Improvements in Methods for Disease Diagnosis and Monitoring

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A review is made of the main scientific studies presented in the section Methods and Means of Diagnosis and Treatment of Various Diseases of the XIVth International Scientific Conference on Physics and Radio Electronics in Medicine and Ecology (PhREME'2020) held in Vladimir City on July 1-3, 2020.

Introduction

Early diagnosis and prophylaxis of diseases using state-of-the-art information, analytical, and medical-technical approaches and technologies is universally considered as the most promising trend in the development of contemporary medicine. It not only leads to prevention of diseases and significantly increases the probability of recovery or remission, but also increases the quality and duration of life and significantly decreases the risk of complications.

This makes interdisciplinary collaborations very important and increases interest among technical scientists in a diverse range of challenges in medical science and practice.

The XIVth International Scientific Conference on Physics and Radio Electronics in Medicine and Ecology (PhREME'2020) was held in Vladimir City on July 1-3, 2020. Within the framework of Section 1, *Methods and Means of Diagnosis and Treatment of Various Diseases*, some 30 reports on improvements and developments in methods and means of detecting, treating, and monitoring various diseases were presented. One special feature of the PhREME'2020 conference was the requirement to switch from the usual face-to-face to online format because of the coronavirus (COVID-19) pandemic. However, this had no impact on the quality of participation in the conference.

The reports covered a wide spectrum of topics, including cardiovascular, bronchopulmonary, and endocrine pathologies, oncological diseases, screening, and the population characteristics of child and adult health. Particular attention was paid to state-of-the-art techniques and methods for the diagnosis of pathological states and their associated risks, analysis of various biological signals, and remote patient management technologies. Experimental studies were also presented, including those using biological models [1-6].

The goal of this work was to provide a brief review of new methods and approaches to the diagnosis and treatment of diseases and pathological states presented at the international scientific conference PhREME'2020.

Methods for the Diagnosis of Pathological States and their Risks

The report [7] reviewed electrocardiographic parameters that, according to the literature, have potential for the early recognition of pathological changes in the myocardium and as predictors for cardiovascular disease and death in the study population. Despite the fact that the electrocardiography (ECG) is one of the oldest and thus far most widely used instrumental methods for clinical diagnosis, scientific reports have appeared showing new prognostic ECG parameters operating as predictors of cardiovascular events. Some of these parameters have yet to receive wide recognition in the medical community.

The review addressed ECG parameters such as wide QRS complexes, spatial angles, Tp-Te (Tpeak-Tend), QT, and QTc intervals, the ventricular gradient, and others. Working from data from large prospective studies, the

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author showed the value of wide use of novel ECG parameters in routine medical practice as predictors of cardiovascular events and lethal outcomes: the ventricular gradient, spatial and frontal angles (QRS/STT), and the electrical axes of the corresponding QRS and T vectors. Making these ECG parameters available for assessment in healthcare practice and including them in automatic ECG analysis software stressing prognostic significance would provide earlier assessment of the risk of adverse cardiovascular events and sudden cardiac death, with timely prophylactic intervention.

Thus, improved ECG instruments may be useful at the population level and can be applied in various types of large-scale investigations, clinical examinations, preventive reviews, out-patient follow-up, and special programs for population health monitoring in areas with high incidence of cardiovascular diseases and mortality [8].

The aim of the report [9] was to carry out prospective observations of the frequencies and reproducibility of arterial blood pressure (BP) phenotypes assessed using clinical measurements, daily monitoring (DMBP), and self-monitoring of BP (SMBP). Patients with arterial hypertension (AHT) were examined taking cognizance of chronic respiratory diseases: chronic obstructive pulmonary disease (COPD) and asthma. The use of various devices to monitor BP (tonometers, daily monitors) in different conditions (medical institutions, other places) can give identical or different BP readings in any given patient relative to confirmed threshold values. This characteristic is associated with the BP phenotype. Phenotypes are undoubtedly associated with the patients' individual features (provided that a known-good measuring device is correctly used); study data show them to be associated with the risks of cardiovascular complications and death.

Using their scientific data, the authors confirmed the need for long-term observations of patients with AHT receiving antihypertensive therapy and especially patients with COPD and asthma using DMBP. This provides better diagnosis of prognostically unfavorable factors such as the latent inefficacy of the treatment of AHT. This phenotype is characterized by normal clinical BP and is often underestimated. It is important for analysis of DMBP results to compare them with clinical BP values and to identify the BP phenotype.

New aspects of the use of laser Doppler flowmetry for the diagnosis of pathological states in diabetes mellitus (DM) were demonstrated in two reports. Zharkikh et al. [10] presented assessment of dynamic measurements of blood microcirculation and oxidative metabolism in DM patients using local temperature treatments (cooling and warming). The proposed approach involves simulta-

neous use of laser Doppler flowmetry and fluorescence spectroscopy with local temperature tests. It has potential for analysis of the functional state of biological tissues. Increases in microcirculation and oxidative metabolism recorded upon use of local thermal tests were significantly less pronounced in DM patients than in healthy subjects. The authors took the view that microcirculation impairments and metabolic processes in DM can be diagnosed using a variety of noninvasive optical methods, as the optical properties of biological tissues undergo significant changes in the process of development of pathological states.

Studies reported in [11] also addressed assessment of microcirculation complications in type 2 DM and described a new approach to analysis of Doppler spectra recorded from patients' skin. Data processing was by computation of cumulative total curves recorded from baseline traces and during responses to warming. The result of these studies was introduction of a novel parameter — the area between the cumulative total curves. This approach was found to be effective in detecting differences between DM patients and healthy volunteers in the thermal test. The authors plan to develop diagnostic criteria to provide classification of the severity of impairments to the microcirculatory bed in DM patients, which may be important for improving approaches to managing patients.

Assessment of Various Biological Signals

Studies addressing novel algorithms for analysis of various biosignals seeking to create intelligent technologies for detection and prognostication of the state of the human body were presented in reports by Britin [12], Zinchenko [13], Antipushina and Nekrasova [14], and Lapitan and Rogatkin [15].

One direction in the studies described in the review by Starodubtseva and Mednikov on the development of medical devices and decision-making systems [16] is linked with the development of methods and means of prognostication and the early and differential diagnosis of various diseases of human organs and systems in terms of energy imbalance of biologically active points (BAT) and target meridional structures. The authors noted that the use of the electrical characteristics of BAT could increase the quality of prognostication and early diagnosis of functional states and reserves of both the body as a whole and its individual systems, as well as assessment of the influence of the environment on the state of human health, fitness, etc. Summarizing the results of biomedical investigations, the authors pointed to the need for combining

“clinical thinking” with the “advantages of artificial intelligence” in hybrid intelligent technologies. In our view, this “tandem” needs to be supplemented with well planned clinical trials.

A similar topic was addressed by Protasova et al. [17] in the report on the development of technologies allowing prognostication of critical states of the human body. Prognosis here was by analysis of the response to sequential test voltage pulses delivered in the critical states of a BAT or groups of points. In the authors’ opinion, the resulting comparative diagnostic characteristics of the intelligent agents involved in determining surgical risks allowed these techniques for analyzing the BAT response to sequential test impulses to be used in medical practice. The study used prognostication of post-operative complications in prostate surgery as an example.

Along with analysis of various biological signals, studies considering the questions of the development and improvement of various laboratory diagnostic systems [18], including those used in the diagnosis of COVID-19 [19], were also presented at PhREME’2020.

Remote Patient Management Technologies

The analytical studies of Antipushina et al. [20] addressing the use of telemedicine (TM) technologies for remote monitoring of patients with chronic obstructive lung disease and asthma are of interest. The social significance of this problem is beyond doubt. The importance of TM technologies increased particularly in 2020 because of the need to take anti-epidemic measures to prevent the spread of the novel coronavirus infection. In the ongoing conditions, the importance of TM information is not limited to monitoring patients with various diseases. The use of different types of remote communications with patients and systems analyzing data coming from patients decreases the risk of spreading the infection and is safer for healthcare workers. Among others, this is important for maintaining the efficiency of medical institutions during the epidemic.

Experimental Studies Using Biological Models

The reports by Gorlina, Tagunova, and Seregina et al. [3-5] addressed promising trends in contemporary neurobiology. These authors identified markers for mitochondrial dysfunction leading to irreversible pathological processes in the brain and operating as key components in the pathogenesis of neurodegenerative diseases. Animal models were used in the studies.

Other Medical Topics

Some reports in Section 1 addressed questions of health of different population groups. In particular, Burenkov and Sushkova [8] presented the results of a retrospective analysis of the main medical-demographic characteristics of the population of the Vladimir district in 1999–2018. Significant oscillations in these characteristics were seen in different territories of the district, confirming the need to develop and introduce regional systems for monitoring population health. The authors formulated monitoring aims and the main stages and measures for the development and creation of such regional systems.

The large study conducted by Smirnova et al. [21] addressed monitoring of polypharmacy in a pediatric department or a pediatric hospital. Adolescents aged 15–18 years were found to have the highest frequency of being prescribed more than five drugs. In non-hospital pneumonia, the mean number of drugs was 10(!). The authors suggested that the simultaneous presence of multiple diseases in children was linked with the prescription of multiple drugs by different specialists.

Chezganov and Evgrafov [22] considered the challenge of monitoring health status in young people, evaluated the current level of such monitoring from the point of view of technical support and its cost, and proposed possible solutions.

Major aspects of the reform of the Russian health-care system conducted in recent decades were considered in [23].

Conclusions

The section *Methods and Means of Diagnosis and Treatment of Various Diseases* of the international scientific conference PhREME’2020 addressed approaches to solving urgent medical challenges on the basis of current advances in science and technology. The overall direction of the discussion within the framework of this section demonstrated the high level of interest of the conference participants in different approaches to assessing the state of the human body and developing new methods and means of disease diagnosis and treatment, as well as in defining the most promising research directions likely to produce important fundamental and practical results.

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