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THE ROLE AND SIGNIFICANCE OF MODERN COMPUTER TECHNOLOGIES IN THE DIAGNOSIS AND TREATMENT OF HEART DISEASES IN ADOLESCENTS AND YOUNG CHILDREN

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Abstract
This article presents a detailed analysis of heart diseases common among children and adolescents, the use of modern computer technologies in their diagnosis and treatment, the diagnostic systems developed based on artificial intelligence, and their effectiveness.

Keywords: Congenital heart defects, arrhythmia, myocarditis, hypertension, rheumatic heart diseases, heart failure, ECG analysis, echocardiography, CT scan, MRI, telemedicine, remote ECG monitoring, virtual consultations, hypertension.

Introduction

Cardiovascular diseases are one of the leading causes of death and disability worldwide. Although common among adults, these diseases are increasingly being diagnosed among children and adolescents in recent years. Congenital heart defects, rhythm disorders, myocarditis, and arterial hypertension significantly affect the health of young children and adolescents. Early detection and effective treatment of these conditions play a crucial role in safeguarding children's health.
Modern computer technologies and advances in artificial intelligence are widely applied in all fields of medicine, particularly in cardiology. Diagnostic and treatment methods aided by computers are significantly more effective than traditional methods, allowing for early identification of heart pathologies and recommending appropriate treatment options for patients.

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MAIN BODY

Prevalence of Heart Diseases Among Children and Adolescents Although cardiovascular diseases may seem rare among children and adolescents, their importance is significant. According to the World Health Organization (WHO), nearly 1 million children are born each year with congenital heart defects globally. Additionally, acquired heart diseases such as hypertension and arrhythmias are increasing among young people.

According to statistics from the Ministry of Health of Uzbekistan, the number of diagnoses related to heart diseases among children and adolescents has increased by 15–20% in recent years. This highlights the need to improve early diagnosis and treatment with the help of modern technologies. The main heart diseases found among children and adolescents include:

Congenital heart defects – abnormalities occurring during embryonic development.

Arrhythmia – disruptions in heart rhythm, manifesting as rapid or slow heartbeats.

Myocarditis – inflammation of the heart muscle, typically caused by viral infections or immune system issues.

Hypertension – although less common in children, it may develop due to lifestyle factors or genetics.

Rheumatic heart diseases – often develop as complications after streptococcal throat infections, damaging heart valves, especially in children aged 5–15.

Heart failure – a condition where the heart cannot meet the body's metabolic needs.

Heart Failure Heart failure (insufficientia cordis) is a syndrome resulting from decompensated myocardial dysfunction. It manifests as increased intercellular fluid volume and decreased perfusion of organs and tissues. The underlying pathophysiology is the heart's inability to function as an effective pump. Left ventricular heart failure is characterized by venous congestion in the pulmonary circulation and symptoms such as dizziness, syncope, and angina. Right ventricular failure leads to inadequate blood ejection into the pulmonary artery and systemic congestion. Depending on the progression rate, heart failure can be acute or chronic.

Signs in infants include fatigue during feeding, cyanosis, rapid breathing, and poor weight gain. Older children may exhibit fatigue, breathlessness (especially while lying down), swelling (in the abdomen or legs), tachycardia, and chest discomfort.

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Globally, over 25 million people are affected by heart failure. In 2016, it accounted for 9.3% of all cardiovascular-related deaths in the U.S., and in Russia, its prevalence doubled from 4.9% in 1998 to 10.2% in 2014.

Hypertension Primary (essential) hypertension is a common condition marked by persistently elevated blood pressure, often due to emotional stress, genetics, poor dietary habits, and disrupted sleep. Its progression includes:

Stage I: Systolic 140–159 mmHg, diastolic 90–99 mmHg without organ damage.

Stage II: Systolic 160–179 mmHg, diastolic 100–109 mmHg with signs such as left ventricular hypertrophy and early kidney impairment.

Stage III: Systolic ≥180 mmHg, diastolic ≥110 mmHg with complications like stroke, heart attack, kidney failure, and vision problems.

Diagnosis in children involves comparing their blood pressure with age-appropriate percentiles. Treatment includes lifestyle changes, physical activity, psychotherapy, and, if needed, medication prescribed by a cardiologist.

Modern Computer Technologies in Diagnosis Early diagnosis is critical for preserving the health of children and adolescents. In addition to traditional methods, modern computer technologies significantly improve diagnostic speed and accuracy:

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING:

AI can analyze MRI, echocardiography, and CT images with up to 95% accuracy.

ECG analysis – detects heart rhythm anomalies.

Echocardiography – visualizes heart muscles and valves. CT and MRI – reveal structural heart abnormalities.

Telemedicine and E-health:

Telemedicine allows remote monitoring and consultation, especially beneficial for children in remote areas.

Telemedicine enables:

Remote ECG monitoring – Patients can monitor heart rhythm at home and send data to doctors.

Virtual consultations – Patients receive medical advice via video call.

Digital platforms – Software tools improve communication and treatment tracking.

Studies in the U.S. show telemedicine is 30% more effective than traditional methods in managing pediatric heart conditions.

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Innovative Technologies in Treatment

Modern technologies are revolutionizing treatment approaches for heart diseases.

Robotic Surgery and Minimally Invasive Procedures

Traditional open-heart surgeries are complex and risky. Robotic technologies now enable surgeons to operate with greater precision and minimal trauma.

Advantages of robotic heart surgery:

Higher precision – Robotic systems outperform human hands in accuracy.

Less blood loss – Minimally invasive techniques reduce trauma.

Faster recovery – Compared to open surgery, patients recover more quickly.

For example, surgeries performed using the Da Vinci robotic system are proven to be safer and more efficient.

Pacemakers and Artificial Heart Devices

For patients with arrhythmias, pacemakers provide an effective solution:

Automatically regulate heart rate and send electrical impulses when needed.

Some pacemakers can transmit data via Bluetooth.

Enable remote monitoring by healthcare providers.

In severe heart failure cases, artificial heart implants are used. In 2020, France developed the Carmat artificial heart, offering new hope to patients with end-stage heart failure.

Gene Therapy and Regenerative Medicine

One of the most promising future directions in medicine is gene therapy and tissue regeneration. Researchers are using stem cells and genetic engineering to repair damaged heart tissues.

At Harvard University, studies showed that gene therapy can successfully regenerate myocardial tissue damaged by heart attacks.

Key advantages of modern technologies:

Higher diagnostic accuracy

Faster, less invasive procedures

Remote monitoring capabilities

Preventive and predictive analytics via AI

Enhanced recovery times via robotic surgery

Challenges and Limitations

Despite their benefits, modern computer technologies face some limitations:

High costs – AI, robotics, and gene therapy are expensive.

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Shortage of trained professionals – Not all doctors are skilled in these technologies.
Data security concerns – Online medical data requires strong protection.
Technical issues – Software errors can lead to misdiagnosis or treatment errors.
Studies recommend cautious use of AI and verify results with additional expert review.

CONCLUSION

The role of modern computer technologies in diagnosing and treating heart diseases in children and adolescents is growing rapidly. Innovations like artificial intelligence, robotic surgery, telemedicine, and gene therapy improve early detection and treatment effectiveness. However, issues such as high costs, lack of specialists, and technical challenges remain. Future efforts should focus on expanding access, training medical personnel, and investing in innovative research and secure digital infrastructure.

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