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**DEVELOPMENT OF CARDIOTOXIC COMPLICATIONS IN CANCER: THE
SIGNIFICANCE OF CLINICAL AND HELIOGEOPHYSICAL FACTORS**



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Abstract: This article examines clinical and heliogeophysical factors associated with the development of cardiotoxic complications in cancer patients. Some anticancer treatments, including chemotherapy, targeted therapy, and radiotherapy, may have adverse effects on the cardiovascular system. The study considers the main clinical manifestations and risk factors of cardiotoxicity, as well as the importance of modern diagnostic approaches. Electrocardiography, echocardiography, and cardiac biomarkers play an important role in the early detection of changes in cardiac function. Particular attention is also given to the possible influence of heliogeophysical factors, including solar activity and geomagnetic fluctuations, on cardiovascular function. Early identification of cardiotoxic complications, assessment of individual risk factors, and regular cardiovascular monitoring are important for improving the safety of anticancer treatment. A comprehensive approach involving oncology and cardiology specialists may contribute to the prevention of severe cardiovascular complications and better management of cancer patients.

Keywords: Cancer, cardiotoxicity, cardiovascular system, chemotherapy, arterial hypertension, heliogeophysical factors, solar activity, geomagnetic activity, cardiac monitoring, diagnosis.

**РАЗВИТИЕ КАРДИТОКСИЧЕСКИХ ОСЛОЖНЕНИЙ ПРИ ОНКОЛОГИЧЕСКИХ
ЗАБОЛЕВАНИЯХ: ЗНАЧЕНИЕ КЛИНИЧЕСКИХ И ГЕЛИОГЕОФИЗИЧЕСКИХ
ФАКТОРОВ**

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Аннотация: В статье рассматриваются клинические и гелиогеофизические факторы, связанные с развитием кардиотоксических осложнений у пациентов с онкологическими заболеваниями. Некоторые методы противоопухолевого лечения, включая химиотерапию, таргетную терапию и лучевую терапию, могут оказывать неблагоприятное воздействие на сердечно-сосудистую систему. Рассмотрены основные клинические проявления и факторы риска кардиотоксичности, а также значение современных методов диагностики. Электрокардиография, эхокардиография и определение сердечных биомаркеров имеют важное значение для раннего выявления нарушений функции сердца. Особое внимание уделено возможному влиянию гелиогеофизических факторов, включая солнечную активность и геомагнитные колебания, на функциональное состояние сердечно-сосудистой системы. Раннее выявление кардиотоксических осложнений, оценка индивидуальных факторов риска и регулярный кардиологический мониторинг имеют важное значение для повышения безопасности противоопухолевого лечения. Комплексный подход с участием онкологов и кардиологов может способствовать предупреждению тяжелых сердечно-сосудистых осложнений.

Ключевые слова: Онкологические заболевания, кардиотоксичность, сердечно-сосудистая система, химиотерапия, артериальная гипертензия, гелиогеофизические факторы, солнечная активность, геомагнитная активность, кардиологический мониторинг, диагностика.

SARATON KASALLIGIDA KARDIOTOKSIK ASORATLARNING RIVOJLANISHI: KLINIK VA GELIOGEOFIZIK OMILLARNING AHAMIYATI

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Annotatsiya: Mazkur maqolada saraton kasalligiga chalingan bemorlarda kardiotsik asoratlarning rivojlanishiga ta'sir qiluvchi klinik va geliogeofizik omillar o'rganilgan. Onkologik davolash jarayonida ayrim kimyoterapevtik preparatlar, maqsadli terapiya va radioterapiya yurak-qon tomir tizimiga salbiy ta'sir ko'rsatishi mumkin. Tadqiqotda kardiotsiklikning asosiy klinik belgilari, xavf omillari va zamonaviy diagnostika usullarining ahamiyati ko'rib chiqilgan. Elektrokardiografiya, exokardiografiya va yurak biomarkerlaridan foydalanish yurak faoliyatidagi o'zgarishlarni erta aniqlashda muhim ahamiyatga ega. Shuningdek, quyosh faolligi va geomagnit o'zgarishlar kabi geliogeofizik omillarning yurak-qon tomir tizimi faoliyatiga ehtimoliy ta'siri tahlil qilingan. Kardiotsik asoratlarni erta aniqlash, xavf omillarini baholash va bemorlarni muntazam kuzatish onkologik davolash xavfsizligini oshirishda muhim hisoblanadi.



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Kalit so'zlar: Saraton kasalligi, kardiotsiklik, yurak-qon tomir tizimi, kimyoterapiya, arterial gipertenziya, geliogeofizik omillar, quyosh faolligi, geomagnit faollik, kardiologik monitoring, diagnostika.

Introduction

Cancer is one of the most important health problems in modern medicine, and its clinical course and treatment outcomes depend on many factors. Chemotherapy, radiotherapy, immunotherapy, and other modern treatment methods are widely used in the management of cancer patients. Although these approaches can significantly improve survival and disease control, some anticancer treatments may have adverse effects on the cardiovascular system. Cardiotoxicity is one of the important complications that may develop during cancer treatment. It can manifest as reduced myocardial contractility, heart failure, cardiac rhythm disturbances, changes in blood pressure, and other cardiovascular abnormalities. Early detection of cardiotoxic complications is essential for improving the clinical condition of patients, allowing timely modification of treatment, and preventing severe cardiovascular outcomes.

The development of cardiotoxicity is influenced by several clinical factors, including patient age, pre-existing cardiovascular diseases, arterial hypertension, diabetes mellitus, impaired renal function, the type of anticancer drugs used, and the duration of treatment. Therefore, regular assessment of cardiovascular function and identification of individual risk factors are important components of the management of cancer patients. In recent years, increasing attention has also been given to the possible influence of environmental factors on human health, including heliogeophysical factors. Solar activity, geomagnetic fluctuations, and other geophysical changes may influence the functional state of the cardiovascular system. Studying these factors may be particularly important in patients whose cardiovascular system is already affected by cancer or anticancer treatment.

Relevance

The relevance of this topic is determined by the increasing importance of cardiovascular complications in cancer patients receiving anticancer treatment. Cardiotoxicity may significantly affect the patient's clinical condition and can limit the continuation of effective cancer therapy. Early identification of cardiovascular risk factors and timely assessment of cardiac function are therefore important for improving the safety of cancer treatment. In addition, studying the possible relationship between heliogeophysical factors and cardiovascular changes may provide additional information about the factors that influence the development of cardiotoxic complications. A comprehensive assessment of clinical and environmental factors may contribute to better monitoring and early prevention of cardiovascular complications in cancer patients.

Aim

The aim of this study is to assess the development of cardiotoxic complications in cancer patients and to evaluate the possible significance of clinical and heliogeophysical factors in their occurrence.

Main part

Cardiotoxicity is an important complication that may develop during cancer treatment and can significantly affect the patient's clinical condition and quality of life. Its development depends on several factors, including the type and stage of cancer, the treatment regimen, the duration of therapy, and the individual characteristics of the patient. Chemotherapy, targeted therapy, immunotherapy, and radiotherapy may have different effects on the cardiovascular system. Some anticancer drugs can directly affect myocardial cells and reduce cardiac contractility, while others may contribute to vascular dysfunction or changes in blood pressure. The risk of cardiotoxicity may be higher in patients with pre-existing cardiovascular diseases, arterial hypertension, diabetes mellitus, obesity, renal dysfunction, or previous exposure to cardiotoxic treatment. Age is also an important factor, particularly in older patients with several concomitant diseases. The cumulative dose of certain



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anticancer drugs may influence the probability of developing cardiac dysfunction. Clinical manifestations may include fatigue, shortness of breath, palpitations, chest discomfort, peripheral edema, and reduced exercise tolerance. However, early cardiac dysfunction may remain asymptomatic. Therefore, assessment of cardiovascular risk before treatment and regular monitoring during therapy are important. Identification of individual risk factors allows physicians to select an appropriate monitoring strategy and detect complications at an early stage. Cooperation between oncologists and cardiologists is particularly important in patients with a high risk of cardiovascular complications.

The diagnosis of cardiotoxicity requires a comprehensive assessment of the patient's clinical condition and cardiovascular function. Clinical evaluation should include a detailed medical history, assessment of cardiovascular risk factors, and identification of symptoms that may indicate developing cardiac dysfunction. Electrocardiography is one of the basic diagnostic methods and can help identify arrhythmias, conduction abnormalities, and other changes in cardiac electrical activity. Echocardiography has an important role in evaluating cardiac structure and function, particularly left ventricular systolic function. Measurement of left ventricular ejection fraction remains an important parameter for monitoring cardiac function during cancer treatment. More sensitive methods, such as assessment of global longitudinal strain, may help identify early myocardial dysfunction before a significant decrease in ejection fraction occurs. Laboratory biomarkers can provide additional information about myocardial injury and cardiac stress. Cardiac troponins may be useful for detecting myocardial injury, while natriuretic peptides can provide information about myocardial wall stress and the development of heart failure. In selected patients, cardiac magnetic resonance imaging may provide detailed information about myocardial structure and tissue characteristics. The diagnostic strategy should be individualized according to the patient's risk profile, cancer treatment, and clinical condition. Baseline assessment before anticancer therapy provides an opportunity to identify pre-existing abnormalities. Repeated examinations during treatment allow physicians to detect changes over time. Combining clinical evaluation, electrocardiography, echocardiography, and laboratory biomarkers provides a more complete assessment of cardiovascular status.

Modern anticancer malignant diseases, but some therapeutic approaches may produce cardiovascular adverse effects. treatment has significantly improved the survival of patients with many types of Different anticancer drugs can affect the cardiovascular system through different mechanisms. Anthracyclines are among the best-known agents associated with myocardial injury and cardiac dysfunction, particularly when cumulative exposure increases. Some targeted therapies may also interfere with myocardial function or vascular regulation. Radiotherapy involving the chest region may affect cardiac structures and contribute to cardiovascular complications in the long term. The clinical presentation of treatment-related cardiotoxicity varies between patients and may occur during treatment or after its completion. Some patients develop asymptomatic changes in cardiac function, while others may present with heart failure, arrhythmias, hypertension, or other cardiovascular abnormalities. Individual susceptibility depends on age, previous cardiovascular disease, hypertension, diabetes, renal function, and other risk factors. The combination of several treatment modalities may further increase cardiovascular risk. For this reason, cardiovascular assessment should be adapted to the specific anticancer treatment regimen. Before treatment, patients should be evaluated for cardiovascular risk, while during treatment their symptoms and cardiac function should be monitored when clinically indicated. If significant cardiovascular abnormalities develop, the treatment strategy may need to be reconsidered through cooperation between oncology and cardiology specialists. The main goal is to maintain effective cancer treatment while reducing cardiovascular harm.

Heliogeophysical factors include changes associated with solar activity, geomagnetic conditions, and other processes occurring in the space environment. Their possible influence on human health has attracted scientific attention, particularly in relation to cardiovascular function.



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Changes in solar activity can be accompanied by fluctuations in the geomagnetic environment, and some studies have investigated possible associations between geomagnetic disturbances and cardiovascular parameters. The cardiovascular system is influenced by autonomic regulation, vascular tone, blood pressure, and heart rhythm, all of which may respond to environmental changes. This issue may be of particular interest in cancer patients because their cardiovascular system can already be affected by the underlying disease, anticancer therapy, or existing cardiovascular risk factors. Patients with arterial hypertension, previous cardiac dysfunction, or treatment-related cardiotoxicity may require closer observation when studying possible environmental influences. Blood pressure, heart rate, electrocardiographic parameters, and clinical symptoms can be evaluated during different periods of heliogeophysical activity. However, the relationship between geomagnetic changes and cardiovascular complications should be interpreted carefully because many other clinical and environmental factors may influence the patient's condition. Heliogeophysical factors should therefore be considered as possible additional factors rather than established independent causes of cardiotoxicity. Further clinical research is necessary to determine the strength and clinical relevance of these relationships in cancer patients. Standardized monitoring of cardiovascular parameters and accurate recording of heliogeophysical conditions may improve the quality of future studies.

Prevention of cardiotoxicity should begin before the initiation of anticancer treatment and continue throughout the entire period of patient management. Baseline cardiovascular assessment is important for identifying patients who have an increased risk of developing cardiac complications. The patient's medical history should include previous cardiovascular disease, arterial hypertension, diabetes mellitus, renal dysfunction, and previous exposure to potentially cardiotoxic therapies. Appropriate instrumental and laboratory examinations can help establish the initial cardiovascular status. During anticancer treatment, patients should be monitored for symptoms such as shortness of breath, fatigue, palpitations, chest discomfort, and edema. Changes in blood pressure, heart rate, electrocardiographic findings, and cardiac function should be evaluated according to the patient's clinical risk. Management of cardiovascular risk factors is an important component of prevention. Adequate control of arterial hypertension and diabetes, maintenance of a healthy body weight, balanced nutrition, appropriate physical activity, and smoking cessation can contribute to better cardiovascular health. When cardiac dysfunction is detected, treatment should be individualized according to its severity and the patient's oncological condition. In selected patients, cardioprotective therapy may be considered based on clinical indications. Decisions regarding continuation, modification, or temporary interruption of anticancer treatment should involve both oncology and cardiology specialists when significant cardiac abnormalities occur. Regular follow-up is also important after completion of cancer treatment because some cardiovascular complications may develop later. Patient education regarding warning symptoms and adherence to medical recommendations can improve long-term management.

Results

The results of the assessment indicate that the development of cardiotoxic complications in cancer patients is influenced by a combination of clinical and treatment-related factors. Patients with arterial hypertension, diabetes mellitus, previous cardiovascular disease, renal dysfunction, and older age may require closer cardiovascular monitoring during anticancer therapy. The most important clinical manifestations include fatigue, shortness of breath, palpitations, changes in blood pressure, and reduced exercise tolerance. Electrocardiography and echocardiography were identified as important methods for detecting cardiovascular abnormalities, while cardiac biomarkers can provide additional information about myocardial injury and cardiac stress. Particular attention should be given to patients receiving potentially cardiotoxic chemotherapy, targeted therapy, or chest radiotherapy, as cardiovascular complications may develop during or after treatment. Assessment of heliogeophysical factors may also provide additional information about changes in cardiovascular parameters, particularly blood pressure and heart rate, although their independent clinical significance requires



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further investigation. The obtained findings support the importance of regular cardiovascular assessment before and during cancer treatment. Early identification of cardiovascular risk factors and timely intervention may help prevent progression to severe cardiac dysfunction. A comprehensive approach involving oncologists and cardiologists is therefore important for improving the safety of anticancer therapy and reducing the risk of cardiovascular complications.

Discussion

The development of cardiotoxic complications in cancer patients is associated with several clinical and treatment-related factors. The present analysis shows that patients with pre-existing cardiovascular diseases, arterial hypertension, diabetes mellitus, renal dysfunction, and advanced age may have a higher risk of cardiovascular complications during anticancer treatment. These factors can reduce the cardiovascular reserve of the patient and increase susceptibility to the adverse effects of certain anticancer therapies. The clinical manifestations of cardiotoxicity may vary from mild and asymptomatic changes to clinically significant cardiac dysfunction. Fatigue, shortness of breath, palpitations, changes in blood pressure, and reduced exercise tolerance should therefore be considered important warning signs. However, the absence of symptoms does not exclude early cardiac dysfunction. For this reason, instrumental monitoring has an important role in the management of patients receiving potentially cardiotoxic treatment.

Echocardiography remains an important method for evaluating cardiac function, particularly for assessing left ventricular systolic function. Electrocardiography can provide additional information about rhythm and conduction abnormalities, while cardiac biomarkers may help identify myocardial injury or increased cardiac stress. The combined use of these methods provides a more comprehensive assessment than relying on a single diagnostic parameter. The type and intensity of anticancer treatment also have an important influence on cardiovascular risk. Anthracyclines, some targeted therapies, and radiotherapy involving the chest may cause different forms of cardiovascular damage. Therefore, cardiovascular monitoring should be adapted to the treatment regimen and individual risk profile of each patient. Cooperation between oncologists and cardiologists is important for maintaining effective cancer treatment while reducing cardiovascular complications.

The possible influence of heliogeophysical factors represents an additional area of scientific interest. Changes in solar and geomagnetic activity may be associated with variations in cardiovascular parameters, particularly blood pressure and heart rate. However, these factors should be interpreted cautiously because cardiovascular changes can be influenced by many clinical, environmental, and treatment-related conditions. At present, heliogeophysical factors should be considered possible contributing factors rather than independent causes of cardiotoxicity.

Conclusion

The development of cardiotoxic complications in cancer patients is influenced by a combination of clinical characteristics, cardiovascular risk factors, and the type and duration of anticancer treatment. Early identification of patients with increased cardiovascular risk is important for preventing severe cardiac complications. Regular assessment using clinical examination, electrocardiography, echocardiography, and appropriate cardiac biomarkers allows early detection of changes in cardiac function. Individualized monitoring is particularly important in patients with arterial hypertension, diabetes mellitus, previous cardiovascular disease, renal dysfunction, and other risk factors. Heliogeophysical factors may also be considered as possible additional environmental factors influencing cardiovascular parameters, although their independent role in the development of cardiotoxicity requires further investigation. A multidisciplinary approach involving oncologists and cardiologists, together with timely diagnosis, prevention, and individualized treatment, can improve cardiovascular safety during anticancer therapy. Thus, comprehensive monitoring of cancer patients is important for reducing the risk of cardiotoxic complications and maintaining the effectiveness of cancer treatment.



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