FRIGID ZONE **MEDICINE**
Perspective • DOI: 10.2478/fzm-2022-0018

Promoting factors behind hypertension in cold areas

Ye Tian*

Received 27 July 2022, accepted 17 August 2022

Southern University of Science and Technology, Shenzhen 518055, China

**Corresponding author Tian Ye, E-mail: yetian6@163.com*

Hypertension has become the primary risk factor for cardiovascular disease in China and one of the most critical causes of death from diseases worldwide[1-2]. In China, as many as 50% of cardiovascular disease, chronic kidney disease, and diabetes patients die of hypertension[3]. Especially in the cold regions of north China, blood pressure demonstrates characteristic seasonal and regional fluctuations[3]. The incidence rate of refractory hypertension, myocardial infarction, heart failure, atrial fibrillation and sudden cardiac death in cold season is significantly increased, while cold as a health killer is often neglected[4]. On the eve of the 13th World Hypertension Day, Professor Tian, Head of Heilongjiang Province Cardiovascular and Cerebrovascular Disease Prevention and Treatment Office and Director of Cardiology of the First Affiliated Hospital of Harbin Medical University, gave a special report on the characteristics of hypertension in the northern cold region and uncovered four major influencing factors of cardiovascular disease.

1 Extreme low temperature

Exposure to extreme temperatures can induce significant changes in blood pressure, heart rate, blood viscosity, and cholesterol level[5]. Professor Tian pointed out that human is the most strictly thermostatic animal. The core temperature (referring to the temperature of main organs such as heart, brain, and lung) usually fluctuates within a narrow range centered at 37°C. In extreme cases, it can increase by 3°C to 40.5°C, and decrease by 1°C to 36°C. Beyond this range, life-threatening events may occur. Public health experts from Harvard University collected 6 513 330 deaths and meteorological data from 50 cities in the United States and analyzed the relationship between extreme temperature and all-cause death by using case crossover design. The data show that the average temperature in cold months in all cities ranges from –4.1°C to 14.5°C, with the lowest extreme cold temperature of –17.2°C found in Minneapolis. Under extremely cold weather conditions, the mortality of myocardial infarction and cardiac arrest can increase significantly[6].

As one of the representative cities in China's cold regions, Harbin, located at 45 degrees north latitude, has five months of freezing weather conditions in a year, and the lowest temperature is often down to –38°C. When the temperature drops below –19°C in the wintertime, the number of deaths in this area increases significantly with decreasing temperature, of which 2.7% of the death can be attributed to low temperature and cold, especially in patients with coronary heart disease[7].

2 Sudden temperature drop

China has a wide latitude from north to south. Due to the high latitude, the cold areas in the north are often exposed to only oblique sun rays, coupled with the short daylight hours, rendering a huge temperature difference between the north and the south. Meanwhile, the northern cold areas are vulnerable to winter wind and cold wave from the northwest, as well as the impact of sudden snowfalls. When the temperature difference between day and night is greater than 9.6°C, the incidence of acute events caused by coronary syndrome and chronic obstructive pneumonia is significantly increased[8].

Canadian physicians observed that the amount and duration of snowfall are closely related to the admission rate and mortality rate of patients with myocardial infarction, and this relationship is most obvious on the second day after snowfall. Continuous snowfall for two to three days will further increase the probability of myocardial infarction[9]. Korean scholars found that when the diurnal temperature range (DTR) increased by 1°C, the admission rates of heart failure and asthma increased by 3% and 1.1%, respectively, particularly in elderly[10].

Studies have shown that for every 10°C drop in atmospheric temperature, the total incidence of coronary events can increase by 13%, coronary events associated mortality by 11%, and recurrent events by 26%[11]. Studies have also found that the incidence of intracerebral hemorrhage is obviously seasonal; the incidence of hemorrhagic stroke is highest in winter, followed by autumn and spring, and the lowest in summer. Professor Tian explained that due to the limited capability of the human body temperature regulation system to deal with emergencies, sudden temperature variation can

cause sudden changes to the human body, such as abrupt increases of blood cholesterol, heart rate, and platelet viscosity and decline of immunity.

3 Seasonal variation

China has a vast territory, with a north-south distance of about 5 500 km. A chronic disease study analyzed the data of 10 regions in China. The blood pressure levels in these 10 regions show a general pattern of seasonal variations, but the seasonal differences of systolic blood pressure in different regions vary to a great extent. For example, the average difference of systolic blood pressure in Zhejiang Province is 16 mmHg between winter and summer, the winter-summer difference in Haikou is only 4 mmHg, and in Harbin is 7 mmHg[12]. The moderate difference in Harbin is unanticipated; Professor Tian explained that although Harbin is located in the northeast region with cold climate, the use of central heating facilities minimizes the winter-summer difference of indoor temperature.

Seasonal changes in temperature are not only closely related to blood pressure levels, but also to other cardiovascular diseases[13]. Some research results show that heart failure caused by myocardial infarction is more vulnerable to temperature than by other cardiovascular diseases[14]. The incidence rates in winter and summer are 42% and 13%, respectively. Researchers also found that the mortality of cardiovascular diseases in China showed seasonal changes and the risk of cardiovascular death in winter was 41% higher than that in summer[15].

A recent study on the data of cardiovascular death from 15 large cities, including 1 936 116 cases, shows that 17.1% of the cardiovascular death in China are attributable to temperature, of which 15.8% are due to cold and 1.3% due to heat[16].

4 North and south migration

Nowadays, more and more middle-aged and elderly people begin to adopt the “migratory bird” life. They leave the cold north in the winter, flock to south areas. However, in the journey from south to north, man-made changes in the climate and environment often lead to cardiovascular events.

Some scholars have found that when the temperature of the U-shaped curve is lower than the cold temperature threshold and higher than the hot temperature threshold, the mortality rate of cardiovascular disease goes up[17]. Epidemiological surveys show that temperature fluctuations have a greater impact on the incidence and mortality of cerebral infarction than the temperature itself[18]. Professor Tian explained that temperature changes will cause fluctuations in blood pressure, and blood pressure will decrease as temperature rises. Once the human body temperature is suddenly increased due to “heat stress”, the blood flow velocity of the middle cerebral artery can be reduced by 30%, facilitating the risk of cerebral infarction.

Expert’s advice: First, residents in cold areas should reduce going-out frequency and duration in extremely cold weather. When going out, one should keep himself warm. Second, patients with hypertension in cold areas must keep regular self-monitoring of blood pressure upon sudden temperature drop and seasonal change, pay close attention to blood pressure value, and be alert to sharp changes in blood pressure caused by outdoor temperature changes. Third, patients with hypertension should seek medical treatment in time when their blood pressure rises sharply and adjust the medication plan of antihypertensive drugs under the guidance by their physicians. Fourth, the elderly who are preparing to migrate from cold zones to the tropics in autumn and winter should have a comprehensive physical examination before migration. When the temperature difference between the two places is more than 30°C, migration can increase the cardiovascular risk caused by the temperature difference. If there is cerebrovascular occlusion or severe stenosis, migration should follow the doctor’s advice.

Knowledge link: Broadly speaking, cold regions include cold regions and severe cold regions, which are concentrated in northern China. Severe cold areas mainly refer to the areas with the coldest monthly average temperature ≤10°C or daily average temperature ≤5°C and lasting for more than 145 days. Cold regions mainly refer to the regions with the coldest monthly average temperature of 0°C–10°C. Cold and low temperature is one of the main characteristics of winter climate in these areas, which is characterized by frequent cold waves, indoor and outdoor temperature difference of 50°C and large temperature difference between day and night. Hypothermia has adverse effects on human cardiovascular system, and the body will show cold stress due to the environment. Cold is closely related to cardiovascular events.

Conflicts of interests

Ye Tian is an Editorial Board Member of the journal. The article was subject to the journal’s standard procedures, with peer review handled independently of this member and his research groups.

References

[1] Mills K T, Stefanescu A, He J. The global epidemiology of hypertension. Nat Rev Nephrol, 2020; 16(4): 223-237.

[2] Mills K T, Bundy J D, Kelly T N, *et al.* Global disparities of hypertension prevalence and control: a systematic analysis of population-based studies from 90 countries. Circulation, 2016; 134(6): 441-450.

[3] Giaconi S, Ghione S, Palombo C, *et al.* Seasonal influences on blood pressure in high normal to mild hypertensive range. Hypertension, 1989; 14(1): 22-27.

[4] Khan A, Finlay J M, Clarke P, *et al.* Association between temperature exposure and cognition: a cross-sectional analysis of 20,687 aging adults in the United States. BMC public health, 2021; 21(1): 1484.

[5] Sun Z J. Cardiovascular responses to cold exposure. Frontiers in bioscience (Elite edition). Front Biosci(Elite Ed), 2010; 2(2): 495-503.

[6] Medina-Ramón M, Schwartz J. Temperature, temperature extremes, and mortality: a study of acclimatisation and effect modification in 50 US cities. Occup Environ Med, 2007; 64(12): 827-833.

[7] Yu B, Jin S S, Wang C, *et al.* The association of outdoor temperature with blood pressure, and its influence on future cardio-cerebrovascular disease risk in cold areas. J hypertens, 2020; 38(6): 1080-1089.

[8] Wolf K, Schneider A, Breitner S, *et al.* Air temperature and the occurrence of myocardial infarction in Augsburg, Germany. Circulation, 2009; 120(9): 735-742.

[9] Gan W, Henderson S B, Mckee G, *et al.* Snowfall, temperature, and the risk of death from myocardial infarction: a case-crossover study. Am J Epidemiol, 2020; 189(8): 832-840.

[10] Lim Y, Hong Y, Kim H. Effects of diurnal temperature range on cardiovascular and respiratory hospital admissions in Korea. Sci total environ, 2012; 417-418: 55-60.

[11] Danet S, Richard F, Montaye M, *et al.* Unhealthy effects of atmospheric temperature and pressure on the occurrence of myocardial infarction and coronary deaths. A 10-year survey: the Lille-World Health Organization MONICA project (Monitoring trends and determinants in cardiovascular disease). Circulation, 1999; 100(1): E1-E7.

[12] Lewington S, Li L M, Sherliker P, *et al.* Seasonal variation in blood pressure and its relationship with outdoor temperature in 10 diverse regions of China: the China Kadoorie Biobank. J Hypertens, 2012; 30(7): 1383-1391.

[13] Stewart S, Keates A K, Redfern A, *et al.* Seasonal variations in cardiovascular disease. Nat Rev Cardiol, 2017; 14(11): 654-664.

[14.] Sheth T, Nair C, Muller J, *et al.* Increased winter mortality from acute myocardial infarction and stroke: the effect of age. J Am Coll Cardiol, 1999; 33(7): 1916-1919.

[15] Yang L, Li L M, Lewington S, *et al.* Outdoor temperature, blood pressure, and cardiovascular disease mortality among 23 000 individuals with diagnosed cardiovascular diseases from China. Eur Heart J, 2015; 36(19): 1178-1185.

[16] Yang J, Yin P, Zhou M G, *et al.* Cardiovascular mortality risk attributable to ambient temperature in China. Heart, 2015; 101(24): 1966-1972.

[17] Kang Y, Han Y, Guan T J, *et al.* Clinical blood pressure responses to daily ambient temperature exposure in China: An analysis based on a representative nationwide population. Sci Total Environ, 2020; 705: 135762.

[18] Kravtsov I, Bogdanov A. Epidemiology and risk factors of ischemic stroke in the Middle Ob region. Zh Nevropatol Psikhiatr Im S S Korsakova, 1991; 91(7): 6-9.