

## **THE ABCS OF EEGS: AN EVOLVING TOOL FOR EPILEPSY DIAGNOSIS (WEBINAR TRANSCRIPT)**

Dr. Laura Lubbers:

Welcome, everyone, to today's webinar. I'm Dr. Laura Lubbers and I am the Chief Scientific Officer for Citizens United for Research in Epilepsy, or CURE, and I want to thank you all for joining us today.

Dr. Laura Lubbers:

Today's webinar is entitled The ABCs of EEG: An Evolving tool for Epilepsy Diagnosis, and it will discuss how epilepsy patients have benefited from advances in EEG technology, and the role of EEG and other neuroimaging tools in the future of epilepsy diagnosis and seizure identification.

Dr. Laura Lubbers:

This is the first installment of our new year of webinars, our 2020 Leaders in Epilepsy Research Webinar Series, where we highlight some of the critical research that's being done on epilepsy. Today's webinar is being made possible by the generous support of our friends at the Band Foundation.

Dr. Laura Lubbers:

CURE's mission is to find a cure for epilepsy by promoting and funding patient focused research. For more than 20 years, CURE has been instrumental in supporting groundbreaking research projects from around the world. Prior to introduction of our speaker today I want to spotlight one of CURE's recent research projects that features the work of Dr. Flavia Vitale who is a 2017 Taking Flight Grant Awardee. Dr. Vitale and her team at the University of Pennsylvania engineered a minimally invasive method of delivering thin, ultra-flexible electrodes deep into the brain. These electrodes are constructed and inserted in a way that limits the tissue damage often associated with existing electrodes used for recording neural activity deep in the brain.

Dr. Laura Lubbers:

In addition to reducing tissue damage, this improved technology may allow researchers and clinicians to better pinpoint changes in brain activity of people with epilepsy. For more information about this project or other successful outcomes from CURE funded research, please visit the epilepsy news section of the CURE website.

Dr. Laura Lubbers:

Today's webinar is also focused on the study of brain activity through the use of electroencephalograms, or EEGs. Today's presenter is Dr. David Burdette, epilepsy section chief for the Spectrum Health Medical Group in Grand Rapids, Michigan. He has been at the forefront of EEG education, having served on the American Board of EEG Technologists. Dr. Burdette's clinical interests include neural telemetry, treatment of refractory epilepsy, as well as status epilepticus, and long term EEG monitoring.

Dr. Laura Lubbers:

Before Dr. Burdette begins, I'd like to encourage everyone to ask questions. You may submit your questions any time during the presentation by typing them into the Q&A tab at the bottom of your Zoom Panel, and then click send. I also want to thank those individuals who submitted questions in advance of the webinar. We'll do our best to get through all of the questions that have been submitted or will be submitted. While we want this webinar to be interactive, we also want to respect everyone's privacy, so we ask that your questions be general and not specific to a loved one's epilepsy.

Dr. Laura Lubbers:

I also want to mention that today's webinar, as well as past and future webinars, are recorded, and are available on the CURE website. So with that I'd like to turn it over to Dr. Burdette.

Dr. David Burdette:

Laura, thank you so much for this opportunity to talk about EEG. I have spent a career interpreting EEGs, doing research with EEGs, and EEGs are my passion. And I think that they are what you might call the sine qua non of understanding epilepsy. Without EEGs we have the most basic at best of understanding of EEG.

Dr. David Burdette:

So what I would like to do is to talk about briefly the evolution of EEG as it applies to epilepsy. With regard to disclosures, my disclosures that are relevant to this talk are two, and this has to do with an area called neural stimulation, and a particular area of interest with me which is thalamic stimulation where my current research interests lie, and so I'm on an advisory board, I'm head of an epilepsy program that is a center of excellence for Medtronic who makes a DBS, and I'm on the speakers bureau and get research, misspelled research with apologies, support from NeuroPace who makes a responsive neurostimulator.

Dr. David Burdette:

Today, I want to cover three topics in this brief time that we have together, and then as Laura said, we'll open up the floor to questions and have a nice interaction. So the first objective is I want to give some basic perspective of EEG. So a little bit of the history of EEG, where we have been, and then talking around a de identified case where we are right now at the present state of EEG and associated technologies, and then finally what the future is likely to bring.

Dr. David Burdette:

So we can't talk about the history of EEG without going back to a little over a century ago, when there was a German cavalry officer who was involved in an unfortunate mishap where he was thrown off of his horse and came this close to being run over by a [inaudible] carrying a cannon. He was this close to being crushed to death, this was something he remembered for the remainder of his life. But what also was interesting was at the same time that he was barely avoiding death, his sister who lived 100 miles

away had this overwhelming premonition that her beloved brother had somehow had some horrendous occurrence befall him.

Dr. David Burdette:

So she ran to their father and had their father fire off a telegram inquiring as to the health of her brother. And when you look at the timing of the telegram and the timing of the accident, it appeared to him that these were almost simultaneous. So he became a lifelong believer in telepathy, and in order to try to understand telepathy he decided that despite no background in electronics or physiology, that once he had pursued his career in psychiatry, that he was going to devote his life to recording brainwaves. And in so doing he never identified telepathy, nor has anyone identified telepathy, but he did establish the foundation for what we now know as modern electroencephalography.

Dr. David Burdette:

And here we have Dr. Hans Berger, the calvary man in question. And here we have some early EEGs. He did hundreds of EEGs on his young son, and he found that when he put an electrode over the back of the brain, when his sons eyes were closed, he would have this nice, somewhat sinuous looking wave form, then when his sons eyes would open, that would attenuate, it would go away, and then when his son closed his eyes again down here, it would reappear. So some have called those Berger waves, after Dr. Berger, we now call that the alpha rhythm.

Dr. David Burdette:

What I'm going to be discussing, in essence, are rhythms of the brain. The EEG is the only technology, or was the first technology, one could argue that magnetoencephalography is also such a technology, but that's much harder to do. So the EEG is our primary technology for identifying the rhythms of the brain. And the rhythms of the brain are ultimately going to come down to a network of neurons, a collection of neurons that are inter connected. This is a simplified view of a neural network, but we may have a neuron that is excitatory, and every time it fires, every neuron with which its connected is more likely to fire. So this neuron synapses with a neuron or a population of neurons and makes them more likely to fire.

Dr. David Burdette:

They in turn make another population more likely to fire, which in turn makes another population likely to fire, which, dot, dot, dot, coming back to the first one, makes it more likely to fire again. When the milieu of the brain is right, then that will in fact boom, boom, boom, start to fire in a rhythmic fashion. So over the back of the brain, I'm awake, I close my eyes, and boom, boom, boom, it starts to fire.

EEG is the study of those rhythms of the brain. So here we have a standard, normal EEG. The EEG, these electrodes that are placed in a specific array over the brain, pick up any electrical signals that impinge upon them. So your eyes, for instance, are just an extension of the brain. This is how we see. Your eyes have electrical potentials, and here we see on this EEG, these prominent deflections. How this EEG is set up is the first four

lines are for the series of electrodes going from front to back, around this person's left temporal area. The next four electrodes are front to back, to the left side of the midline. We then have two in numbers nine and ten here in the midline, and then we have four on the right side near the top of the head, and then around this side we have the last four, and then we have an EKG because the heart can cause some deflections that we can see on the EEG.

Dr. David Burdette:

So this is set up so that the left half of the brain is up top, and the right half of the brain is below. Each of these prominent deflections is an eye blink. Every time we blink our eyes, we will have a brief upward movement of the eye, called the Bells Phenomenon, named after Dr. Bell, the neurologist who first described this. And so this individual's eyes are open, and it's blink, blink, blink, blink, and then the EEG technologist asks them to close their eyes so we get a bigger deflection, and then no more blinks.

Dr. David Burdette:

At the same time that the eyes are closed, we have the appearance of Hans Berger's alpha rhythm, Berger waves. This alpha rhythm is a rhythmicity of the brain that has intrigued epilepsy doctors, neurologists in general, psychologists, many individuals have been intrigued by this very aesthetically pleasing rhythmicity that we generate when we close our eyes and our occipital lobe, the back of our brain, is in a resting state.

Dr. David Burdette:

This would be abnormal rhythmicity. So this is what we call burst suppression. It's rhythmic. We have a burst of activity, a flat, a burst, a flat, a burst, a flat. This is what you might call an agonal brain rhythm. It is one step shy of flat line. And we will see this in two settings, either when something horrendous has befallen this individual, or something as simple as general anesthesia. If we anesthetize the brain, we suppress that brain function, not all the way to flat line, but we may well suppress to burst suppression. So this would be a coma sort of pattern, but again, it is rhythmicity.

Dr. David Burdette:

We can tell you what state of arousal you have, are you awake? Are you, God forbid, in a coma? Are you just asleep, in stage two sleep? We see this broader wave, it's called a K complex, but overriding it, we see these little ripples of activity that run about 14 cycles per second. They are sleep speckles. They are a hallmark of stage two sleep. In fact, we can't say that you're in stage two sleep unless we see either K complexes or sleep speckles, but again, they are normal rhythmicity of the brain.

Dr. David Burdette:

When we go later in sleep, we may dream. And when we dream we have REM sleep, the REM of course is rapid eye movement, because our eyes act out our dreams. We are in fact paralyzed during REM sleep, all of our muscles are paralyzed, except the muscles that control our eye movements and those for our respiration. So here, the same set up, left half of the brain, right half of the brain. And here, let's look at the right eye. We see this sort of oddball movement, the eye is kind of flitting around, this person

is acting out their dream. But similarly with all states of arousal, we have a brain signature, and that brain signature are these little wave forms called saw tooth waves.

Dr. David Burdette:

So the history of EEG was one of defining what are the signatures of normal brain function, and what are the signatures of abnormal brain function. Basically defining the foundation for what we do nowadays.

Dr. David Burdette:

Here is rhythmicity, but that's not normal rhythmicity, this is an absence seizure. And we see with this rhythmicity a real brief burst of activity, it looks like a spike so we'll call it a spike. And after it, we'll see a slow wave. So they seem to be time locked, so we'll call it a spike wave. So these are spike wave discharges, and they're occurring boom, boom, boom, boom, boom. Quite fast, then they slow down and they stop.

Dr. David Burdette:

So this is rhythmicity of the brain still from a network of nerve cells, but it is one that evolves. This is not normal rhythmicity of the brain, and this of course is the hallmark of a seizure, a hallmark of epilepsy, and what a neurologist, an epileptologist does is we devote our lives to trying to take this abnormal rhythmicity of the brain and to keep the brain from firing in that fashion, either with medication or lifestyle changes, or even implantable devices and various surgical approaches, and try to return this abnormal rhythmicity back to a normal firing pattern.

Dr. David Burdette:

So that is the past, that is the foundation with which we are working. Anyone who has epilepsy or our loved one has epilepsy, we can't do or interpret EEGs in a meaningful fashion without having that foundation. So now let's move to the present. The big, arguably the largest difference between the first 50 years of EEG where that foundation was being established, to current day, was the advent of computers. And the use of computers to record EEGs and to allow us to process those wave forms. So very briefly, I'll tell you the story of a young man who is just a regular guy.

Dr. David Burdette:

You'd meet this guy on the street, you would have no idea he has epilepsy. He is your prototypical epilepsy patient. Unfortunately, since he was about 13 years of age, he has had a tendency to have seizures. These seizures have continued despite trials of six different anti-seizure medications and lifestyle changes, and they are incredibly frustrating such that he was able to struggle his way through school, but now he has difficulty finding gainful employment, life is a struggle. What can we do for this guy?

Dr. David Burdette:

So this is an early EEG from probably a decade ago that he came into the hospital in what we call status epilepticus. He was having seizure, seizure, seizure. And this illustrates what we can currently do with the EEG. The EEG is recorded by computer, that computer can take those squiggly lines and break it down by frequency. Are the

squiggly lines going very quickly and oscillating 20 times per second, or are they slow and going at one cycle per second? Well here, you see this is six-hours-worth of information. And each one of these lines down low on the line is down around one cycle per second, and up high is at 20 cycles per second.

Dr. David Burdette:

These are just analyzing the squiggly lines that we see with an EEG. And how hot it is, how bright that, if it's really hot it's red, and then maybe yellow and then blue is cold. So however hot it is is how much power there is at each of these frequency bands. So he's going along and all of the sudden there's a big burst of activity and then it evolves. Remember, seizures evolve, and it slows down and it goes away, and another half hour later, a little less, 15 minutes, boom, it happens again. It goes a little bit longer, but then here's a longer seizure.

Dr. David Burdette:

These seizures are occurring in a recurrent fashion. So when we're treating this young man, it's helpful to know real time how we're doing with our medications. So he was in the hospital, in this case in the intensive care unit, and the neurointensivist was able to look at this DSA, a dense spectral array, basically a spectrographic, a pretty picture of the brain, and was able to see when the seizures were occurring. And as medication was administered, these slowed down and eventually stopped. So trending, in the short term, is what we currently do, and is exceedingly helpful, particularly in the short term treatment of people who are in the hospital and having seizures.

Dr. David Burdette:

Once he came to the attention of an epilepsy center, then we get his history and it becomes apparent that these seizures are a problem for this young man. And so we get some adjunctive tests. Let's define, perhaps, where those seizures are coming from. So we get a PET scan, and the PET scan, nice colorful test, that's the beauty of computer technology is it gives us pretty pictures, and pretty pictures are engaging and we get a lot of information from them. Not just because they're pretty, but because they give us all kinds of good information.

Dr. David Burdette:

So what we're looking at with the PET scan is the metabolism of the brain. How active the individual neurons are, and so in his case, we see that over the left half of his brain, he is quite active, you'll have to take my word for it, normal looking brain, but it's not quite as hot on this side. Something funky is going on over his right frontal lobe that may be associated with his seizures, and it probably is not helping him in his ultimate goal of getting gainfully employed. It's making life difficult.

Dr. David Burdette:

We also got a magnetoencephalogram, MEG, it's kind of like EEG, we just switch the M to an E. What does that mean? Well, when you think back to basic high school physics, you have something called the right hand rule. And so if you have current going through a wire or in this case a nerve cell, it creates a magnetic field that wraps around

like your fingers do. So the EEG, the brainwaves have a hard time penetrating the skull. So whenever you have an EEG that is of the type that Hans Berger did, we're looking at a very gross view of the brain. It's like the 30,000 foot view.

Dr. David Burdette:

What MEG goes, it's very hard to record, you have to be in a magnetically shielded room, et cetera, but you can see the magnetic fields produced by the brain. So we got a magnetoencephalogram on this young man, and we saw that this is the right half of the brain, this is the left half of the brain, and these are all those spikes, those bursts of activity, and we calculated where they were likely coming from, and there was just this mishmash of these, diffusely throughout the front part of the right half of his brain.

Dr. David Burdette:

So, he's very motivated, he wants something done. So we got a functional MRI. This is, you're all aware of an MRI scan, this is a functional MRI that maps out brain functions. So here we're looking at the brain. This is set up such that it's kind of flipped, actually it's not. It's like we're looking down at the brain. And we see that we've peeled away the left half of the brain, and anywhere there's yellow is the part of the brain with which he talks. It turned out that he, like most people, is strongly left hemispheric dominant for speech, but his seizures are coming from the right side.

Dr. David Burdette:

So that means that there's more that we can do to help him from a surgical perspective because life is better with an intact brain. We don't want to, if we had to take out this part of his brain to stop his seizures, the risk benefit ratio is not so good, that he would have difficulty talking but he's not having seizures, that's still not a great quality of life. We're about quality of life. Fortunately speech on the left side, seizures on the right. And we have now gone through the skull and we have put electrodes directly onto the brain. So instead of the 30,000 foot view, we have the 500 foot view. We're looking more closely at the brain itself. And this is before a seizure starts, once again we see those spike waves, just like we saw with the absence seizures, it's a network, the network is firing out of control, and they're going to evolve, and they're going to really start to take off, and finally every one of those electrodes gets involved.

Dr. David Burdette:

So once again, we see the evolution, and we're looking at the rhythmicity of the brain, our best way of seeing that rhythmicity is with the EEG. So we then reverse the current on some of those electrodes and we map out his brain, and it turns out that the seizures were coming from anywhere there's an E. So they were these broad onsets, and anywhere there's some color were areas of the brain that he needs. And there's clear overlap between where the Es are, particularly in this area, and areas of the brain that he needs to control movement of the left side of his body.

Dr. David Burdette:

So it would be too dangerous to take out all of those E areas because we would leave this young man with difficulties moving the opposite side of his body, and even to some

degree talking. So not a good situation. So we ended up implanting a device, permanently implanting electrodes over that area of the brain, and let's see how this device works. Now we're starting to move to the future. So we've got a device that can measure brain waves, can interpret when a seizure or seizure like phenomenon is happening EEG wise over the brain, and then maybe disrupt that seizure with some judiciously applied current.

Dr. David Burdette:

So we do something called a long term trend, and what we do is we take that EEG and pretend like it's a piece of spaghetti. And we take two seconds of that EEG, or in this young man's case four seconds, and we snip that piece of spaghetti, take it out, and see how long it is. And if the EEG is going really fast, it's going to be a longer piece of spaghetti. If it is waa, waa big, it's going to be a longer piece of spaghetti. If it's just flat it's going to be a short piece of spaghetti. And we take that running piece of spaghetti, and we compare it with the baseline, and we told him down here at the bottom, we told that little computer that if that four seconds increases by 75%, we're going to call that a seizure.

Dr. David Burdette:

So we got four seconds. And this guy was having approximately weekly seizures, he did really well for a few months, then about six months in, he has a seizure. This is an EEG recorded directly from his brain, it turns blue when the seizure is detected. So this is the broad view, let's focus in and look at the 20 second mark, we see the onset of the spike waves. It looks very similar to what we saw when we were recording from his brain itself. It looks very similar to the absence seizure that we saw, even though this is focally within the brain, and we see it go, and one second, two second, three second, four seconds in it senses it because we've told it to wait four seconds, and then it stimulates the brain.

Dr. David Burdette:

But it's a little too late. It doesn't do the trick. So we change it to two seconds, and long story short, this young man was seizure free for the first eight months except for that one seizure, and everything is hunky dory, one of my colleagues sees him for a return visit, and, sorry I have to get close here and read it because I don't have my bifocals, in September of '18, and he's having some issues with depression, which is very common when you have refractory epilepsy, so my colleague's deal is helping him work through those issues, but otherwise he's very happy, he's getting ready to go on a job interview, things are going well, and then all of a sudden, this is long term trending, and what we've got here is a read out that this is quantifying whenever he is likely to have a seizure.

Dr. David Burdette:

So this is quantifying what we call long episodes. Not all of these are seizures, but it's a measure of brain excitability. This is sort of the future, if you will, of what we will be able to do, and frankly can do right now with EEG.



Dr. David Burdette:

So the brain excitability built up, and then went down. What could have happened? Well, he was started on a medication for depression, a very reasonable medication, that usually is very seizure friendly, but in his case, it wasn't. He had his second seizure. We're jumping in a little earlier, but he still had a seizure. The antidepressant was discontinued, and he came down to base line. So this long term trending allows us to see bad things when they happen. Maybe someone god forbid drinks too much alcohol and we see that uptick, or they take a medication and we see that uptick in seizures, or on the flip side, maybe they're running at a baseline high level, and then we start a medication, we see the long episodes fall. So this long term trending can get me as an epileptologist insight into how my patients brain is responding to substances in either a good way or a bad way.

Dr. David Burdette:

Other areas for the future, my personal interests has to do with thalamic stimulation. If you have ongoing seizures, and I can prove all of your seizures are coming from one part of your brain, and that that part of the brain is expendable, we recommend either a section of that part of the brain or ablation with a laser, and that person has a relatively high chance of being seizure free. That is a minority of patients, however. If your seizures are starting more broadly over one hemisphere, then it would be a bit dangerous to take out that hemisphere unless you're very young. So what do I have to offer?

Dr. David Burdette:

Well what we are doing at Spectrum is we will implant either a strip of electrodes, or an intracerebral electrode and use that same stimulating device, and we will also put another stimulating electrode deep into the brain, into a part of the brain called the thalamus, and the thalamus has all these little nuclei that in essence create those rhythms of the brain. It plays a key role in the rhythms of the brain.

Dr. David Burdette:

So here are three patients, this patient has an electrode in her part of the brain called the inslab near the surface and in the anterior nucleus, and what we see is that in the anterior nucleus of her thalamus with a little pretty spectrogram, I can see onset of the seizure. This individual has more broad onsets, and I can see the onset of the seizure in the cortex, but I can also see it in something called the central median nucleus of the thalamus. And finally, this person has seizures toward the back of their brain, not unlike where Hans Berger recorded the alpha rhythm in his son, and I can see changes in a part of the brain called the pulvinar.

Dr. David Burdette:

So my particular area of interest is using stimulation of that deep part of the brain called the thalamus to alter those rhythms of the brain in a way that is incompatible with seizures, and finally before I open up the floor, the future future of EEG is exemplified in this worked on by Max [inaudible] and [inaudible] at UCSF, and what they did was they took those recordings, like the ones that we saw in my young man who was started on

an antidepressant, had an increase in seizures and we were able to bring him back down has done quite well.

Dr. David Burdette:

So here we see a line that is looking at this dark line in the upper plot is tracing how active these individuals brains are, and this is one individual, so this individual's brain is, and when it's high there are more of these seizure prone times, and when it's low, it's less. Each of these dots is a clinical seizure that the person noted, and immediately we see that there's a tendency for these dots to occur, these seizures to occur on the upswing of brain excitability, and that's in fact what we saw in my young man from a little bit ago.

Dr. David Burdette:

What Max and Bickram did was they broke this down into little, they did wavelet analysis. And what they identified were some rhythms of the brain that were rhythms of rhythms. So we have this sort of yellow mustard colored line and this is a ten day rhythm, that there would be this rhythmicity for over ten days, individuals would be a little more likely to have a seizure than a little less, but there was this intrinsic rhythmicity.

Dr. David Burdette:

They also found a 20 to 30 day rhythm that individuals had, male or female, we have these rhythms that are almost monthly, we don't know why they occur. Maybe it's phase of the moon, I don't know, but we have these rhythms of the brain when we are more likely to have a seizure and when we're less likely. And this is information that is helpful to know because let's say for instance that you come to me and say "Burdette, I'm still having seizures, golly gee, what can we do?" And I'm like that is so frustrating, let's tweak your medication a little bit, or let's add a new medication, or make an adjustment in your neural stimulator. And if it just so happens that you are on the upswing of this multi day rhythm, we call it a multidian rhythm, or even your diurnal rhythm, your 24 hour cycle, then you might go home and I didn't know you were on the upswing of that, you go home and have two seizures.

Dr. David Burdette:

So I'm going to think and you're going to think that oh it was the change I made. I caused that by adding this medication, or adjusting your stimulation in a certain way, when in fact it may have had nothing to do with that. It may have been due to you being on the upswing of this multidian rhythm, this ten day rhythm, whatever.

Dr. David Burdette:

So there is work being done to identify these longer term rhythms of the brain so that we can integrate them into what we're doing. So I will conclude on that note, that ultimately what EEG is is an analysis and evaluation and insight into the rhythms of the brain at the brain level, but not just the rhythms of the brain, the future would say that we are going to look at the rhythms of the rhythms of the brain, and that will inform our treatment decisions and give us greater insight into epilepsy and how we can treat it and ideally some day eradicate it.

Dr. David Burdette:

Thank you.

Dr. Laura Lubbers:

Thank you Dr. Burdette, that was fascinating. It's so helpful to understand the basics of the EEG, but to think about where we're going as a community is really exciting, that we can be much more sophisticated about the way we try to help people. So thank you so much for that information. We'll now go ahead and start the Q&A session, and again, if you're in the audience and you have questions, please submit them in the Q&A tab located at the bottom of your Zoom panel, click send, and we'll do the best we can to get through as many of them as possible. Again, we had a number of questions already submitted, so we'll start with those.

Dr. Laura Lubbers:

So Dr. Burdette, one of the questions, first question is, how often should a patient get an EEG if the EEG has been shown to be abnormal? At what point do you elect to have a 24 hour versus a 60 minute sleep deprived EEG?

Dr. David Burdette:

That is an interesting question for which there's not necessarily a right answer or a wrong answer, but I will give you an answer, and that is why do we get an EEG? If someone has what I would consider a prototypical seizure, if it walks like a duck and quacks like a duck it's probably a duck. And if someone has seizures that walk and quack like seizures, they're probably seizures. And if they walk and quack like a focal seizure, what we used to call a partial seizure, then I'm going to treat it as a partial seizure. I may not even need an EEG with which to do that.

Dr. David Burdette:

I'll get an EEG, just a one off type EEG to make sure I'm not just totally out to lunch, but that EEG may end up being normal and that person may probably still have seizures. So if they respond to the first medication that I try, as many people do, arguably 47% of people do, then that's great. There is no compelling reason in my mind to repeat that EEG. If however that person doesn't respond to the first medication, I'll usually have a plan B, so we'll try the plan B. If that doesn't work, I need more information.

Dr. David Burdette:

I need to get some insight into how that person is doing, so I may get a sleep deprived maybe two hour long EEG so that way I can see those brain waves when they're awake, drowsy, and asleep. Because often times we need that sleep in order to really see the rhythmicity of the brain and for me to figure out ah I was wrong. It was walking and quacking like a partial seizure, but in fact it was a generalized seizure and I chose the wrong medication.

Dr. David Burdette:

So ideally that doesn't happen, but it could. And so in that instance I would get a sleep deprived EEG or I might get an ambulatory EEG. So over 24, 48 hours, I can see that waking, drowsy sleep rhythmicity and see what's going on. If the individual still has seizures, or the sleep deprived EEG and the ambulatory EEG are unhelpful, then I will have the person come into the epilepsy monitoring unit. The place in the hospital where the healthiest people are, and we bring them in, it's the one time in your life we want you to have a seizure, so we crash the person off their medications, sleep deprive them every other night, and ideally record a seizure.

Dr. David Burdette:

So that is a typical progression from an epileptologist perspective. I am generally not a fan of say every six month EEGs, or annual EEGs in adults. In children however, there are forms of epilepsy, many of which are genetically determined that may appear in childhood and the person may outgrow them. And so then, serial EEGs are necessary to identify that progression. So I would say in brief, it depends. I know it's not a great answer, but it depends. And if your seizure is of a type that requires the every six month, then so be it, but the majority of adults, and I see predominantly adults, I see some kids, but predominately adults, do not require every six month EEGs.

Dr. Laura Lubbers:

Thank you so much. I think that really helps explain the differences and the progression of approaches that epileptologist may use to help assess somebody, and it actually addresses some of the other questions that had come in around when should a patient be hospitalized for an in-patient EEG. So thank you for that extensive explanation.

Dr. Laura Lubbers:

Another question, regarding the rhythms that you showed at the end of the presentation, are those in epileptic patients only, or do we know whether healthy patients have similar multi day rhythms?

Dr. David Burdette:

There will be an element of speculation to my answer because we don't know. But I don't think it's too much of a leap of faith to say that though that multidian variation, the diurnal variation that we see in tendency towards seizures and therefore seizures themselves, is being driven by a rhythm that is intrinsic to the brain itself. So in essence, the likelihood is that seizures or no seizures, epilepsy or no epilepsy, we all have those rhythms. How they manifest though is difficult to say unless you have seizures.

Dr. Laura Lubbers:

Okay. Very good. Still lots to learn about our rhythmicity.

Dr. David Burdette:

Yeah. A famous neuroscientist once said that if the brain were simple enough to understand, we would be too simple to understand it.\* (Note nice quote) We're trying to understand ourselves, which is incredibly hard to do.

Dr. Laura Lubbers:

Very good point. So here's another question. Can you explain subclinical seizures and EEG signatures that are called PLEDs, burst, and birds? This is a very detailed question about these different signatures.

Dr. David Burdette:

So we'll start with subclinical seizures. Seizures, you typically divide into generalized seizures where one second the brain is fine, boom, next second both hemispheres are going. And we have focal seizures. And focal seizures are, as the name implies, going to start focally in the brain. You've probably heard this notion that we only use ten percent of our brain. If we could use 90% we could telekinesis, we could do whatever. Who knows, maybe people could telekinesis, I wouldn't know. But I do know that we use our entire brains. We know from a PET scan, a PET scan will light up the glucose metabolism the brain cells that are working, and the whole brain lights up.

Dr. David Burdette:

So we're using our brain, it's just we can only define what 10% of the brain does. When I do brain mapping on someone in anticipation of epilepsy surgery, 90% of the parts of the brain that I map I can identify nothing that happens when I stimulate it, and the person with epilepsy cannot identify that I've done anything. So 10% of the brain is what we call eloquent.

Dr. David Burdette:

If you have a seizure in eloquent cortex it's going to cause a symptom. If you have a seizure in a part of the brain where it would be active if you heard an oncoming train, then when you have a seizure you're going to have an auditory hallucination of an oncoming train. But for 90% of the brain, if the seizure starts there and stays focally there, then there's a reasonable chance you're going to have no symptoms. So we would call that a subclinical seizure. We can see it on the EEG, particularly if we're recording from directly within the brain itself. A seizure is happening, but it is subclinical, it's causing no symptoms.

Dr. David Burdette:

With PLEDs, PLEDs or LPEDs, we change the name sometimes but it's the same phenomenon, this is a sign of excited brain. So if either some badness happens to the brain, a stroke or something like this, then the area around the stroke will have excessive excitability. Or, if someone has known epilepsy, and they go into that status epilepticus I mentioned, one seizure after another after another, then the excitability of the brain really goes up in that area, and the end result is that the brain keeps pushing toward a seizure. So it pushes toward a seizure causing boom, a burst of activity that then shuts down that part of the brain for a second as it recovers, and then it happens again, boom, and then it shuts it down, and then boom.

Dr. David Burdette:

So you'll see it's periodic, so it's like a metronome, fires, fires, fires, fires, it's lateralized, it's over one half of the brain, epileptic form discharges. So these are boom, boom, boom, this is a highly epileptogenic state, but it is transient. So once you correct whatever is the underlying issue, it should resolve.

Dr. David Burdette:

Bursts, I believe you said bursts, was that correct? Bursts are a more descriptive term. So brains going, there's a burst of activity, kind of like we saw earlier in my presentation where it's burst, suppression, burst, suppression. So that is a descriptive term that is applied to any sudden outpouring of electrical activity within the brain, and we will see that in a broad array of clinical situations from burst suppression to various epileptic or epilepsy related phenomena, and its in essence this large outpouring of synchronous brain activity.

Dr. David Burdette:

And then the final, birds have been applied in a few ways, but these are these brief, rhythmic discharges, intermediate birds, that are not quite seizures, but show a strong tendency towards seizures. This is a term that is most commonly used in neonatal EEG where in adults, I have life easy, I see the brain waves going along, I see a burst of activity, looks like a spike, we call it a spike.

Dr. David Burdette:

In the neonatal brain, their brains are active, they're developing really fast, they get these spikes all the time and they can be normal. So to try to differentiate these bursts of activity from the normal to the abnormal, then we come up with various descriptors to say well, if you see those spikes but they're rhythmic and they last a certain period of time, then that is more worrisome for seizures. So that is most commonly how birds are used.

Dr. Laura Lubbers:

Thank you, thank you for those descriptions. Another question, how sensitive are ambulatory EEGs? Is there a difference in the ability to pick up seizures between ambulatory versus in patient monitoring?

Dr. David Burdette:

Ambulatory is more sensitive than a routine EEG. A routine EEG, 20 to 30 minutes. What are the odds that we're going to pick up some abnormality in 20 to 30 minutes? Well it depends how active someone's seizures are. If they're having a seizure every five minutes, we'll probably pick it up in a 30 minute EEG. Most people, however, are not. Most people have more widely dispersed seizures and therefore, by extension, more widely dispersed abnormal bursts of activity, those spikes, whatnot, that we associate with seizures that we will use in making clinical decisions.

Dr. David Burdette:

So the longer we can record an EEG, the greater our likelihood of coming up with an answer that will inform our treatment options. So a 20 to 30 minute EEG gives us some information. A 24 hour EEG gives us much more information because we see those brainwaves wakefulness, drowsiness, stage one, two, three, four, and REM sleep. So then the next step is the epilepsy monitoring unit. If you go into an epilepsy monitoring unit and there are no medication changes made, you might as well have it done at home, because you're less restricted at home.

Dr. David Burdette:

But typically what we do in the epilepsy monitoring unit is we are evaluating situations where the ambulatory EEG didn't give us the answers we needed. So what the in-patient epilepsy monitoring unit EEG allows us to do is to take you off of medications, and in essence not necessarily to induce a seizure, but to remove your protection from seizures so that we can record an actual seizure. That would be dangerous to do in many situations at home because there are risks of having multiple seizures. You could go into status epilepticus, you could god forbid have sudden unexpected death from epilepsy, it's a scary situation. But in the hospital it's a monitored situation. An EEG tech is watching the screen 24-7 and when a seizure happens boom, they push a button, nurses come running, they give medications to abort the seizure.

Dr. David Burdette:

But that's the main difference is ambulatory EEG you're probably on medication, in the epilepsy monitoring unit we're taking away the medication. So it's a dicier situation.

Dr. Laura Lubbers:

Thank you for that. Well I have one more question, how do I know if my doctor knows the latest about performing an EEG? Are there any questions I can ask?

Dr. David Burdette:

I would ask did they do an EEG or epilepsy fellowship. So when someone goes into training in neurology, you do your internship right out of medical school where you get some basic training and learn more about treating patients with various maladies of some sort. Then you do your neurology residency, and you focus in on just brain, spinal cord, nerve, and muscle related issues, and you really cut your teeth on the neurology area of the brain. And part of that is that you learn some basics of EEG, and you learn the basics of taking care of a broad range of issues from Parkinson's disease to tremors, to peripheral neuropathy to epilepsy.

Dr. David Burdette:

So typically someone develops seizures, they often will start with seeing a neurologist. And frankly, the majority of people do very well with seeing a neurologist. If, however, a person continues to have seizures, then it is time to move it up a notch. And that next notch are neurologists that did extra training for one or two years in either clinical neurophysiology, EEG, or in epilepsy which also includes an EEG component. And so that by itself means that that person is going to have a greater level of comfort, more in

depth knowledge of seizures and epilepsy related issues, and then you can see, if your provider is board certified.

Dr. David Burdette:

Board certification will establish that that person has a minimal amount of knowledge. It doesn't say that they're the greatest thing since skim milk, but it assures some degree, a minimum level of competence. And so I think I tend to check if my doctor is board certified in the area that I am seeking their opinion. That having been said, some of the best epileptologists I know have never taken a board exam. Because you don't have to take a board exam to practice epilepsy.

Dr. David Burdette:

So I would say the commonality is if your seizures are well controlled, and by well controlled I mean you are seizure free, then your general neurologist is more than adequately capable of taking care of you. If you are still having seizures, one a month, one a week, one a day, one a year, and adjustments are not effective, then it is time to seek opinion from a specialist and that would be someone who has done that extra training, and then if that doesn't work out, you kick it up a notch and you see someone who is in an NAEC level four epilepsy center. So that's the National Association of Epilepsy Centers. They have a certification process whereby they will evaluate who the epileptologists are, the neuropsychologist, the nurse practitioners, the entire epilepsy team, and do they have all of the credentials that indicate them to be highly competent in their field, and if they do they will give those individuals a level three or the highest level is level four designation. And if you're having ongoing seizures and have tried multiple approaches, then ultimately you want to end up at an NAEC level four center.

Dr. Laura Lubbers:

Great advice. Thank you so much for sharing your knowledge and your expertise about EEG technology. Truly appreciate your time and we also appreciate the support for the Band foundation for providing the opportunity for us to host this today. I'd also like to thank the audience for your great questions and tuning in regularly.

Dr. Laura Lubbers:

If you have additional questions about this topic or wish to learn about any of CURE's research programs or future webinars, please do visit our website at [www.cureepilepsy.org](http://www.cureepilepsy.org). Also please do stay tuned for an announcement of our future webinars as part of our leaders in epilepsy research webinar series.

Dr. Laura Lubbers:

Thank you again Dr. Burdette, and thank you all.

Dr. David Burdette:

And thank you, you guys are doing incredible work, thank you for that. That is huge. Thank you.