ECG Making Waves: 3D Visualization of the Heat in Immersive Technology Like Mixed Reality

Announcer: Welcome to Mayo Clinic's ECG segment Making Waves Continuing medical education podcast. Join us 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. Anthony Kashou: Welcome to Mayo Clinic's ECG segment making waves. Today we're diving into the world of cardiac anatomy and electrophysiology through the lens of innovative teaching methods and technologies. While traditional methods of teaching often rely on textbooks and lectures, there's immense value in using three dimensional and mixed reality technologies to enhance understanding. These advanced techniques provide real time immersive insights into the heart structure and function. We're fortunate to have with us, Dr. Klaudia Proniewska with us today, who will guide us through her research and experience on this topic. Dr. Proniewska completed her PhD in bio cybernetics in biomedical engineering at the A GH University of Science and Technology and Krakow. Her research journey includes prestigious internships at the ThoraxCenter Heart Disease Center, in Erasmus mc in Rotterdam in the American Cardiovascular Research Foundation in New York. Currently, she is a researcher and deputy director at the Center for Digital Medicine in robotics at the Jagiellonian University Medical College in Kraków. Dr. Proniewska is a pioneer in the field of mixed reality for medical education, leading several projects to integrate 3D visualization and immersive technologies into teaching cardiac anatomy and electrophysiology. Dr. Proniewska, thank you so much for joining us today.

Dr. Klaudia Proniewska: Thank you for your invitation.

Dr. Anthony Kashou: Oh, it's such an honor and what you're doing is exciting, but let's go back and start with the basics and you can bring our audience up to speed. Can you explain, you know, why three dimensional structures are so important for teaching electrophysiology of the heart?

Dr. Klaudia Proniewska: Thank you for this. Question three-dimensional structures are crucial in teaching electrophysiology of the heart for several key reasons. First, I would like to say that anatomical accuracy, the heart is a three-dimensional order with the complex structures including chambers, valve and specialized conduction system. Understanding the spatial resolution ship and organization of this components is shelf for knowing how the electric electrical impulses trial through the heart. Then we are going from, for electrophysiological pathways, the pathway for electrical conductions in the heart, such as electron load or AV node, A bundle of his and percutaneous system. Vipers are naturally in 3D. So to visualize this pathways through this organs helps students understand how electrical signals propagate and how the effects of the conduction system of different parts of the hearts are working. And also we should admit clinical point of view

and correlation in this area. Many cardiac conductions and arrhythmias are better to understand from the 3D perspective. For example, origins of certain arrhythmias can be related to anatomical location with specific structures which are more accurate represented in 3D models. So to help to understand the mechanism and treatment approach such a catheter ablation for example, we should look at the structures in the heart from spatial resolution capability and then we can think about the navigation with the heart. This leads us to some kind of educational tool, advances in 3D imaging, and now we can admit about immersive technology. Nowadays I'm working on with my group in Kraków which allows us to see 3D models in 3D perspective. We as a human being, we are naturally people who are looking in 3D in our environment. So see the structures in the 3D using the immersive technologies make us more aware of 3D structures.

Dr. Anthony Kashou: That's quite unique and that, as you mentioned, our whole lives as we we see it, are are 3D, you know, and to bring that into the learning environment is quite unique. How do you see the ECG relating to heart anatomy and you know, why do you find this relationship fundamental to really understanding cardiac electrophysiology?

Dr. Klaudia Proniewska: When we think about electrical activity mapping of the heart, the ECG records, electrical impulses that trigger heartbeats, which are generated and propagated through specific anatomical structures. For instance, the P wave corresponds to atrial depolarization and sinus node the QRS complex to ventricle depolarization and then T-wave to ventricular repolarization. And according to the research we're doing under the project itm, which is interactive teaching of medical treated cardiac anatomy, anatomy supported by mixed reality, we want to visualize this correlation and disconnection. Let's focus for example on atrias and the polarization of atrias within the sinus node in its standard close to the superior vena cava junction position. The P wave on the ECG usually appears as a smooth upright deflection in lead one to A VF, often biophasic in V one and inverted in lead A VR and obviously deviations in the sinus node position extend and atrias activation side within perineal atria can significantly impact the morphology of P wave. So going to this anatomical differences in sinus node, we can see different propagation of P wave and then we can easily visualize this in 3D and dimension. We can immerse to this 3D object and look inside of the heart and also see on the top of the anatomical structure of the heart how this propagation related to specific structures in their heart are related. A shift of sinus node, for example, to the left or right as an anatomical perspective may also modify P wave morphology. So having this in mind, we can use this information in a teaching approach and show that all anatomical structures can be modeled for specific case studies and see that several scenarios for education. So we can prepare specific case studies based on retrospective data, having information about anatomy from medical imaging data, raw data like Computed tomography or MRI DICOM data from dedicated patients. And we on top of that, we have also information about ECG morphology for this patient. And using the advanced modeling and information from both medical data, so imaging and electricity of the heart, we can simulate the possibility of propagation of this wave in the heart. So going to in into the clinical settings, this integration of information from specific data ECG data with 3D - anatomical data can be used to assist for medical doctors in

planning and guiding cardiac procedures such as ablation, providing a detailed map of cardiac structures and electrical activation patterns.

Dr. Anthony Kashou: You know, that's so unique and especially as you mentioned, there's anatomic, you know, we know what normal is, what the expected normal pattern of, you know, say sinus node conduction, but there's anatomic variance in I really, it's unique to see, and we run through these all the day where there's variants of different patterns and perhaps, you know, the conduction system varies amongst individuals and we could potentially see that. And I certainly see the learning potentials of this. Have you ever implemented any of these innovative teaching methods or technologies to enhance the experience for learners today?

Dr. Klaudia Proniewska: Yeah, I have several years of this experience. I started few years ago with talking with doctors who have physicians, what is your unmet need about 3D data visualization? And the answer usually was like, how I can see 3D models, 3D relationship between organs onto this screen. That was the first thing that brought me to immersive technologies. And I start to look for possibilities on the market and how we can implement this unmet needs to first educational approach and then to clinical. So we find a solution. So you can use device glasses for immersive technologies and you can put in this 3D perspective, some anatomical models, but then when you are talking with a cardiologist, they want to know something more about electro electrical propagation and also a mechanism of the heart. So on top of that, we built a concept of new curve for our medical students. It's additional course for our students how we can implement this medical cases in the way of teaching and clinical approach. So together with our specialist from the university, we try to find the solutions between new technologies and medical approach and how to teach medical students in modern way. And we usually use problem-based learning approach. So we think about case study, what is about clinical information for this case study, also what kind of raw data we can gutter for this case study. So imaging data like was talking before, for example, MRI scans, CT scans, ECG, sometimes we have a echocardiography also for this patient. So some kind of combination of raw data for this patient and how we can build accurate model with information about the electricity of, of the heart for this case. And then we were preparing classroom because you need a spec specific, let's say an environment to, to teach in immersive technology. So we have dedicated rooms and we then gathers our students and our teachers in one space and we make a virtual room and everybody is connected in the same virtual room, let's say this way. And the see the same object in the middle of the classroom and people can go around this 3D model, can look into the model immerse in this 3D visualization of the cardiac anatomy and discuss. And this is I think, the most interesting part of this approach for education, that this interaction between teacher and students is really active, I would say it's really something they never had. And I see that they are very excited about that, that they can discuss the case study in this completely different approach with this interaction with 3D models, but also with this interaction of new technologies with this very fancy and nice for modern generation, I would say

Dr. Anthony Kashou: I'm just amazed and blown away by that. I really wish I was a, a student on the wall of one of your courses or in there. I i I know I would benefit. Now in your experience, have you found some ways that are most effective in conveying some of the complex 3D structures and the dynamic processes that we see in the art and electrophysiology to learners

Dr. Klaudia Proniewska: Conveying complex 3D structures and dynamic of processes in cardiac anatomy, anatomy and electrophysiology can be challenging for, for our medical teams and then also teachers. So to find common way to incorporate our solutions to everyday practice, we try to build interactive 3D visualization tools with some comments and annotations from our experts, our doctors, our cardiologists. So the most important thing thing is to build a platform that you can be able to rotate to visualize structures at every level of your work. So you can use this in the classroom, but also in operating theater. So this is challenging, but makes our cooperation really working. And then they see some advantages of this special relationship in anatomical structures, especially for cardiac disease, that they can use it basically wherever they want. So it makes me as a, a person who wants to deliver something which is interesting for cardiac environment, for physicians, a clear message make for us a tool, a platform and models in, in the way that they will be useful for everyday practice. Because I think this is the most challenging part of new technologies that it has to be easy to use. And also idea that person who is bioengineer or a medical physicist as a background from, and this job per perspective that is next to the doctors, that they can see what is this unmet need for everyday practice for clinicians. So we can update our point of views every day. So this close cooperation in intern disciplinary team makes our solution better every day. That, that, that would be my conclusion for what I'm doing that I really appreciate this interdisciplinary cooperation with clinical en environment.

Dr. Anthony Kashou: Wow. Thank you so much. So from education to actually practical application, but as you mentioned, the interdisciplinary relationships, what a, a blessing it is. And just to learn from each other. Today we explore the intersection of cardiac anatomy, electrophysiology, and innovative teaching technologies. Dr. Proniewska shared her insights on the importance of three dimensional structures in teaching and how mixed reality can enhance the learning experience. As we wrap up today's episode, it's clear that integrating advanced visualization tools into medical education can provide profound benefits offering immersive real-time insights into the heart's function. A sincere thank you to Dr. Proniewska for joining us in sharing her groundbreaking research and experience. Thank you so much.

Dr. Klaudia Proniewska: Thank you for invitation. Thank you Anthony.

Announcer: Thank you for joining us today. We invite you to share your thoughts and suggestions about the podcast at cveducation.mayo.edu. Be sure to subscribe to a Mayo Clinic cardiovascular CME podcast on your favorite platform, and tune in every other week to explore today's most pressing electrocardiography topics with your colleagues at Mayo Clinic.

Announcer: This has been a Mayo Clinic podcast.