

Modern Methods Of Diagnosis And Treatment Of Cardiovascular Diseases:

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Abstract

The paper presents an analytical review of modern approaches to the diagnosis and treatment of cardiovascular diseases (CVD) with an emphasis on the achievements of the last decade. The main focus is on the development of non-invasive imaging, including coronary computed tomography angiography (CT angiography) and fractional blood flow reserve technologies calculated from tomography (FFR-CT), the use of highly sensitive troponins in the early diagnosis of coronary artery disease and acute coronary syndrome, the integration of artificial intelligence and wearable devices into continuous monitoring of cardiovascular risk, as well as the evolution of interventional and drug-based approaches, including transcatheter implantation of the aortic valve (TAVI), modern antilipidemic agents and type 2 sodium-glucose cotransporter inhibitors (SGLT2 inhibitors).

The review is based on an analysis of publications from 2020-2025 in leading international journals on cardiology and radiology, as well as recommendations from professional communities.

It has been shown that the introduction of CT angiography, FFR-CT and artificial intelligence methods can significantly improve risk stratification and personalize the choice of treatment tactics. It has been demonstrated that SGLT2 inhibitors, modern antithrombotic regimens, and catheter interventions on heart valves lead to a reduction in mortality and hospitalization rates for heart failure in various patient groups.

It is noted that the key trend is the integration of diagnostic and therapeutic solutions into a single digital ecosystem, providing continuous monitoring, timely correction of therapy and a more accurate prediction of outcomes.

Keywords: cardiovascular diseases, diagnostics, CT angiography, artificial intelligence, wearable devices, heart failure, SGLT2 inhibitors, interventional cardiology.

INTRODUCTION

Cardiovascular diseases continue to be the leading cause of morbidity and mortality worldwide, despite significant progress in prevention and treatment over the past decades. According to international

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epidemiological studies, the specific contribution of coronary heart disease and chronic heart failure to the mortality structure remains consistently high, and the aging of the population and the increasing prevalence of risk factors lead to an increase in the absolute number of patients with severe forms of CVD [2]. Against this background, it is the introduction of high-tech diagnostic and treatment methods that allows us to shift the prognosis towards improving the survival rate and quality of life of patients.

At the beginning of the 21st century, invasive coronary angiography and traditional functional tests such as loading electrocardiography and stress echocardiography dominated [16]. However, in the last decade it has become obvious that the development of noninvasive imaging and computing technologies is radically changing the approach to assessing coronary blood flow and structural pathology of the heart [14].

Modern reviews emphasize that coronary CT angiography, enhanced by artificial intelligence algorithms and FFR-CT calculations, is gradually becoming one of the key tools for the noninvasive diagnosis of stable coronary artery disease and coronary artery atherosclerosis [15].

At the same time, highly sensitive troponins were introduced, which significantly accelerated the diagnosis of acute coronary syndrome and reduced the time spent by patients in emergency departments. New diagnostic algorithms based on sequential troponin measurements with intervals of one to two hours have demonstrated high sensitivity and specificity for myocardial infarction and have been included in international recommendations [9].

Another important area of development has become the interdisciplinary field of digital medicine, which uses wearable devices, sensors and remote monitoring platforms, as well as artificial intelligence methods to analyze large amounts of data on heart rate, physical activity and behavioral factors. Current reviews emphasize that wearable devices and machine learning algorithms can detect asymptomatic episodes of atrial fibrillation, rhythm disturbances, and early signs of ischemia, opening up new opportunities for the prevention of stroke and sudden cardiac death [11].

No less significant changes have occurred in the treatment of CVD in recent years. In the field of heart failure, SGLT2 inhibitors have been added to basic therapy drugs, which in a series of large randomized trials and meta-analyses have shown a reduction in the risk of cardiovascular death and hospitalization, regardless of ejection fraction and the presence of diabetes mellitus [6].

There has been a technological shift in the treatment of valvular defects towards transcatheter interventions, primarily TAVI for severe aortic stenosis. Modern registries and randomized trials have shown that in high- and intermediate-risk patients, TAVI is not only as good as surgical valve replacement, but also provides better clinical outcomes in certain subgroups.

The purpose of this work is a comprehensive review of modern methods of diagnosis and treatment of cardiovascular diseases with a focus on the latest achievements and clinical evidence published mainly in the period from 2020 to 2025, as well as an analysis of the prospects for their integration into everyday clinical practice.

Materials and methods of research.

The study was conducted in the format of a structured literature review with elements of an analytical comparison of the results of clinical trials and technological developments.

The research methodology can be described as multilevel: a systematic search and selection of literature was used at the source level, qualitative and comparative comparison of diagnostic and therapeutic strategies was used at the analysis level, tabular and graphical forms were used at the presentation level, providing visibility and the possibility of a holistic assessment of the modern arsenal of remedies for cardiovascular diseases.

Results and discussions.

One of the most notable achievements in recent years has been the steady strengthening of the position of coronary CT angiography as the primary noninvasive technique for assessing coronary atherosclerosis.

Modern reviews emphasize that the development of detectors, reduced radiation exposure, and increased spatial and temporal resolution have led to a significant increase in the accuracy of the method in detecting significant stenoses and evaluating the prognosis [4].

The next step was the introduction of FFR-CT, in which the distribution of pressure and blood flow along the coronary tree is modeled using computational fluid dynamics and artificial intelligence algorithms based on CT angiography data. This allows us to obtain a functional assessment of the significance of stenosis without an invasive measurement of the fractional reserve of blood flow. Modern works demonstrate the high diagnostic accuracy of FFR-CT compared to the invasive "gold standard" and emphasize its potential role in reducing the number of diagnostic coronary angiographs and unjustified revascularization [8].

At the same time, the methods of magnetic resonance imaging of the heart and echocardiography were improved, including stress regimes and technologies for deformational analysis of the myocardium. However, the integration of imaging with biomarkers has become a key qualitative shift in diagnostics. The introduction of highly sensitive troponins has allowed the formation of new protocols for the early diagnosis of acute coronary syndrome, in which crucial information about the presence of a heart attack can be obtained in the first hours after the patient's admission. Clinical studies have shown that such protocols do not worsen safety in relation to missed heart attacks, but they make it possible to significantly reduce the burden on hospitals [1].

Wearable devices and remote monitoring systems occupy a special place in modern diagnostics. An analysis of recent reviews shows that devices that record ECG, photoplethysmogram, and physical activity indicators, combined with machine learning algorithms, are able to detect asymptomatic atrial fibrillation and other rhythm disorders, assess heart rate variability, and predict adverse events. These systems are gradually moving from the field of consumer devices to the field of medical services, integrating with electronic medical records and telemedicine platforms.

To summarize the main diagnostic areas and their characteristics, Table 1 was compiled, reflecting the key methods and their clinical role.

Table 1. Modern diagnostic methods for cardiovascular diseases and main characteristics (summary of data from reviews and clinical trials)

Method	The main prescription	Key advantages	Limitations and problems of implementation
Coronary CT - angiography	Noninvasive imaging of the coronary arteries and assessment of atherosclerotic plaque	High sensitivity in detecting stenoses, the ability to quantify plaques and prognosis, reduction in the number of invasive studies	Radiation exposure, the need to monitor heart rate, limitation in the presence of calcification and arrhythmias
FFR-CT based on CT angiography	Functional assessment of the hemodynamic significance of stenoses without invasive intervention	Diagnostic accuracy comparable to invasive FFR, the possibility of simultaneous anatomical and functional assessment	Demands on the quality of the original CT images, the need for computing resources, limited availability so far
Highly Sensitive Troponins (hs-Tn)	Early diagnosis of myocardial infarction and risk stratification in	Reduction of the time before diagnosis, the possibility of rapid exclusion of a heart	The risk of overdiagnosis in the absence of an ischemia clinic, the need for standardization of

	case of suspected acute coronary syndrome	attack, improvement of prognostic stratification	protocols and interpretation
Wearable devices and remote monitoring	Detection of arrhythmias, assessment of workload and monitoring of high-risk patients	Continuous data collection, early detection of rhythm disturbances, increased patient engagement, potential for personalized treatment	Heterogeneity of device quality, problems of validation and integration with subsystems, data privacy issues
Artificial intelligence in ECG analysis and visualization	Automated diagnosis and prediction of outcomes	Increased sensitivity and specificity, identification of "hidden" patterns, reduction of interpretation time	The need for validation and transparency of algorithms, the risk of algorithmic bias, regulatory barriers

Among the medicinal achievements of the period 2020-2025, SGLT2 inhibitors occupy a central place. Originally developed as sugar-lowering drugs, they demonstrated a pronounced cardioprotective effect. A series of large randomized trials and meta-analyses have shown a reduction in the relative risk of cardiovascular death and hospitalization for heart failure when using this group of drugs in both patients with reduced and preserved ejection fraction, as well as in acute situations, including decompensated heart failure. These results led to the inclusion of SGLT2 inhibitors in the basic therapy of heart failure in international recommendations [11].

Along with this, the development of lipid-lowering therapy continues, where classical statins and ezetimibe are replaced by monoclonal antibodies to PCSK9 and drugs based on small interfering RNAs, which make it possible to achieve a deep and sustained reduction in the level of low-density lipoproteins, especially in patients with hereditary hypercholesterolemia and very high risk. New data indicate an additional reduction in the incidence of adverse cardiovascular outcomes when using these drugs against the background of standard therapy, although the problem of high cost and accessibility remains a significant limitation for widespread use [3].

In the field of interventional cardiology, transcatheter valve implantation, primarily TAVI in severe aortic stenosis, has become a key area. Since the first interventions in the early 2000s, the technology has gone from an option for extremely severe patients who are not subject to surgery to a method of choice for high- and intermediate-risk patients and is gradually being considered to expand indications to lower-risk groups. Modern registries and randomized trials demonstrate a steady decrease in perioperative mortality, improvement in hemodynamics and quality of life, including in specific subgroups such as women and patients with bicuspid aortic valve. At the same time, the issues of durability of prostheses, the risk of paravalvular regurgitation and the need for implantation of an electro-cardio-stimulator continue to be discussed [7].

Current work in the field of TAVI highlights that the technology has become a "model" for evaluating new device-oriented interventions in cardiology: from early trials to multicenter randomized trials and the formation of long-term registries.

An important trend is the integration of drug therapy and interventional methods within a single strategy. Patients with severe heart failure and valvular pathology often receive combination therapy, including SGLT2 inhibitors, mineralocorticoid receptor antagonists, sacubitril/valsartan and, if indicated, TAVI or other catheter interventions. Such a multi-level strategy provides a more pronounced reduction in the risk of complications and an improvement in the quality of life than the isolated use of one of the approaches [12].

To structure information about modern therapeutic approaches, a second summary table 2 was prepared.

Table 2. Current therapeutic strategies for CVD and their clinical effects (summary of reviews and meta-analyses)

Direction of therapy	Main representatives or technologies	Key clinical effects	Main limitations
Treatment of heart failure using SGLT2 inhibitors	Dapagliflozin, empagliflozin and other drugs of the class	Reduction of cardiovascular mortality and hospitalizations for heart failure, improvement of symptoms and quality of life, effectiveness at different values of the ejection fraction	Possible side effects (urogenital infections, extensive dehydration), the need to monitor kidney function, the cost of therapy
High-tech lipid-lowering therapy	Monoclonal antibodies to PCSK9, drugs based on small interfering RNAs	A profound decrease in LDL levels and a decrease in the frequency of major adverse cardiovascular events in very high-risk patients	High cost, limited availability, and the need for long-term therapy
Transcatheter valve interventions (TAVI et al.)	Modern transcatheter aortic valve platforms, developing technologies for mitral and tricuspid valves	Improved survival and quality of life in patients with severe valvular pathology, reduced invasiveness and hospital workload compared with open surgery in high- and intermediate-risk patients	Issues related to the durability of prosthetics, the risk of paravalvular regurgitation and conduction disorders, the need for highly qualified teams and infrastructure
Personalized antithrombotic therapy	Modern P2Y12 inhibitors, direct oral anticoagulants	Reducing the risk of stent thrombosis, stroke, and systemic embolism while optimizing dual and triple therapy regimens	The balance between prevention of thrombosis and the risk of bleeding, the need for individual dose selection and duration

Modern reviews emphasize that individual diagnostic and therapeutic innovations are gradually being integrated into digital ecosystems, forming the contours of the so-called "digital cardiology". The coronavirus pandemic has accelerated the introduction of telemedicine consultations, remote monitoring,

and digital rehabilitation programs; this has led to the active development of platforms combining data from wearable devices, laboratory and instrumental research results, and information about prescribed therapy.

Artificial intelligence is used for automated analysis of ECG, CT and MR images, forecasting the risk of hospitalization and death, as well as to optimize the selection of drug therapy. In the field of visualization, machine learning and deep learning methods allow segmentation of the heart structure, analysis of atherosclerotic plaques, and modeling of coronary blood flow. This increases diagnostic accuracy and reduces the burden on imaging specialists, but at the same time raises questions about the transparency of algorithms, validation of models on different populations, and regulatory regulation of their use [6].

To illustrate the place of key modern methods in the system of evidence-based cardiology, a conditional graphic image was constructed reflecting the high level of evidence for several leading technologies.

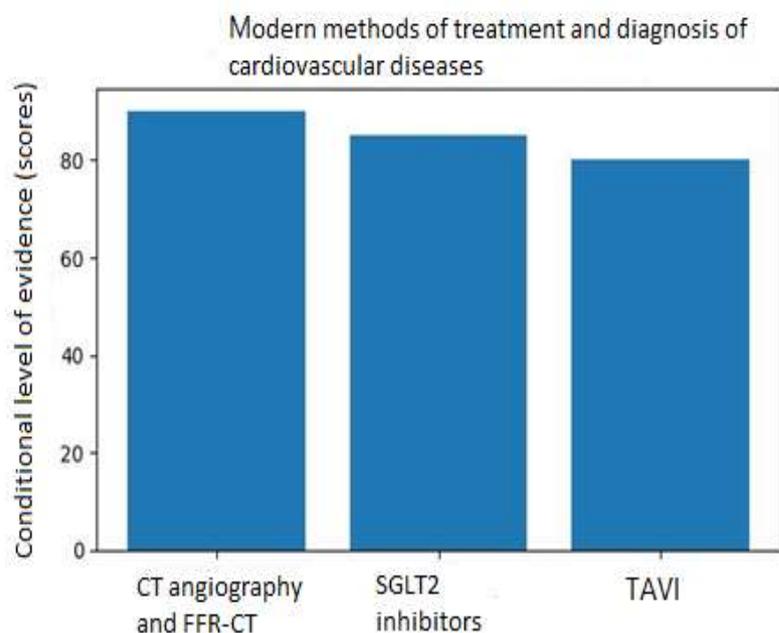


Figure 1. Conceptual comparison of the conditional level of evidence for CT angiography with FFR-CT, SGLT2 inhibitors and TAVI (schematic values based on a summary assessment of data from randomized trials and meta-analyses)

The figure illustrates that all three areas – advanced noninvasive coronary artery imaging, modern pharmacotherapy of heart failure, and transcatheter valve interventions – have a high level of evidence and have already taken a firm place in clinical recommendations. The differences between the conditional indicators reflect not so much the actual gradation as the specifics of the evidence base and the duration of data accumulation for each technology.

Conclusion

Modern methods of diagnosis and treatment of cardiovascular diseases form a multicomponent ecosystem in which high-tech imaging, advanced pharmacotherapy, minimally invasive interventions and digital solutions complement each other. The development of coronary CT angiography and FFR-CT has made it possible to move from a purely anatomical assessment of stenoses to functional risk stratification at a non-

invasive level, thereby reducing the number of unjustified invasive procedures. The introduction of highly sensitive troponins has radically accelerated the diagnosis of acute coronary syndrome and improved the work of emergency services.

A key breakthrough in the treatment of heart failure was the appearance of SGLT2 inhibitors, which demonstrated a reduction in mortality and hospitalization in a wide range of clinical situations and thus took their place at the heart of modern pharmacotherapy. In the field of valvular malformation treatment, TAVI has evolved from an alternative option for inoperable patients to one of the main strategies for high- and intermediate-risk individuals, and in the future for broader groups of patients, as evidenced by the growing evidence base.

Digital technologies are becoming particularly important: wearable devices, remote monitoring platforms, and artificial intelligence algorithms. They provide continuous monitoring of the patient's condition, early detection of arrhythmias and decompensation, as well as support for medical decisions. However, their widespread adoption requires addressing issues of standardization, cybersecurity, and ethics of medical data processing.

Taken together, an analysis of recent advances shows that the future of cardiology is linked to the further integration of diagnostic and therapeutic technologies within a personalized approach, when the choice of treatment method is determined not only by the diagnosis, but also by individual risk profile, genetic characteristics, behavioral factors and continuous monitoring data. Realizing this potential will require interdisciplinary collaboration between cardiologists, imaging specialists, clinical pharmacologists, engineers, and digital solution developers, as well as consistent updating of clinical guidelines based on a rapidly evolving evidence base.

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