

## Editorial



# Carotid Arterial Stiffness and Attenuated Heart Rate Recovery in Uncomplicated Hypertensive Patients

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### Conflict of Interest

The authors have no financial conflicts of interest.

## HEART RATE RECOVERY AS A MARKER OF CARDIAC AUTONOMIC FUNCTION

The cardiovascular system is under the direct control of the autonomic nervous system in both health and disease states. During exercise, sympathetic activity increases and parasympathetic activity is reduced. During recovery after exercise, the opposite process occurs. Heart rate recovery (HRR) is defined as the maximum heart rate reached during exercise, which falls to a lower rate within minutes after the termination of exercise, and reflects the coordinated interplay between parasympathetic reactivation and sympathetic withdrawal.<sup>1,2)</sup> HRR is a non-invasive assessment of autonomic nervous system function and physical performance.<sup>2,3)</sup> Attenuated HRR signifying autonomic dysfunction is associated with an increased risk of cardiovascular events and all-cause mortality in the general population<sup>4)</sup> as well as ischemic heart disease and heart failure.<sup>5)</sup>

## HRR IN HYPERTENSION

Hypertension is known to have an adverse impact on HRR. In patients with hypertension and prehypertension, HRR was reduced compared to normotensive subjects.<sup>6)</sup> HRR was inversely correlated with blood pressure, age, serum glucose concentration, and waist circumference. There may be a dose-response relationship between elevated blood pressure and HRR reduction.<sup>6,7)</sup> High blood pressure in hypertensive patients is likely to result in autonomic dysfunction and optimal blood pressure may be related to an improved sympathetic-vagal balance in recovering hypertensive patients. Considering previous studies in patients with heart failure, it is unlikely that a decrease in HRR is due to beta blockers.<sup>8)</sup>

## HRR IN DIABETES MELLITUS

In diabetes mellitus, significant pathologic and functional abnormalities in both the sympathetic and parasympathetic nervous systems are seen.<sup>9)</sup> Direct damage to

cardiovascular autonomic nerves may result in heart failure or metabolic derangements. It is not known how early the damage to the cardiovascular-related autonomic nervous system begins in an individual with clinical cardiovascular disease or how much functional impairment occurs. Because the vagus nerve is the longest nerve in the body, parasympathetic dysfunction is the earliest manifestation of cardiac autonomic neuropathy.<sup>10)</sup>

Recently, attenuated HRR was associated with the risk of diabetes in a general population.<sup>11)</sup> In a meta-analysis including 9,113 subjects, the risk of diabetes was increased up to 2.4 times during a mean 8.1 years of follow up. A dose-dependent relationship was observed, and the hazard ratio for risk of diabetes mellitus for every 10 beats/min decrement in HRR was 1.29 (95% confidence interval, 1.13–1.48). One explanation is that the autonomic nervous system is important in modulating glucose metabolism. The parasympathetic nervous system stimulates pancreatic beta cells to release insulin, and the sympathetic nervous system inhibits insulin secretion but stimulates glucagon secretion from pancreatic alpha cells.<sup>12)</sup> HRR is associated with traditional cardiovascular risk factors. Although traditional cardiovascular risk factors are closely related to diabetes and metabolic syndrome, the prognostic value of HRR was considered to be independent of such risk factors.<sup>11)</sup> This is probably because HRR reflects cardiovascular fitness.

## POSSIBLE ASSOCIATION OF HRR WITH CAROTID ARTERY STIFFNESS

Yang et al.<sup>13)</sup> proposed the possible association between carotid artery stiffness and attenuated HRR in normotensive adults without significant atherosclerosis. In their results, decreased HRR was associated with brachial-ankle pulse wave velocity and post-exercise carotid arterial vasodilation assessed with ultrasound. Participant mean age was  $53 \pm 10$  years and 52% were men. Mean resting systolic and diastolic pressure were  $114 \pm 14$  and  $66 \pm 9$  mmHg, respectively. Mean HRR at 1 minute after peak exercise was  $39 \pm 11$  beats/min. In relatively young and healthy people, HRR may be associated with large arterial function. Although the mechanisms that explain the direct relationship between heart rate variability and aortic stenosis are unclear, the results of this study seem to be plausible because both HRR and carotid arterial stiffness are known to be risk factors reflecting cardiovascular outcomes.

In summary, attenuated HRR is a cardiovascular prognostic indicator that comprehensively reflects traditional cardiovascular risk factors, autonomic function, and cardiorespiratory fitness. The association with carotid arterial stiffness is plausible. Is large arterial function related to the autonomic nervous system in patients with hypertension? Further studies are needed to elucidate the detailed pathologic mechanisms.

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