ECG Diagnosis of Left Ventricular Hypertrophy

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. We're so glad you could join us today. We have an exciting episode planned for you as we look at the diagnosis of left ventricular hypertrophy by means of the electrocardiogram, the ECG. We have an expert discussant joining us who will help us better understand this important topic. Left ventricular hypertrophy represents pathological thickening of the left ventricle. Pressure overload from systemic hypertension or aortic stenosis are two of the most common causes. Identification of left ventricular hypertrophy is important as it is considered an independent cardiovascular risk factor associated with adverse clinical outcomes. Over the years, dozens of ECG criteria have been proposed to detect left ventricular hypertrophy. However, despite the routine use in clinical practice today such ECG criteria have rather poor sensitivity. And as a result, this remains an important area of research. We are fortunate to have Dr. Ljuba Bacharova here with us today to discuss this important topic. Dr. Bacharova is a senior researcher in the International Laser Center, CVTI, in Bratislava, Slovakia. As well as an instructor at Comenius University's Medical School. In 1971, she graduated from that medical school. She went on to train in internal medicine in medical informatics. And in 1986 she defended her PhD thesis on topographic presentation of the orthogonal ECG. In 2000, she received an MBA degree at the University of Leeds Business School in the UK. In 2011, she received a Doctor of Sciences for her innovative approach to the ECG diagnosis of left ventricular hypertrophy. From 1997 until 1999 and then again in 2005 until 2014, Dr. Bacharova served as the president of the International Society of Electrocardiology. From 2009 to 2015 she also served as a member of the Board of Directors of the International Society of Computerized Electrocardiology. In 2005, she became an executive editor of the Journal of Electrocardiology. Dr. Bacharova has also had a particular interest in research and her main focus is in the evaluation of the cardiac electric field with a special interest in left ventricular hypertrophy. Since 2006, she's organized the International Research Interdisciplinary Schools, the IRIS for young researchers. Dr. Bacharova, what an honor to have you with us today. Thank you for joining.

Dr. Bacharova: Thank you for inviting me.

Dr. Kashou: Oh, we're so glad to have you. You know, as I mentioned earlier, left ventricular hypertrophy, whether it is detected by ECG or echocardiography, it's an important cardiovascular risk factor. Given the low sensitivity of the ECG to detect left ventricular hypertrophy echocardiography is often a more reliable tool for us. But at the same time, we still use the ECG criteria for diagnosing left ventricular hypertrophy in everyday practice. And perhaps you could start by sharing where you see the problems in the diagnosis of left ventricular hypertrophy is with ECG.

Dr. Bacharova: Well, first I would like to thank you for including ECG diagnosis of LVH as interesting topic. Because when you were talking about it, so there are two keywords and it is the increased QRS voltage as a significant risk factor, and the other one is the independency of the increased left ventricular mass. Actually, if we rephrase it on one hand so the increased QRS voltage indicates that there is something wrong with the myocardium but at the same time it is not directly related to the increased mass. So there is something wrong, but we somehow don't know what to do. Related problem is the misunderstanding of the role of ECG in diagnosis of LVH. By principle, electrocardiography cannot measure dimensions, size, or mass as can do imaging methods. It provides information of the distribution of electrical potentials on the surface of the torso. So again, it is sort of misunderstanding or ill-state question to estimate the size of the heart by the mean of ECG. And another misunderstanding or misinterpretation is the hypertrophy as such. Because by definition it is true that it is the increase of an organ or its part, but in the case of left ventricular hypertrophy the increased mass is not a healthy myocardium. It is pathologically changed myocardium.

Dr. Kashou: Yeah, it's, you know, and so intuitively, as you've mentioned, we think of increased ventricular mass should correspond to an increase in QRS amplitude or voltage. However, we've come to learn that that's not always the case. In fact, QRS voltage seems to be not not so reliable for detecting left ventricular hypertrophy. What are some of the key factors influencing the resultant QRS voltage in left ventricular hypertrophy?

Dr. Bacharova: So we need to go back to the definition of hypertrophy. That it is increased of organ or its parts but the tissue itself is changed. And in the case of left ventricle, both cardiomyocytes and interstitium are changed, and they are heavily changed. The cardiomyocytes are enlarged and hypertrophied. The distribution of gap junctions and its amount is heavily changed. And also the Connexin 43 is pathologically changed or the expression or the functions. So regarding the interstitium, the proportion of the electrically active tissue, it means healthy or functioning cardiomyocytes and the fibrosis is changed and the amount of fibrosis increasing. And it could be diffused or it could be localized. As well, there are areas of inflammation, mostly cardiovascularly, and all these factors they influence the activation sequence during depolarization which is naturally reflected in the QRS pattern. And it has been shown in a simulation study, but also in human or animal studies, that there are two opposing processes which could influence the QRS complex. I mean the voltage. One is the amount of fibrosis where the proportion of the electrically active myocardium is reduced so the voltage can decrease, or the activation sequence is slowed and then the QRS voltage is increasing. So, these two factors are working in opposite way. So it meaning that for the ECG pattern, for Left ventricular hypertrophy, there is not one simple pattern. That it could be a variety of QRS patterns we need to decode somehow.

Dr. Kashou: Yeah, it is fascinating. You know, you think of maybe fibrotic tissue not having the same corresponding voltages that we see, but yet you still have a, you know, hypertrophied ventricle and maybe some of those patients that have an underlying, you know, disease. Whether it's from, you know, pressure overload from hypertension, or aortic stenosis, to even an infiltrative process. It looks different, but we still kind of call it, you know, a hypertrophy or, you know, increased ventricular mass. Now, I know one thing that kind of does favor the ECG

diagnosis of left ventricular hypertrophy is its relative high specificity. What are your thoughts, you know, on this spec specific aspect?

Dr. Bacharova: Yes, high specificity is sort of, yes it is true. And majority of papers, they really document high specificity. But actually the systematic review which was published in 2007, showed that actually the specificity ranged from 53 to 100. So 53, it is half of the cases. So it means, in other words, that there are there are other cardiac pathologies which could lead to increased QRS voltage. One of them is ischemia. And we know already that ischemia is present in left ventricular hypertrophy, or as a disproportion between the increased mass and the blood supply, or as a development of coronary artery disease. So this myocardium is ischemic. But independently, on the left ventricular hypertrophy, when we talk about ischemic myocardial, like in the coronary artery disease, there is a number of situation or number of papers documenting the increased QRS voltage. It is seen in animal studies, in animal models of myocardial infection, where the increased voltage was recorded during the ischemia. It is seen in stress test in clinical study where the increased QRS voltage is one of the signs of acute ischemia. And it is seen, and it was published in Emergency Medicine as a transient increase in QRS voltage that it occur in patients with acute coronary syndrome. What was interesting when reading these papers was that actually the increased voltage is considered sort of confounding factor, not a manifestation of ischemia beyond the process. So, in the case of ischemia, there is the increased voltage. It is considered confounding, or transient, or non-specific, or whatever you can call it. But actually the electrophysiological changes during ischemia, they alter significantly the electrical properties of the heart and they affect ventricle activation. Actually these changes are extensively studied in relation to arrhythmias, to ventricular arrhythmias. But somehow they are not studies studied in relation like to interpretation of the increased voltage. So this is sort of paradox which is for me as a researcher, very interesting.

Dr. Kashou: Yeah, it is fascinating and, you know, we see this still using it every day. And, you know, like you said, 53% specificity up to a hundred, but still, you know, lots of room for improvement. Now, perhaps the, the question we all wonder and hope maybe you can answer, is how do we escape from the high QRS voltage trap for making the diagnosis of left ventricular hypertrophy?

Dr. Bacharova: Well, I will start the sort of philosophical comment that we need to realize to accept the fact that you, over the years, hundred years, we develop a series of holistics of mental shortcuts for ECG diagnosis to simplify and speed the diagnostic process. And ECG LVH is a great example. But it is also known that simplified rules, they lead to systematic errors or cognitive biases. And this is actually the case with left ventricular hypertrophy. We need to realize that ECG records electrical field not the size. And we need to decode the different patterns which can occur in left ventricular hypertrophy. Because it is not a uniform anatomical or histological manifestation. So our new research, both experimental and human, needs to go beyond the estimation of left ventricular hypertrophy. But in understanding how to interpret the pattern of QRS in relation to the activation process. And in this, we have a great helper, and it is computer simulation and 3D visualization which can show beautifully how the process is how the activation is manifested and how it is reflected in the QRS pattern. So please, what we need to, hmm or what we owe to our patients, that we need to understand the altered electrophysiological property of myocardial in left ventricular hypertrophy and move beyond the

mass. Mass is for imaging methods. For ECG, it is the electrophysiology. Because we can predict the risk we can predict the occurrence of arrhythmias and those qualities which are the domain of electrocardiography.

Dr. Kashou: Yeah, I could see this is a big topic in perhaps an area that has been oversimplified and maybe we have to go back to the drawing board and see where we could, where we went wrong, and how do we actually use that. And I think you're right, some of those models that are coming out are fabulous to help us do that. Detection of left ventricular hypertrophy is important in the clinical management of our patients. However, ECG diagnostic criteria proposed are not very sensitive. And the intuitive increase in QRS voltage is not so reliable. Similar to other diagnostic tests, it's important to understand the strengths and limitations of the ECG in carrying out any assigned task. A lot of research still lies ahead in better understanding the relationship of left ventricular hypertrophy and the corresponding ECG findings. Nevertheless, we can still remain optimistic. Dr. Bacharova, thank you so much. I've learned a lot from our discussion and I'm so excited and grateful to have you on. Thank you so much for making time to join us today.

Dr. Bacharova: Thank you very much for inviting in. I am very optimistic. Because I think that actually the ECG has a great future just to learn more, not just measuring the LV mass.

Dr. Kashou: I agree. Thank you so much.

Dr. Bacharova: Thank you.

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