily activities of each resident.¹⁶ Further alignment is achieved when the videos are constructed to address the specific competencies on which the residents will be assessed. In our programs, one or two residents were rotating through the clinical neurophysiology service at the same time, but all were able to experience the same standardized, milestones-based didactic curriculum, timed to coincide with the period of maximum exposure to EEG.

Creating video miniature lectures requires a significant investment in up-front time if the videos are going to be matched to the milestones or other curriculum objectives.¹⁷ Planning, recording, and editing each of these videos required at least 5 hours of faculty time. However, these videos proved acceptable and useful in the training of residents in two different residency programs, of different size, duration and in different countries. Arguably, responsibility for production of similar videos relating to other topics could be shared between institutions, with local modifications made as needed. There are many ways that a flipped curriculum saves faculty time in residency training. In most programs, there are a small number of neurophysiologists who are principally responsible for introducing residents to the basics of EEG interpretation. These neurophysiologists have to start from the beginning with each new resident, a process that can consume both time and teacher enthusiasm. In a flipped curriculum, the introduction to the basics occurs during self-study, and thus the neurophysiologist has more time to engage in teaching more complex and nuanced components of EEG interpretation or in focusing on specific areas of the

basic material that residents are struggling with. We believe that this leads to greater enthusiasm and a better teaching/learning experience for everyone involved. Further, with some authors predicting the disappearance of lectures in medical education,¹⁸ it is possible that we will soon have no choice but to embrace new technology such as online videos as a foundational component of any curriculum.

It is not the videos alone that make the curriculum, and on their own, even the best-designed teaching videos are of limited value.⁵ We believe the real value in the flipped-classroom model of EEG education is in aligning the virtual didactic sessions with what the residents are doing during their clinical neurophysiology rotation, and the standards by which they are evaluated, the Neurology Milestones.

Our evaluation of the curriculum is limited by the fact that we recorded only residents' general impressions of the curriculum, and not their performance in EEG interpretation. We intended only to test the feasibility of a flipped classroom method of EEG instruction, and to determine whether this method would be acceptable to learners. We did not include measurements of resident performance, mainly because every resident participated in this curriculum, and thus there would be no comparison group. We did not consider historical controls a valid comparison, because the specific activities of the residents on the clinical neurophysiology rotation at one of the institutions in this study changed significantly during the year prior to implementation. A future direction for research could include a comparison of residents randomized to receive standard instruction or flipped didactics. Ideally, the outcome for comparison would be performance in a real-life task, such as interpretation of routine EEG recordings.

We have shown that a curriculum of video-based miniature lectures is feasible and acceptable for teaching the foundations of EEG to neurology residents. We have also outlined some ways in which this approach can be taken in other aspects of neurology resident education, and how we believe this approach can enhance standard teaching strategies.

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Prior Presentations

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Ethical Approval

This publication contains data obtained from human subjects and received ethical approval.

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