CineECG vs. 12-Lead ECG: A Comparative Exploration of ECG Approaches

Announcer: Welcome to Mayo Clinic's ECG Segment: Making Waves, Continuing Medical Education podcast. Join us every other week for a lively discussion on the latest and greatest in the field of Electrocardiography. We'll discuss some of the exciting and innovative work happening at Mayo Clinic and beyond with the most brilliant minds in the space, and provide valuable insights that can be directly applied to your practice.

Dr. Kashou - Welcome to Mayo Clinic's ECG Segment Making Waves. In this episode, we will delve into the intriguing world of Electrocardiographic approaches, comparing cineECG with the conventional 12 lead ECG. We're honored to have Dr. Peter van Dam, a distinguished expert and innovator in the field. Joining us as our esteemed guest today, Dr. van Dam was born and raised in the Netherlands. He has a global outlook on his work, and you're gonna be really fascinated to see the work he's done. He began his career as an electrical engineer at Vitatron a pioneering Dutch company known for pacemaker innovations. And following Vitatrons acquisition by Medtronic led by a fellow Dutchman Earl Bakken. Dr. Van Dam transitioned from development to research specializing in signal processing and computerized modeling. Under the guidance of renowned expert Adriaan van Oosterom, Dr. van Dam focused on advancing practical clinical applications of inverse cardiac modeling, optimizing algorithms in reducing the number of electrodes in the 12 lead ECG configuration to 9. Alongside his research, Dr. van Dam is an entrepreneur who established his first company 15 years ago through a combination of cutting edge ECG based diagnostic solutions and collaborations with universities and scientists worldwide. Dr. van Dam's technologies are introducing novel approaches for ventricular ablation planning and enhancing ECG-based diagnostics. Today we're fortunate to have Dr. Peter van Dam, the visionary behind ECG excellence in their pioneering cineECG technology joining us to discuss this further. Dr. van Dam, thank you for joining us again today.

Dr. van Dam: Thank you very much. I'm really pleased to be again on your show.

Dr. Kashou: You know, we spoke to Dr. Gorgels recently, We had you on earlier, and I, I really enjoy the work that you're leading your whole team is doing and I know it, it, it gets a lot of excitement especially at the, the ISC meetings. So I'm glad to have you back and just share a little bit of your work and what's been going on. So I guess before we even get going, maybe our audience you could tell them what really fascinates you and drives you in your work, particularly in the realm of 12 lead ECG.

Dr. van Dam: Yeah, thanks for this question and also thanks for being on this platform. Again, as a kid already, I always asked why apparently that's what drove me into technology. Why does it work like this? Why does it work like that? And during my engineering, my first internship was already in the medical hospital, the university hospital. And basically I was always trying to connect there. I I really loved to work in a medical field and I did. Then also my bachelor's also did my, no, yeah my civil service. So instead of military service, my my civil service in, in the same hospital. And then a couple of years later I got a job at Vitatron Pacemaker Company, also owned by Medtronic. And they gave me basically a lot of opportunity to ask a lot of whys why does the heart the way it works? But also I was allowed to do a, a master again they sponsored

my whole study and that's where I met my supervisor, Adriaan van Oosterom where I did then also my master trying to simulate Electrograms from the atria which nobody had done with his cardiac model. And I thought, that's good for developing algorithms for pacemakers. And one of the things I've been doing there too is really program pacemakers, design them, system designs and design also the algorithms inside the pacemaker. Then in 2008, I was already on my way doing my PhD asking still more whys the company got sold or basically got killed by Medtronic, said we don't need this Dutch company anymore. And by that time my whole career was already shifted towards the ECG because that's what Adriaan van Oosterom was interested in. So I started my own company first developing ECG SIM in another time. So that's educational software with which you can manipulate the electricity of the heart and then see what it does to the ECG wave form. So simulating ischemia, PVCs, those kind of things. So cause effect, and this is what you also need in an inverse procedure where you have the body surface map or the ECG electrodes on the and you want to know what happens inside the heart. So you try to get inverse into the heart basically developing that kind of technology. I've, I've been developing tools and tools and then met the Dr. Michael Laks, the founder of ISCE and he got me to the UCLA and that's where I started to conduct my research in the cath lab running in and out and asking time, how does this work? Why do you do this, why do you do that? And from that, more and more algorithms started to develop because of Vitatron. I was used to writing patents. So I kept that tradition basically in and now I'm here the founder of ECG Excellence and and cine ECG, the simplest inverse basically. It's really fascinating to see and you know how you started as a child asking why and it's the question that we continue to ask. And I think what we'll start to see in some of the things we'll talk about is how cine ECG can help us to understand why.

Dr. Kashou: And so, you know in the context of utilizing this 12 lead ECG to assess cardiac electrical dyssynchrony and identifying disease pathways through ventricular depolarization how do you actually accomplish this and, and what are the potential benefits that this can offer clinicians?

Dr. van Dam: Again, a great question and happy to answer that. One of the key aspects of inverse cardio modeling is to create a sort digital twin. Hey, basically everybody, every every physician has that in his head. But now we want to create this in, in a computer. Basically I try to model the cardiac activity. I try to simulate how much current is produced by the heart or I try to, and the try to estimate where is this activation actually located in the heart? Let's take a PVC. It starts in one point, so that's where it then should start and it ends at the other side of the heart. And that's what this line should represent how this average activation travels through the heart. For PVC, it's very clear but you can do this and that's what I found out building it you can also do that for all kinds of patterns and activation patterns, including conduction disorders and therefore also dyssynchrony. If you have a part of the hiskingia system that breaks left bundle then the activation starts in the right chamber and it should move to the left. And that's exactly what cine ECG shows first moves often a little bit towards the apex. So it's activating from the right free wall moves towards the apex and from the apex all up to the left base. And that's basically what exactly what this mean line shows it shows an activation starting in the right chamber and ending in the left. So you have a visual connection you have an anatomical connection. 'cause the, all these kind of models that are in in KO's head for instance, or Michael X they visualize that mentally but could not quantify it. The nice thing about a computer model is that you can quantify it now I can say how far it starts in the right or how far it ends up in the

left. So how dyssynchronous is it? I, I've seen left bundles where where the cine ECG stays close to the septum probably tells you that there's maybe some activity still in the left chamber, just delayed. All these kind of things are a big question at the moment which I like a lot of wise, why does it stay there? But there is potential in it to tell how this synchronous is this hard left, right, right, left. But we are are focusing here on the synchrony measures and and that's what I'm with several groups in in London, Ontario, Prague here in Krakow want to develop. How can we determine this thing the synchrony measure from right to left.

Dr. Kashou: I guess for our audience that's not really familiar with it and I'm sure I I have a lot to learn. Maybe you can kind of convey again what the cine ECG is in this approach and then how it actually differs from the traditional conventional 12 lead ECG that so many of us are, are used to in, in daily practice

Dr. van Dam: The cine ECG uses the, the electrocardiogram the vector cardiogram tells you the the direction of activation over time. So at at one it tells you at one millisecond I always count a milliseconds at time one millisecond it tells for a normal activation, for instance, it goes transseptal. Usually that's very small. So you, you will not see the initial factor 'cause the amplitudes are so small. What cine ECG does is I don't care about the amplitude I just care about the direction and I just take a fixed step in that direction. So let's say one millimeter each time step. So if this very minute vector points transseptal and the next one too, and the next one too it'll travel by that through the septum. Then what you normally see is that it bends back to the left mass. That's where the most masses. So you get a kind of phi, so activating transeptal then back to the left because that's where the most masses so the average activation is somewhere in the left cavity and then the T-wave goes always to the apex. What you see in in standard ECG interpretation is you look at the frontal axis you look at cure duration, but you don't take most people do not take the horizontal plane into account. And so from a vector direction the third dire dimension is often not used because of this pro proximity effect. How do you compare ECG signals and horizontal plane to the frontal plane signals go much further away. That's what what seen ECG combines heuristically but very effectively. And then there are a bunch of ECG criteria with does it have slurring, does it have notching? Those kind of things. Then can tell indirectly that there is conduction delay or and or if there is scar. This is basically what you see with, we've seen ECG, it's I I recently saw an ECG where there was a mid septal scar and what you now saw is that it starts on the right side. So probably the right bundle, we don't have proof. The right bundle activates first, then it moves to the left and then terminally it activated the septal from behind. Is this the truth? I don't know, but this, this is the kind of story you can tell to see ECG that's impossible from an ECG. You need a lot of fantasy for that. You're essentially taking the data from the, the 12 lead and using it to create this vector cardiogram that looks at kind of gets rid of all the amplitude and just focuses on what is the direction and what is that direction over the time course and kind of maps it out.

Dr. Kashou: Okay, yes, maybe I'm getting my my head around it now. So now if, if we continue with that and now that we see there is value in it, it's it's different than the standard 12 lead and what that can offer and adds another dimension. Now, when you compare this approach to the utilization of ai artificial intelligence for improving ECG interpretation what are the key similarities and differences to the cine ECG?

Dr. van Dam: Well, the, the, the, the major one is really that you try to build a digital twin of this patient. So cine, ECG at the moment uses an a, a generic heart. And with that you can already tell a lot left, right? Similar things you could do with artificial intelligence. But if the, if it's just ECGs, basically it can only tell look at this segment because based on this segment I say this is AF or this is ischemia or this is a left bundle. You still have to interpret it to the anatomy. That's something also AI cannot do or you have to learn it but how there's no mathematical way. It, it, it's just association you can make just like what a physician does in his head. Whereas this model really says, okay this is the activation so it it must be on the right or it must be on the left. If somebody has a dilated left heart, yeah, then cine ECG will be somewhat off, but still this curve will be more or less correct. And you just understand that if that's dilated that it moves more to the left for instance. Those kind of things you cannot get from, from ai. It's just the patterns that are there that it can tell just like chat GBT, you're just, there are millions of ECGs so perfect, but then you have to have good gold standard data. So all these mo millions of ECGs have to have some kind of reference, this is this and this is that. And we know already that the ECG is not qualified that good. I prefer to build this with this modeling even further. And then I would like to use AI because if I use cine ECG and now AI tells me, look at this segment I can immediately relate it to the, to the heart. And then AI might even be helpful telling you now it's maybe not really this left side, it's, it's more the the inferior part of the heart that causing this. This is where I think AI helps, but just taking only the ECG, I think it'll be only telling you this is the pattern that's associated with this, but I don't know why.

Dr. Kashou: You think of it when we build some of these models, we're taking, you know a number of ECGs and you using it to whatever we consider the gold standard is. But you're right, it that's a challenging process. You know, which ECG we choose is challenging. There's subjective measures that go in it and and so it leads a lot of variation and and even getting quality data can sometimes be an issue. And looking at the, the signal to noise ratio instead you're essentially from what I I'm understanding you're starting with the why just how we started this episode and you know how you're raised is you start with the understanding the explainability and then you go to the, the application. Is that what you would say? Or maybe I'm not characterizing

Dr. van Dam: No This that's exactly right. You, you you want to, if I can explain it, then AI can help. Mm. That, that's what I think. But if you, you, you start phishing with ai you only will find patterns but it'll not help you to explain why this is a G wave form is this disease. And my big firm guess is that basically every typical ECG waveform has at least two diseases. I, I'm not sure, but that that's a kind of rough approximate. So you need some extra information to tell is it this one or is it this one? And maybe there are some that are even have three waveform three diseases. So you need anyhow extra information. So one of the things that I would really love to have is always 3D dimensions of the body. There's really a huge difference. If there is an an an, an 80 90 kilo guy like me lying under the camera, under the ECG or a tiny woman of of 50 kilo or or 300 pounds, there is a difference. And if you can take that into account then AI again is perfect because that's the kind of stuff AI is good in multimodality. So I, there's definitely room for, for ai but I would say you want to know why and then we can use really AI to to answer those why's for this patient.

Dr. Kashou: I, I like that your understanding instead of the associations going with the cause and the effect the understanding of the why which helps us understand some of these models. And, and I really appreciate you, you know, using that. 'cause sometimes it could be easy to look for associations but you know for adoption to practice that sometimes be becomes an issue. So now as we wrap up here we had the privilege of gaining insights from Dr. van Dam again, he's back here and hopefully we have him again. He's a visionary in the 12 lead ECG field. And so stay tuned for a lot of the stuff he has coming out. He shared his expertise on assessing cardiac electrical dyssynchrony and identifying disease pathways. And we're just touching the iceberg on that. We explored some of these innovative approaches, the cine ECG, that's he's the visionary behind discovered those unique differences between the traditional conventional ECG and some of the similarities. And we also looked a little bit behind AI and how that can help us perhaps even after an add to what his work has done. We extend our heartfelt gratitude for Dr. van Dam for joining us again and providing his invaluable knowledge and we hope to have him back in the future. Thank you. Thank you for joining us today.

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