

ОГЛЯД ЛІТЕРАТУРИ

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CARDIOVASCULAR DISEASES: SEARCHING FOR ALTERNATIVE SOLUTIONS TO THE PROBLEM FROM A BIOPHYSICAL PERSPECTIVEGanna Nevoit^{1,*}, Kristina Poderiene², Nadiia Liulka³, Maksim Potyazhenko⁴, Ozar Mintser⁵, Gediminas Jarusevicius⁶, Alfonsas Vainoras^{7*}¹Laboratory for Automatization of Cardiovascular Investigations, Cardiology Institute, Lithuanian University of Health Sciences, Kaunas, Lithuania²Department of Health and Rehabilitation, Lithuanian sports university Institute of Sports Science and Innovation, Kaunas, Lithuania³Department of Internal Medicine and Emergency Medicine, Poltava State Medical University, Poltava, Ukraine⁴Department of Internal Medicine and Emergency Medicine, Poltava State Medical University, Poltava, Ukraine⁵Department of Fundamental Disciplines and Informatics, Shupyk National Healthcare University of Ukraine, Kyiv, Ukraine⁶Laboratory for Automatization of Cardiovascular Investigations, Cardiology Institute, Lithuanian University of Health Sciences, Kaunas, Lithuania⁷Laboratory for Automatization of Cardiovascular Investigations, Cardiology Institute, Lithuanian University of Health Sciences, Kaunas, LithuaniaORCID: 0000-0002-1055-7844, e-mail: ganna.nevoit@lsmu.ltORCID: 0009-0000-4151-0742, e-mail: kristina.poderiene@lsu.ltORCID: 0000-0002-2301-5374, e-mail: nadincardio@ukr.netORCID: 0000-0001-9398-1378, e-mail: m.potiazhenko@pdmu.edu.uaORCID: 0000-0002-7224-4886, e-mail: omintser@gmail.comORCID: 0000-0001-9205-1902, e-mail: gediminas.jarusevicius@lsmu.ltORCID: 0000-0002-5732-8520, e-mail: alfonsas.vainoras@lsmu.lt***Correspondence:** e-mail: ganna.nevoit@lsmu.lt; e-mail: alfonsas.vainoras@lsmu.lt

Abstract. Modern cardiology is rapidly developing, driven by the achievements of the technical revolution. Progress in cardiology over the past 50 years has been tremendous and obvious. The expansion of visualization's technical capabilities and the possibility of using artificial intelligence play significant roles in successfully transforming cardiology. These innovations provide diagnostic accuracy and advances in interventional cardiology. However, cardiovascular diseases continue to be a serious global medical problem. Cardiovascular diseases (CVDs) are the leading cause of death worldwide and rank first in the structure of chronic non-communicable diseases (NCDs). Because the incidence of CVDs and NCDs has reached the level of a pandemic worldwide, the search for new and alternative solutions to solve the problem continues and is relevant. CVDs continue to be a challenge for modern scientists in the biomedical field. The review is devoted to the search for new directions for solving the problem of cardiovascular diseases in the future. The aim of this study is to briefly describe the current state of development of interdisciplinary and transdisciplinary knowledge that can become the basis for further scientific research on this topic.

Materials and methods. General scientific and theoretical methods were used during the theoretical research. The review describes new areas such as quantum cardiology, magneto cardiology, the concept of biophoton signaling, and the influence of the Earth's electromagnetic fields on the pathogenesis of cardiovascular diseases.

Conclusions: 1) The biophysical direction of cardiology's development is an invariant and important direction for deepening the medical paradigm, which opens up new ways of solving the problem of cardiovascular diseases. 2) Research into the features of electromagnetic communication in cardiovascular system cells is an important task and challenge for modern scientists. This research will reveal the mechanisms of cellular integration into a single organism. 3) Knowledge of the fundamental aspects of electromagnetic communication of cells of the cardiovascular system and the whole organism will become a new basis for deepening the paradigm of the pathogenesis of cardiovascular diseases and chronic non-communicable diseases. They will allow us to reveal aspects of the electromagnetic influence of the heart on other internal organs and tissues, as well as on the mutual electromagnetic exchange of energy and information at the level

of the entire organism. 4) Knowledge of the fundamental aspects of electromagnetic communication between the cells of the cardiovascular system and the entire organism will make it possible to understand how exactly the electromagnetic parameters and mechanisms of functioning in the human body are connected with the electromagnetic parameters and chronobiological dynamics of the Earth's electromagnetic field.

Keywords: cardiovascular diseases, chronic non-communicable diseases, quantum cardiology, quantum pathogenesis, magnetocardiology, electromagnetic field of the Earth

Introduction. Modern cardiology is rapidly developing, driven by the achievements of the technical revolution. Progress in cardiology over the past 50 years has been tremendous and obvious [1]. The expansion of visualization's technical capabilities and the possibility of using artificial intelligence play significant roles in successfully transforming cardiology [2, 3]. These innovations provide diagnostic accuracy and advances in interventional cardiology. However, cardiovascular diseases continue to be a serious global medical problem. Cardiovascular diseases (CVDs) are the leading cause of death worldwide and rank first in the structure of chronic non-communicable diseases (NCDs) [4, 5]. Because the incidence of CVDs and NCDs has reached the level of a pandemic worldwide [6], the search for new and alternative solutions to solve the problem continues and is relevant. CVDs continue to be a challenge for modern scientists in the biomedical field.

Significant progress is also being made in physics. Quantum physics is rapidly developing and transforming the paradigm of fundamental science [7]. Medicine is a transdisciplinary branch of science that develops due to the emergence of new fundamental knowledge in other disciplines [8]. It is well known that physics is the science of the properties and structure of matter, the forms of its motion and change, and the general laws of natural phenomena. The emergence of quantum physics [9-11] transformed all branches of natural science, and quantum biology [12, 13] and quantum chemistry [14, 15] emerged. Therefore, the change in the physical paradigm certainly predetermines the development of medicine as well. Due to the emergence of the Standard Model [17-18], scientists in the biomedical field of the 21st century must work, taking into account modern biophysical views on the structure of matter. According to the ideas of the Standard Model, it became clear that there are quantum levels of the structure of matter [19]. These quantum levels are formed by field structures (fermions and bosons) or, in other words, electromagnetic fields/energy (Figure 1).

The substance has no atoms at a depth of over 10-19 cm. It contains only electromagnetic energy in different manifestations. These are quantum levels of the structure of matter. This is true for all matter on Earth and all living biological organisms, including humans. This scientific knowledge transforms and deepens ideas about molecular and submolecular interaction mechanisms and the human body's structure and functioning. It contributes to forming new sections and subsections in all branches of medicine, considering new ideas about the influence of quantum levels on increasingly higher levels of the human body's hierarchical structure. This is the basis for further deepening scientific understanding of the pathogenesis of CVDs. What alternative solutions to the CVDs problem are being outlined? What new promising paths of scientific research in cardiology can be determined by the progress of biophysics and quantum physics? This review aims to answer these questions and provide a brief description of the current state of development of interdisciplinary and transdisciplinary knowledge that can form the basis for further scientific research on solving the problem of CVDs.

Quantum Cardiology, or Cardiology of the Subatomic Level of the human body. As noted earlier, thanks to the progress of quantum physics, science has penetrated the depths of the structure of matter. These quantum levels are formed by field structures or, in other words, electromagnetic fields/energy. An important fact is that the quantitative and qualitative characteristics of the state of these subatomic electromagnetic structures predetermine the state of atoms and molecules in cell structures. Therefore, the course of all biochemical reactions in the cell is predetermined by the electromagnetic parameters of the

subatomic components of the atomic structure [21, 22]. It turns out that changes in the state of the quantum level entail changes at the level of atoms and molecules. The quantum level is primary, and changes in biochemical reactions between molecules are predetermined by it. Thus, it is now clear that there is a quantum level of pathology of processes that scientists must comprehend and describe. This can be called quantum pathogenesis of diseases [19]. Therefore, an important future direction for the development of cardiology can be considered the need to conceptualize the quantum pathogenesis of CVDs. Science can and should now move from describing interactions in a molecular model to developing a description of this at the subatomic and quantum levels. No matter how fantastic it may sound, it is possible and necessary to do it in the future. The possibility of this has long been demonstrated by collaborations between doctors, mathematicians, and physicists. For example, a mathematical model of viral hepatitis C has already been created [23], and so on.

What processes can be the basis for the conceptualization of quantum pathogenesis of CVDs? The phenomenon of biological life of a cell in vivo at the cellular level is realized due to the emergence of polarization/depolarization processes of membrane structures in the cell and the circulation of electromagnetic currents in cells and at higher hierarchical levels of the human body structure [21, 22].

At the molecular level, this is described in the energy transfer model from the adenosine triphosphate molecule to the biopolymer in the model with a soliton mechanism [24-26]. Therefore, the quantum level should be based on physical and mathematical models of energy transfer/redistribution between components of atoms in cell struc-

Conventional hierarchical levels of structural organization of the human body

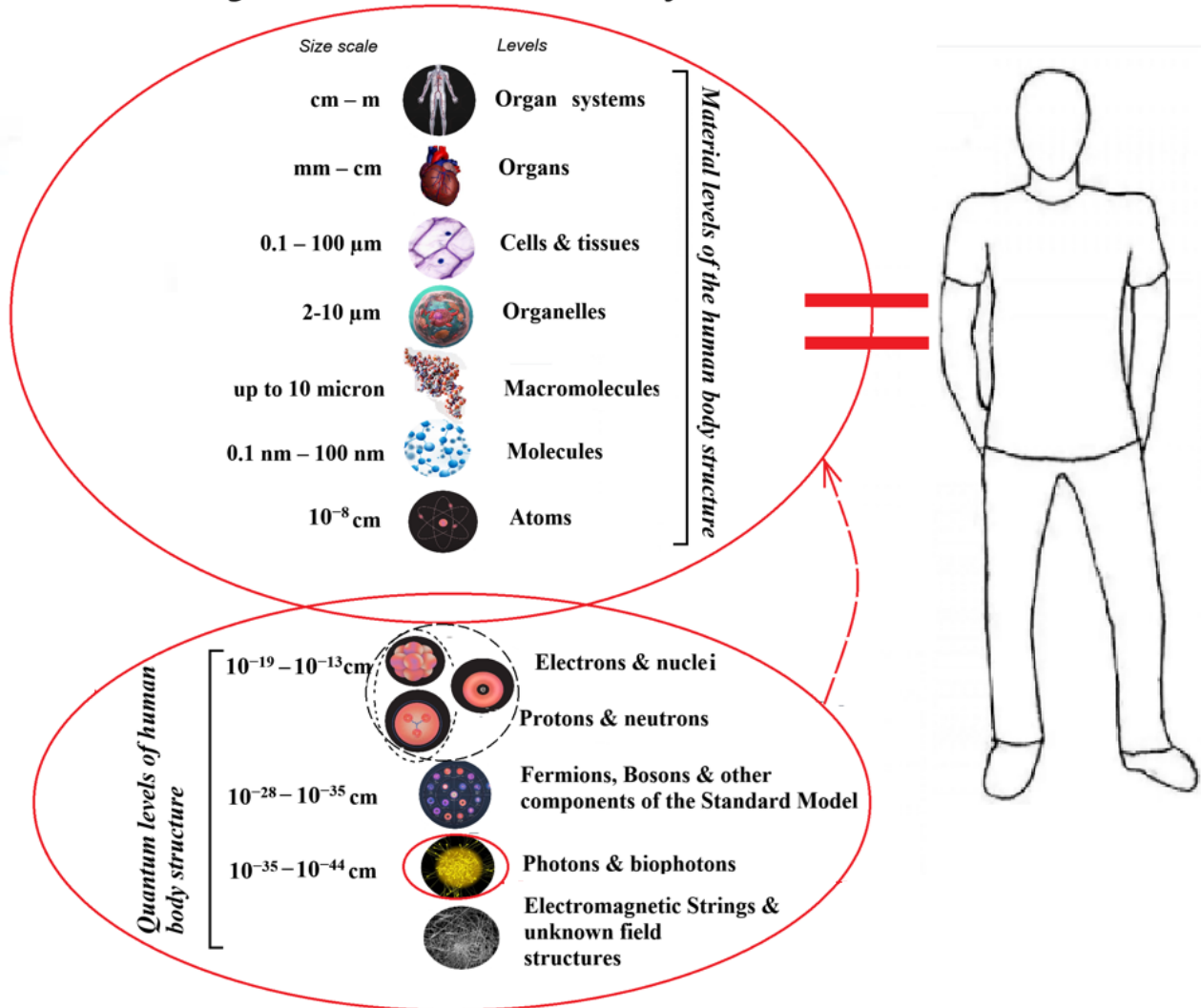


Figure 1. Scheme of hierarchical levels of human body structure. Fragment from [20].

tures. Therefore, the quantum level must rely on physical and mathematical models of energy transfer/redistribution between components of atoms in cell structures. Scientists in the biomedical field will have to develop biological concepts for describing this at the level of tissues and organs, considering medical knowledge unknown to specialists in technical specialties. Therefore, conceptualization of the mechanisms of formation and transmission of electromagnetic energy at the quantum level of cardiomyocytes should be given considerable attention. This is also because this energy transfers information due to its coherence. This is electromagnetic/biophotonic signaling of intercellular interaction [27, 28]. How does this happen in the heart? This needs to be studied in the future.

Studying the quantum pathogenesis of CVDs opens up a new perspective on tissue-level processes. Understanding that electromagnetic signal transmission occurs between cells creates a different perspective on the role of

the intercellular and intracellular matrix in these processes. Why? Because the transmission of an electromagnetic signal depends on the state of the environment in which it is propagated. Changing the quantum-mechanical characteristics of the cell matrix and intercellular space changes the transmission of an electromagnetic signal [29]. What does this mean? For example, consuming large amounts of preservatives and other chemicals with food will lead to their excessive entry into the intercellular space. Will these “foreign to cells” change the quantum parameters of the intercellular environment? They are expected to change, and if there are many of them, they can become an obstacle to transmitting the electromagnetic signal of communication within and between cells. What will be the result of this? This will lead to the cells “under-receiving” the electromagnetic signal or being distorted. As a result, coordination of metabolic reactions will be observed, and the cell will begin to function differently [29]. This is one

possible description of how quantum mechanisms can be integrated into the concepts of disease pathogenesis.

Mitochondria play a significant role in the quantum pathogenesis of CVDs. The study of mitochondrial dysfunction is at the forefront of modern cardiology and medicine in general [30-33]. The role of mitochondrial dysfunction in the mechanisms of influence of risk factors for the development of CVDs has been conceptualized [34]. The role of mitochondrial dysfunction in the development of such leading pathological syndromes of CVDs as endothelial dysfunction [35], chronic inflammation [36, 37], and dyslipidemia [38, 39] has been proven. Mitochondrial dysfunction is an important etiological factor in the development and progression of atherosclerosis, destabilization of cholesterol plaques, and the development of CVDs complications [40-43]. Therefore, a detailed study of the role of the intercellular matrix and aspects of electromagnetic signal transmission/biophoton signaling in the cells of the cardiovascular system may open up a new understanding of the quantum pathogenesis of hypertension, coronary heart disease, and arrhythmias.

Magnetocardiology. The heart is the organ that generates the strongest electromagnetic field in the human body [44, 45]. At present, significant scientific material has been accumulated, which is the scientific basis for further progress in the field of magnetocardiology [46, 47]. Modern progress in quantum physics, Field Theory, the conceptualization of the Magnetochemical Theory of Metabolism and Life [21, 22], and the creation of the concept of biophoton signaling [29] open up new perspectives for interpreting the obtained results of magnetocardiography. In the future, it is necessary to expect the results of decoding the information contained in the magnetic component of the signal from myocardiocytes. There is no doubt that the information is there. This is confirmed by the works on the analysis of heart rate variability [49-52]. Therefore, the fact that the heart's electromagnetic signal relates to the human body's systemic information processes is proven. Understanding its information role in the human body is very important. This will open new paths to understanding the essence of intercellular communication at the organism level. This will be important for deepening the understanding of the fundamental mechanisms of the functioning of the cardiovascular system in normal conditions and CVDs.

CVDs, NCDs, and the concept of Biophoton Signaling. Except for congenital pathology, CVDs never occur in the human body instantly. The occurrence of CVDs is preceded by a period of varying duration of metabolic disorders/metabolic patterns against the background of dysfunction of other internal organs. This period, which forms the pathogenetic basis for the clinical manifestation of CVDs, was called the period of action of risk factors in the Theories of Cardiovascular Continuum [53-55]. This indicates that the pathogenesis of CVDs is associated with the functional state of the organs and systems of the human body. The study of the pathogenesis of CVDs at the present stage allows us to assert that the continuum of CVDs is associated with other NCDs and is part of it [34]. Each person has their continuum of NCDs, the manifestations of

which are determined by the combination of their pathology of organs and systems. The existence of anatomical, neuro-reflexive, and biochemical connections between organs is scientifically proven. Now, thanks to the progress of physical knowledge, electromagnetic communication has been proven [27, 28]. The concept of biophoton signaling complements the mechanisms of biochemical and electrical communication between cells, tissues, and organs [56]. Understanding that tissues and organs exchange electromagnetic energy and information can radically change our understanding of the pathogenesis of CVDs and NCDs. The laws of quantum physics and Field Theory are universal. They also operate in the human body. Each cell and organ generates electromagnetic fields with different electromagnetic power, density, and frequency parameters. Therefore, there are patterns of how this electromagnetic energy generated by tissues and organs is redistributed in the human body. These patterns should be studied in the future. The discovery of these patterns will form a different in-depth view of the pathogenesis of CVDs, NCDs, and comorbidity from the position of biophysical concepts of biophysics and magnetobiology in particular.

CVDs and the Earth's electromagnetic field: search for new mechanisms of pathogenesis. Thanks to the progress of fundamental physics, the human body can be represented in several physical models. According to the Standard Model, the human body is a conglomerate of electromagnetic fields at the micro level of its structural organization [21, 22]. The human body is a multi-hierarchical system of many oscillatory circuits [21, 22]. The human body is a liquid crystal system, the semiconductor properties provide unique possibilities for transmitting an electromagnetic/biophotonic signal at various hierarchical levels of its structure, and so on [21, 57]. All physical models characterize different biophysical aspects of the manifestation of the phenomenology of biological life, are comparable with similar models of other biological organisms, and correspond to the universal laws of nature. Electromagnetic mechanisms are the universal basis for the phenomenon of biological life on planet Earth. Therefore, it is quite logical that there is a scientifically proven connection between electromagnetic processes in the human body and electromagnetic processes at the planetary level. It has been scientifically proven that the Earth's electromagnetic field is an important external component for the implementation of magnetochemical processes of the phenomenology of biological life [58-61].

Dynamic changes in the parameters of the Earth's electromagnetic field affect the processes of cellular metabolism [61-65]. Initially, the existence of so-called me-teosensitivity in some people was confirmed [65]. Now, thanks to technological progress and the creation of a system of magnetometers, it has become possible to study the relationship between changes in the parameters of the Earth's electromagnetic field and the functioning of the human body [66]. The correspondence of the frequencies of the Earth/Schumann resonances to the frequencies of the brain has been proven [67-70]. The high level of coordination of the functioning of the cardiovascular system

by the brain explains the connection between the indicators of the Earth's electromagnetic field and cardiovascular disease)___ future.

Conclusions.

1) The biophysical direction of cardiology's development is an invariant and important direction for deepening the medical paradigm, which opens up new ways of solving the problem of cardiovascular diseases. 2) Research into the features of electromagnetic communication in cardiovascular system cells is an important task and challenge for modern scientists. This research will reveal the mechanisms of cellular integration into a single organism. 3) Knowledge of the fundamental aspects of electromagnetic communication of cells of the cardiovascular system and the whole organism will become a new basis for deepening the paradigm of the pathogenesis of cardiovascular diseases and chronic non-communicable diseases. They will allow us to reveal aspects of the electromagnetic influence of the heart on other internal organs and tissues, as well as on the mutual electromagnetic exchange of energy and information at the level of the entire organism. 4) Knowledge of the fundamental aspects of electromagnetic communication between the cells of the cardiovascular system and the

entire organism will make it possible to understand how exactly the electromagnetic parameters and mechanisms of functioning in the human body are connected with the electromagnetic parameters and chronobiological dynamics of the Earth's electromagnetic field.

Prospects for further research. To continue to investigate the biophysical direction of cardiology development, which is an invariant and important direction of deepening the medical paradigm, which opens up new ways to solve the problem of cardiovascular diseases.

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СЕРЦЕВО-СУДИННІ ЗАХВОРЮВАННЯ: ПОШУК АЛЬТЕРНАТИВНИХ РІШЕНЬ ПРОБЛЕМИ З БІОФІЗИЧНОЇ ПОЗИЦІЇ

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Резюме. Сучасна кардіологія стрімко розвивається завдяки досягненням технічної революції. Прогрес кардіології за останні 50 років був колосальним і очевидним. Значну роль в успішній трансформації кардіології відіграє розширення технічних можливостей візуалізації та можливість використання штучного інтелекту. Ці інновації забезпечують діагностичну точність і прогрес в інтервенційній кардіології. Проте серцево-судинні захворювання залишаються серйозною глобальною медичною проблемою. Серцево-судинні захворювання (ССЗ) є основною причиною смертності в усьому світі та займають перше місце в структурі хронічних неінфекційних захворювань (НІЗ). Оскільки захворюваність на ССЗ та НІЗ досягла рівня пандемії в усьому світі, пошук нових та альтернативних шляхів вирішення проблеми продовжується та є актуальним. Серцево-судинні захворювання продовжують залишатися проблемою для сучасних вчених у біомедичній галузі. Огляд присвячений пошуку нових напрямків для розв'язання проблеми серцево-судинних захворювань у майбутньому.

Матеріали і методи: загально наукові і теоретичні методи були використані у теоретичному дослідженні. В огляді описані нові напрямки як квантова кардіологія, магнітокардіологія, концепт біофотонного сигналіngu, вплив електромагнітних полів Землі на патогенез серцево-судинних захворювань.

Висновки: 1) Біофізичний напрямок розвитку кардіології є інваріантним та важливим напрямом поглиблення медичної парадигми, який відкриває нові шляхи вирішення проблеми серцево-судинних захворювань.

2) Дослідження особливостей електромагнітної комунікації клітин серцево-судинної системи є важливим завданням та викликом для сучасних учених, яке відкріє механізми клітинної інтеграції в єдиний організм.

3) Знання фундаментальних аспектів електромагнітної комунікації клітин серцево-судинної системи та всього організму стануть новою основою для поглиблення парадигми патогенезу ССЗ та НІЗ, дозволять розкрити аспекти електромагнітного впливу серця на інші внутрішні органи та тканини, а також на взаємний електромаг-

нітний обмін енергією та інформацією на рівні.

4) Знання фундаментальних аспектів електромагнітної комунікації клітин серцево-судинної системи та всього організму дадуть можливість зрозуміти те, як саме електромагнітні параметри та механізми функціонування в тілі людини пов'язані з електромагнітними параметрами та хронобіологічною динамікою електромагнітного поля Землі.

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