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EDITORIAL

The impact of blood pressure variability on cardiovascular diseases

El impacto de la variabilidad de la presión arterial en las enfermedades cardiovasculares

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Cardiovascular diseases are among the leading causes of death worldwide, with hypertension being an important risk factor [1]. Hypertension-related target-organ damage represents a public health challenge in different settings. This situation persists despite the continuous optimization of antihypertensive strategies and improvements implemented to achieve better control of elevated blood pressure [2].

The burden of cardiovascular disease attributable to hypertension remains considerable, and overall blood pressure control rates continue to be suboptimal [2]. In fact, a previous study demonstrated that the severity of nocturnal hypertension is significantly associated with the occurrence of cardiovascular events [3].

Over recent decades, hypertension has been reported as the most common chronic noncommunicable disease among individuals in low- and middle-income settings [4]. The increasing prevalence of hypertension is related to population aging, changes in diet and lifestyle, high illiteracy rates, poor access to health services, poverty, high medication costs that remain unaffordable for a large proportion of the population, and the social stress faced by individuals [4]. Likewise, prehypertension has been described as a precursor of hypertension and has a strong positive linear relationship with cardiovascular morbidity and mortality [4].

It is important to recognize that blood pressure and cardiovascular risk exist along a continuum. Epidemiological studies have shown that the risk of developing cardiovascular disease begins at blood pressure values of 120/80 mmHg [5]. The high prevalence of prehypertension is associated with an increased risk of developing cardiovascular disease and its potential complications involving the heart, brain, and kidneys [5]. Individuals with high-normal blood pressure, defined as systolic blood pressure between 130 and 139 mmHg or diastolic blood pressure between 80 and 85 mmHg, are 1.5 and 2.0 times more likely to develop heart disease and stroke, respectively, than those with blood pressure <120/80 mmHg [6].

Mechanical stress induces oxidative stress through excessive production of reactive oxygen species, which directly damage endothelial cells and activate proinflammatory signaling pathways [2]. An important aspect of nocturnal blood pressure variability is that it is influenced by multiple factors, including excessive salt intake, increased cardiac output, increased sympathetic activity, and progressive arterial stiffness, which significantly impairs the buffering capacity of the arteries [2,7,8]. In individuals exposed to high altitude and hypobaric hypoxia, this phenomenon becomes more pronounced at night, causing greater arterial vasoconstriction. In addition, central apnea or hypopnea may occur during sleep, further increasing hypoxia and, consequently, nocturnal hypertension [7].

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Moreover, individuals at greater risk of nocturnal hypertension have been described as those who consume excessive amounts of salt, particularly salt-sensitive individuals, as well as those with increased nocturnal sympathetic activity influenced by various psychosocial factors, such as an uncomfortable sleeping environment, inadequate nighttime sleep duration, frequent nocturnal awakenings, anxiety, depression, and cognitive impairment [7,8]. The presence of comorbidities such as diabetes mellitus, chronic kidney disease, and obstructive sleep apnea syndrome should also be taken into consideration.

Blood pressure fluctuations across different time scales have become an important source of information for therapeutic decision-making. This variability can be measured over the long term, such as seasonally or between clinic visits; over the medium term, through measurements obtained on consecutive days or weeks; or over the short term, by evaluating differences between daytime and nighttime blood pressure or changes induced by other daily activities and conditions. Furthermore, increased blood pressure variability, whether long-, medium-, or short-term, is associated with poor cardiovascular prognosis independently of elevated mean blood pressure [9].

One method for assessing blood pressure variability is 24-hour ambulatory blood pressure monitoring (ABPM), which allows identification of different elevated blood pressure phenotypes and classification into four categories: normotension, white-coat hypertension, masked hypertension, and sustained hypertension. Some individuals have normal blood pressure during the day but elevated blood pressure at night, a condition referred to as masked nocturnal hypertension. Others exhibit elevated blood pressure only during the daytime, whereas nighttime measurements remain normal; this pattern is referred to as white-coat hypertension.

Nighttime blood pressure is a better predictor of cardiovascular events than daytime blood pressure [10]. The prevalence of nocturnal hypertension is high, ranging from 40% to 60% of the population [8]. A systematic review and meta-analysis of 449 studies found a prevalence of nocturnal hypertension of 45% in the general population, with higher percentages among individuals with hypertension (57%), diabetes mellitus (56%), obstructive sleep apnea (60%), and chronic kidney disease (64%). The prevalence of isolated nocturnal hypertension was reported to be 23% in the general population, whereas the prevalence of a nondipping nocturnal blood pressure pattern was 39%. However, these prevalence estimates should be interpreted according to the population studied and the methodologies used [10].

Clinical studies conducted in diverse patient populations have consistently identified blood pressure variability as an independent risk factor that often outperforms mean blood pressure in predicting target-organ damage and other cardiovascular events [2].

One study reported that individuals with masked nocturnal hypertension have a higher risk of developing cardiovascular diseases, including myocardial infarction and stroke, compared with those who have normal blood pressure both during the day and at night [1]. This finding is clinically relevant because many individuals with masked nocturnal hypertension may not be diagnosed in a timely manner when assessment is based solely on office blood pressure measurements obtained during the daytime. Depending on the clinical context, appropriate methods for assessing elevated blood pressure, such as ABPM or nighttime home blood pressure measurements, may improve early detection and help guide more effective strategies for the prevention and treatment of hypertension [1].

Accurate assessment of blood pressure variability provides valuable information for improving blood pressure control and may support the use of chronotherapy. According to Liu et al. [8], chronotherapy for nocturnal hypertension remains controversial because of inconsistent findings across different studies and trials. There is no conclusive evidence supporting nighttime administration of antihypertensive medications, either for the prevention of cardiovascular events or for nocturnal blood pressure control. This reinforces the importance of using long-acting antihypertensive agents capable of providing 24-hour blood pressure control. Appropriate management should emphasize addressing modifiable risk factors associated with hypertension. Lifestyle interventions, including promotion of a healthy diet and increased physical activity, are essential and have been shown to be effective in preventing the progression of hypertension and reducing further target-organ damage [5]. Finally, 24-hour blood pressure variability should be considered when optimizing blood pressure control, with the aim of reducing hypertension-related morbidity and mortality.

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