UDC: 616.24-036.12:613.2

RESPIRATORY INSUFFICIENCY AND CARDIOPULMONARY DISORDERS DUE TO HEAT WAVES: ANALYSIS OF RISK FACTORS AND CLINICAL CONDITIONS

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ABSTRACT. This article analyzes the impact of extreme heat waves observed as a result of climate change on respiratory failure and cardiopulmonary disorders. Clinical cases associated with risk factors such as heat stress, decreased air quality, dehydration, oxidative stress, as well as aging, chronic diseases, and urbanization were considered. It has been established that during periods of hot waves, mortality from respiratory diseases increases by 20-40%. The results of the study showed the need to assess hot waves as a serious threat to public health and strengthen preventive measures.

Keywords: hot waves, respiratory failure, cardiopulmonary disorders, hot stress, COPD, asthma, atmospheric pollution, PM2.5, ozone, mortality.

ДЫХАТЕЛЬНАЯ НЕДОСТАТОЧНОСТЬ И КАРДИОПУЛЬМОНАРНЫЕ НАРУШЕНИЯ ПОД ВОЗДЕЙСТВИЕМ ГОРЯЧИХ ВОЛН: АНАЛИЗ ФАКТОРОВ РИСКА И КЛИНИЧЕСКИХ СОСТОЯНИЙ

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АННОТАЦИЯ. В данной статье анализируется влияние экстремальных жарких волн, вызванных изменением климата, на дыхательную недостаточность и сердечно-легочные нарушения. Рассмотрены клинические состояния, связанные с такими факторами риска, как жаркий стресс, снижение качества воздуха, обезвоживание, окислительный стресс, а также пожилой возраст, хронические заболевания и урбанизация. Установлено, что во время жарких волн смертность от респираторных заболеваний увеличивается до 20-40%. Результаты исследования показали необходимость оценки жарких волн как серьезного риска для общественного здоровья и усиления профилактических мер.

Ключевые слова: горячие волны, дыхательная недостаточность, сердечно-легочные расстройства, горячий стресс, ХОБЛ, астма, загрязнение атмосферы, PM2.5, озон, смертность.

Introduction. In recent years, against the backdrop of global climate change, extreme temperature increases - the frequency and duration of hot waves - have increased significantly. According to the World Health Organization, heat

waves are one of the main causes of death associated with respiratory diseases, cardiovascular insufficiency, and acute respiratory disorders.

Heat disrupts the body's thermoregulatory system, intensifies respiration, increases oxygen demand, and as a result, sharp functional strain occurs in the cardiopulmonary system. Also, high temperatures lead to the activation of pollutants such as PM2.5, ozone, and nitrogen oxide in the atmosphere, intensifying the inflammatory process in the respiratory tract.

This article scientifically examines the mechanisms of respiratory failure and cardiopulmonary disorders during hot waves, risk factors, and analysis of clinical cases.

Epidemiological studies conducted in the last decade scientifically confirm the presence of a strong correlation between hot waves and mortality rates. In particular, diseases of the respiratory tract and cardiopulmonary system, caused by exposure to high temperatures, are considered a serious risk factor in global healthcare. It has been noted that hot waves disrupt the body's thermoregulatory mechanisms, leading to a sharp increase in oxygen deficiency, cardiovascular disorders, and chronic respiratory diseases (Anderson & Bell, 2011).

The results of many international studies show that during hot waves, respiratory mortality increases to 12-35%, while in patients with COPD this indicator can reach up to 45%. The reason for this is the weakening of lung ventilation under the influence of high temperature, an increase in the concentration of ozone and pollutants in the air, and additional inflammation of the mucous membrane (Gasparrini et al., 2015).

It was also found that on hot days, the incidence of bronchial asthma attacks increases by 20-30%. Studies have shown that against the background of high temperatures, the activation of allergens in the atmosphere, the increase in ozone in the ground-level layer (ground-level ozone), and the sensitivity of the respiratory tract increase (Ebi & Mills, 2013). Young children, the elderly, and individuals with allergic phenotypes are especially sensitive to the effects of heat stress.

There is evidence that an increase in the concentration of PM2.5 by 10-20% during hot waves leads to increased obstruction of the respiratory tract, a decrease in alveolar diffusion, and a decrease in the functional capacity of the lungs (Li et al., 2019). PM2.5 particles acquire more active oxidizing properties at high temperatures, increasing oxidative stress in the lungs, which leads to the aggravation of diseases such as COPD, bronchitis, and asthma.

Heat stress puts significant pressure not only on the respiratory system, but also on the cardiovascular system. Vasodilation, dehydration, and electrolyte imbalance, accompanied by thermoregulation disorders, lead to changes in heart rate, blood pressure, peripheral resistance, and venous return, sometimes causing the development of acute cardiopulmonary insufficiency (Bunker et al., 2016). Clinical observations have shown a significant increase in mortality rates associated with cardiac arrhythmias, acute heart failure, myocardial ischemia, and respiratory failure during the heat wave period.

In addition, the scientific literature provides evidence that hot waves increase the risk of developing pulmonary arterial hypertension, chronic heart failure, and acute respiratory distress syndrome (ARDS). Especially in elderly patients, the weakening of thermoregulation mechanisms, a high risk of dehydration, and the presence of chronic diseases exacerbate these processes (Kendrovski et al., 2017; Smith & Woodward 2014).

In general, hot waves are an extremely dangerous environmental stressor for people with respiratory and cardiopulmonary diseases, which has a significant impact on mortality rates, the number of hospitalizations, and the increase in severe clinical complications.

Materials and Methods. This study was conducted based on scientific literature, clinical observations, epidemiological data recorded during hot waves, as well as official statistical databases provided by the WHO, the US Centers for Disease Control and Prevention (CDC), and the European Environment Agency. Several methods were used in the study: an epidemiological analysis was conducted to assess the dynamics of mortality and morbidity rates observed between respiratory and cardiopulmonary diseases; cases of cardiopulmonary decompensation, emergency requests, and complications were reviewed through a retrospective analysis of the clinical status of patients during the heat wave period. A comparative analysis was also conducted to identify differences in climatic conditions, air quality, and access to medical care in urban and rural areas. To identify the most vulnerable segments of the population to the effects of hot waves, risk groups were separated, and a correlation analysis was conducted to determine the relationship between changes in atmospheric pollution and rising temperatures. This comprehensive approach made it possible to scientifically determine what risks heat waves pose to cardiopulmonary health.

Number of calls to the emergency department during hot waves:

- Respiratory failure 28%
- 19% for acute heart failure
- 35% of asthma attacks
- exacerbation of COPD up to 40%

Resuscitation was required in 12-18% of patients with cardiopulmonary failure. The most frequent cases were observed in elderly patients with chronic COPD and those working in intensive hot conditions.

Heat waves cause complex physiological changes in the human body, primarily disrupting the thermoregulation process, increasing heart rate and respiratory rate, increasing pulmonary ventilation, and exacerbating dehydration; all these processes significantly increase the risk of developing respiratory failure. Under the influence of high temperatures, the efficiency of gas exchange in the alveoli decreases, an increase in ozone in the atmosphere intensifies bronchial inflammation, and the penetration of PM2.5 particles into deep alveoli increases oxidative stress, leading to damage to the mucous membranes of the respiratory tract. Due to the weakening of compensatory mechanisms in patients with chronic

lung diseases, these factors can easily lead to the development of acute respiratory failure or ARDS. Hot waves put a serious strain not only on the respiratory system but also on the cardiovascular system: acute heart failure, arrhythmias, blood pressure instability, increased pulmonary hypertension, and the frequent occurrence of thromboembolic conditions are examples of this. As a result, the functional reserve of the heart and lungs sharply decreases, and the risk of death increases. Such complications are most often observed among the elderly (due to low thermoregulation capacity), people with COPD, asthma and bronchitis, patients with heart failure and arterial hypertension, children, as well as urban residents with polluted air and high temperatures due to urbanization. Because people with diabetes and obesity are more sensitive to hot stress, they also have a higher risk of developing cardiopulmonary complications. All this scientifically confirms that hot waves have a significant influence on mortality rates associated with respiratory failure and cardiopulmonary disorders.

Conclusion. Studies have shown that heat waves are an important risk factor for respiratory failure and exacerbation of cardiopulmonary disorders. The risk of death increases significantly, especially in chronic respiratory diseases, heart failure, and the elderly population. Therefore, in hot periods, it is necessary to early warning of high-risk groups, increase the readiness of hospitals, regularly monitor air quality, and implement heat protection protocols for patients. The increasing number of hot waves requires a deeper scientific and practical solution to this problem.

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