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COMMENT

# Blood pressure variability and arterial stiffness: the chicken or the egg?

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**Keyword** Blood pressure variability · Arterial stiffness · Brachial-ankle pulse wave velocity

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Elevated blood pressure is the leading cause of cardiovascular disease, including coronary artery disease, stroke, heart failure, and atrial fibrillation. Although current guidelines for the management of high blood pressure recommend substantial approaches to prevent cardiovascular events, there is a persistent residual risk of cardiovascular events despite control of blood pressure to the target levels [1, 2]. It is well known that blood pressure fluctuates over time in a clinical setting. Several investigators have shown that higher blood pressure variability (BPV) is also an independent risk factor for cardiovascular events [3, 4]. Liu et al. demonstrated that high BPV is significantly associated with a higher risk of cardiovascular events in subjects with optimal blood pressure regardless of the presence of hypertension [5]. However, the underlying mechanism of the relationship between BPV and cardiovascular events is not fully understood. BPV is defined as blood pressure fluctuations over a defined period of time: very-short-term BPV (beat-to-beat), short-term BPV (within 24 hours), medium-term BPV (within days), long-term BPV (over months and years), visit-to-visit BPV (between clinic visits), and seasonal BPV [3, 4]. Multiple factors (environmental factors, mental health conditions, neuroregulation factors, hemodynamic factors, humoral factors, aortic compliance, systemic capacitance, and therapies) affect BPV [3, 4]. Effective treatment for high BPV is not yet well defined [3]. Several studies have demonstrated that BPV and arterial stiffness are closely related to each other [6]. Impaired arterial stiffness induced by arterial remodeling increases BPV due to reduction in arterial compliance and low baroreflex sensitivity [7]. On the other hand, higher BPV causes stress on the arterial wall leading to unfavorable changes in vascular function, increased extracellular matrix deposition, and enhanced proliferation of vascular smooth muscle cells and collagen fibers [7]. Therefore, it has remained unknow whether increased BPV is a cause or a consequence of impaired arterial stiffness (Fig. 1) [6, 7].

In this issue of Hypertension Research, Tian and colleagues reported the results of evaluation the temporal relationship between brachial-ankle pulse wave velocity (baPWV) and long-term visit-to-visit variability in systolic blood pressure over years in 6632 subjects [8]. Cross-lagged analysis was used to assess the temporal relation between baPWV and systolic BPV (SBPV). The authors showed that the path from baseline baPWV to follow-up SBPV has a more causal relationship than does the path from baseline SBPV to follow-up baPWV, suggesting that an increase in arterial stiffness precedes an increase in SBPV. This unidirectional relationship was found in subgroups of hypertension, without hypertension, controlled hypertension, and uncontrolled hypertension. In addition, the authors evaluated the temporal relationships of SBPV and baPWV on the incidence of cardiovascular disease (myocardial infarction and stroke). After adjustment for confounders, high baseline baPWV and high follow-up SBPV were significantly associated with an increased risk of cardiovascular disease compared with low baseline baPWV and low follow-up SBPV group (hazard ratio, 5.82; 95% CI, 2.50–12.60). The results of this study suggested that early interventions to improve arterial stiffness prior to worsening SBPV may be useful to prevent cardiovascular events.

Although Tian et al. have clearly shown that arterial stiffness is associated with subsequent high SBPV unidirectionally in subgroup analyses (hypertension, without

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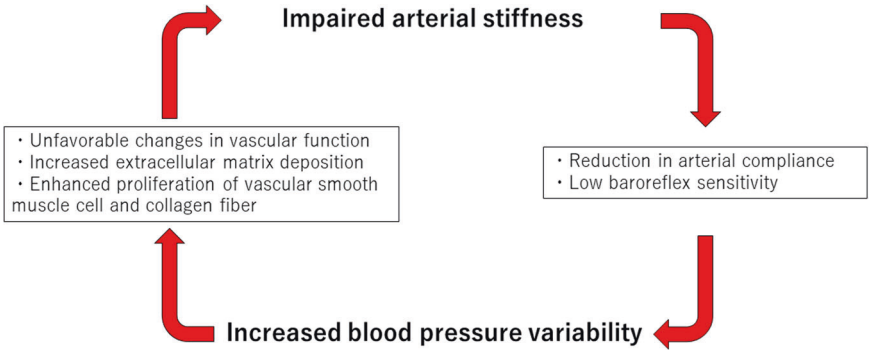


**Fig. 1** The relationship between blood pressure variability and arterial stiffness

hypertension, controlled hypertension, and uncontrolled hypertension), effective interventions to prevent or treat this phenomenon remain unknown [6]. Lifestyle modification, reducing sodium intake, physical exercise, antihypertensive drugs, and statins have been shown to improve arterial stiffness [9]. However, evidence regarding the usefulness of these interventions to prevent subsequent high BPV is still lacking. In addition, we need to investigate management strategies such as monitoring the interval of arterial stiffness, optimal timing of interventions for impaired arterial stiffness, and a method for evaluation of intervention effects to prevent progression of high BPV. To reduce the risk of cardiovascular events, questions on the potential of arterial stiffness management in early identification and prevention strategies for high BPV need to be answered.

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## Compliance with ethical standards

**Conflict of interest** The authors declare no competing interests.

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