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The Effects of High Temperature and Cardiovascular Diseases

Mingtao Li

Department of Health Science, Boston University, Boston, United States

mingtao9@bu.edu

Abstract:

Due to the rise of the temperature worldwide, people nowadays are facing a more frequent, long-lasting, and hotter heat waves than they did several decades ago. It attracts the attention of researchers to embrace the problem existed in high temperature and cardiovascular disease. High temperature worldwide may become a potential risk factor that trigger cardiovascular diseases. The rise of temperature not only means that the world is getting hotter, but also may triggered various dangerous side effects and negative impacts to the ecosystem. This review describes the relationship between high temperature and cardiovascular diseases. After the research, the result indicated that there is a positive relationship between high temperature and cardiovascular disease. Many studies shown that high temperature has a great possibility to cause myocardial injury and heart failure due to the innate human sweating mechanisms. It is always hard to avoid the exposure to the heat during hot summer. However, the duration exposed to the heat is also crucial that people should also pay attention to.

Keywords: High temperature; cardiovascular diseases; myocardial Injury; heart failure; arrythmias.

1. Introduction

Nowadays, the world temperature is rising rapidly. It is not hard to notice that every year the temperature of summertime become higher. According to Thompson, the nowadays summer is transforming that people nowadays are facing a more frequent, long-lasting, and hotter heat waves than they did several decades ago. The fact is clear that the data shows that the global warming is heating the world to a 1.2 degrees Celsius above its average in the 19th century. As the latest Intergovernmental Panel on Climate Change (IPCC) report on Impacts, Adaptation and Vulnerability confirms that at the current rate, the world will become 1.5 degree Celsius hotter in 2040 [1]. The rise of temperature not only means that the world is getting hotter, but also may triggered various dangerous side effects and negative impacts to the ecosystem. If the prediction of 2.7 degrees Celsius is reached, scientists claimed that the areas of the tropics and subtropics will suffering from unlivable heat, the biodiversity will be enormously depleted, food security will drop, urban infrastructures will be destroyed, and the human health will face the unavailability of protection. In fact, today‘s summer

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heat is much more than just making us sweat and soak our clothes, it comprises deadly public health threat to human beings. According to Lewis, heat waves kill more people than any other type of severe weather in US, and the drastic climate change make it more frequent and unpredictable. A recent CDC report found that there were more than 3,500 emergency visits for heat-related illness within two months, and nearly 80% of these visits occurred during the worst heat wave period. It's best for human body to function at the temperature of 37 degrees Celsius, when the body overheat and become dehydrated, the blood will thicken, and the heart has to pump harder than usual. This may potentially evoke the probability of developing cardiovascular diseases.

Cardiovascular diseases are the known leading cause of death globally, which resulted in the fact that 928,741 people died from cardiovascular disease in 2020 in US and total 17.9 million people died from cardiovascular disease in 2019 globally, which representing a 32% of all global death. The cost of cardiovascular disease from 2018 to 2019 is about $407.3 billion, including healthcare services and medicine, with the direct cost of $251.4 billion and $155.9 billion indirect cost. Cardiovascular diseases affect the blood vessels and heart. Cardiovascular diseases may affect human health by narrowing the blood vessel in the heart, other organs, or throughout the body, affecting heart valves, and heart rhythms. Symptoms of cardiovascular diseases including chest pain, chest pressure, heaviness, and discomfort, as known as a feeling of "belt around the chest", shortness to breath, dizziness, and fatigue. According to the CDC, most cardiovascular diseases have risk factors such as tobacco use, unhealthy diet and obesity, harmful use of alcohol, air pollution, and physical inactivity.

2. The Relationship Between High Temperature and the Cardiovascular System

As the weather temperature continues to increase, the potential impact of it on cardiovascular diseases cannot be ignored. This review introducesthe connection between high weather temperature and cardiovascular diseases and discusses the effect of high temperature on cardiovascular diseases. The relationship between high temperature and the cardiovascular system. According to the study conducted by Alahmad, et al., the association between extreme hot weather temperature and the cardiovascular system related mortality was effectively shown to the public. Researchers utilized the unified data collection protocols among Multi-Country Multi-City Collaborative Network to create a database of daily counts of specific cardiovascular caused death in 567 cities in 27 countries across 5 continents from 1979 to 2019. The result of regression analysis showed that the relative risk (RR) for heart failure drastically rise to 1.12 when exposed to extreme high temperature, placed at the highest rank among ischemic heart disease and stroke, with the respective RR of 1.07 and 1.10. The RR of heart failure skyrocketed to 1.8 when the temperature exceeded the 99 percentiles of temperature, which was the extreme high weather temperature [1]. It shows that high weather temperature has huge adverse impact on the cardiovascular system. Furthermore, the assessment on excess death from high temperature cause-specific diseases showed that there are 2.6 excess death cases for every heart failure death. The excess deaths showed the extreme pressure given on the cardiovascular system that are more likely cause deaths when exposed to high temperature.

With the help of previous research on relative risks when people exposed to high temperature, another research specifically about the mechanism of cardiovascular response. Chaseling, et al. also find that the extreme heat brings pressure to the cardiovascular system by elevating the heart rate among both younger adults and older adults. During heat exposure, the increasing in body temperature activates the heat loss response of dilation of blood vessels in skin and sweating. Although the dilation of blood vessels helps to regulate body temperature, but it'll decrease the peripheral vascular resistance [2]. If sweating can't be compensated with adequate fluid intake; the central blood volume will decrease. Therefore, there must be an elevation of cardiac output in order to meet the regulation of blood pressure, however, the elevation of cardiac output can only be met by increasing the heart rate and heart contraction.

Another research by Lin, et al. shows that there is a positive relationship between high temperature and the cardiovascular system when the temperature exceeds the threshold 29.4 degrees Celsius by examining the hospital admission rate. The result showed that for each degree Celsius above the threshold temperature, the risk of cardiovascular diseases admission increased 3.6% [3].

To narrow down the range of population, research by Yin, et al. on the association between consecutive days' heat wave and cardiovascular diseases mortality in Beijng showed a positive relationship between duration of heat exposure and mortality rate. For instance, when the daily maximum temperature is higher than 35 degrees Celsius and occur continuously, on the fifth days, the excess mortality risk (ERs) rise to about 51% and for the threshold of 32 degrees Celsius, 33 degrees Celsius, and 34 degrees Celsius, the Ers rise to about 16%, 29%, and 31%, respec-

tively [4]. All in all, high weather temperature shows close relationship with cardiovascular diseases.

3. Effect of High Temperature on Cardiovascular Disease

3.1 Myocardial Injury

The understanding of the pathogenesis of myocardial injury is changing overtime. Historically, the well-known reason of having Acute Myocardial Infraction (AMI) is the blood flow of certain part of the heart decrease or stop, which resulted in myocardial infraction or injury. This is mostly caused by the blood clot in the epicardial artery. However, Saleh, et al. stated that not all the causes of AMI must contain this blood clot because with further understanding of this infraction, there is always a supply-demand ratio need to be met [5]. It means that in all living tissue, the blood supply must equal to the oxygen demand of the muscle. The current understanding is that if an imbalance occurs in this ratio, such as too much demand or too little supply, a very rapid heart rate or a drop in blood pressure will occur and may lead to myocardial damage. This new understanding of the pathogenesis of myocardial injury leads to a new direction of research. Ebi, et al. researched about the effect of hot weather and extreme heat to cardiovascular health stated that higher temperature may affect heart strain. The human body response to heat stress in a primary way of redistributing blood flow to the skin to improve heat transfer from muscle to skin to the environment. It is mainly physiologically expressed as sweating that evaporates and carries away body heat. As blood redistributes and flows to the skin due to skin vasodilatation, this increases cardiac demand while decreasing cardiac filling pressures. These responses require the heart to pump more vigorously and more rapidly, thereby increasing coronary artery tissue oxygen demand [6]. The imbalance of the supply-demand ratio occurred during this process that the high demand of oxygen by the heart exceed the amount of oxygen the heart can supply. It usually leads to heart ischemia, infarction, and eventually cardiovascular failure.

3.2 Heart Failure

Heart failure is a clinical syndrome that results when the heart is unable to provide sufficient blood flow to meet metabolic requirements or accommodate systemic venous return. A series of compensatory mechanisms may appear to help heart attempt to maintain adequate function when heart failure first happens, including Frank Starling mechanism, ventricular remodeling to increase ventricular volume and wall thickness, and the activation of neurohormonal systems to maintain tissue perfusion. Although these mechanisms may initially benefit the heart, all of the compensatory mechanisms will lead to a vicious cycle of heart failure in future development. For people with a healthy heart, when the Left Ventricular End-Diastolic Volume (LVEDV) increase, the Left Ventricular End-Diastolic Pressure (LVEDP) also increase, which will cause the stretch of myocardium, that result in an elevation of the Cardiac Output (CO). The stroke volume of people with heart contraction dysfunction has a lower stroke volume (SV) than people with healthy functioning heart. As the SV get lower, LVEDV elevate, which result in a rise in the compensation given by CO. Eventually, with the vanishing effects of the compensatory mechanism, the elevation of LVEDV and LVEDP will lead to pulmonary congestion, which resulted in a drop of CO [7].

Cui et al. suggested that the clinical report showed that people with cardiovascular diseases were more vulnerable to heat injury. They studied the effects of heat stress on cardiovascular and autonomic functions in people with chronic heart failure (CHF). Healthy people have the great ability to receive the hot environment, which is about a 3 degrees Celsius interior temperature elevation. However, people with cardiovascular diseases don't have the ability to bear such an increase in body temperature. When they are exposed to hot environment, the core temperature will rise, and they must transfer the heat to the environment from their interior. It'll apparently increase SkBF by an estimate increase from 300 ml/min to 7500 ml/min or above, or we can say an increase of cardiac output from 5-10% to 50-70%. Cardiac output have to increase in order to maintain artery blood pressure under such apparent skin vasodilation. Increasing in the cardiac output is mainly due to an increase in heart rate. For healthy people, the increase in SkBF will not result in the change of cardiac output and the reduction of arterial blood pressure. For patient with CHF, the cardiac output will increase rapidly when exposed to heat, which result in a further deterioration of the CHF [8].

4. Conclusions

Due to the rampant global temperatures nowadays, this results in people being exposed to high temperatures for long periods of time during the summer months. Exposure to high temperatures or prolonged exposure to high temperatures can negatively affect our cardiovascular system, including myocardial injury, heart failure, and arrythmias. This review deepens the understanding of the relationship between heat and cardiovascular disease. It is important to recognize this effect and take care to prevent prolonged

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exposure to high temperatures or to detect and treat problems early.

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