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COMMENT

Can pulse transit time-estimated blood pressure become a savior for blood pressure research?

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Hypertension is one of the strongest risk factors for cardiovascular death [1]. The concept of blood pressure (BP) was first proposed by Dr William Harvey in 1628 [2]. Dr. Stephen Hales measured dog BP in 1706 (details unknown) and horse BP in 1711 using a method in which a brass tube was directly inserted into the artery of a live horse and connecting it with a glass tube, enabling measurement of the height of the blood column in the glass tube. In 1896, Riva-Rocci invented the cuff compression method for the upper arm, which is widely used today. The auscultation method was proposed by Korotkoff in 1905. Life insurance doctors have mainly investigated the relationship between mortality and BP ascertained using the Riva-Rocci-Korotkoff method with a mercury sphygmomanometer [3]. However, this method is being replaced by the oscillometric method due to the widespread availability of electronic sphygmomanometers and concerns regarding mercury pollution.

Using the Riva-Rocci- Korotkoff method with the oscillometric method, systolic BP is measured by stopping and resuming intermittent blood flow after wrapping a cuff around the upper arm [4]. The Riva-Rocci- Korotkoff method measures vascular sound, while the oscillometric method measures cuff pressure fluctuations that reflect vessel wall vibration. Commercially available monitors can also measure BP at the wrist or fingertips using the oscillometric method, but these measurements are considered inaccurate and prone to errors for anatomical reasons. Some commercially available smart watches even include oscillometric BP monitors, but these BP monitors have a common drawback. They cannot measure beat-to-beat BP because they measure BP using the response when the artery is compressed or released. It would be highly meaningful to determine the BP variability caused by cold, anger, or exercise [5].

Various methods have been proposed for performing noninvasive, continuous BP monitoring, one of which is pulse transit time-estimated BP (PTT-eBP) [6]. To contactlessly estimate BP without a cuff, we can calculate the pulse transit time, defined as the time delay between the R-wave of the electrocardiogram (from a chest lead of the electrocardiogram using amplitude and slope criteria) and the arrival of the pulse wave in the periphery (the peak value of the differentiated signal, corresponding to the steepest part of the ascent of the plethysmography signal at the finger) [7]. Despite various efforts to improve the accuracy of PTT-eBP, it is still an estimation of BP based on parameters correlated with BP. However, this does not mean that PTT-eBP is meaningless. The most significant feature of PTT-eBP is that it enables continuous and noninvasive measurement, which is not possible with the Riva-Rocci- Korotkoff and oscillometric methods. Although 24-hour ambulatory BP monitoring is widely clinically used to evaluate BP throughout the day [8], this method requires cuff compression for measurement, which can be taken once every 30 min at most. Therefore, it is not possible to evaluate BP changes in minutes or seconds. On the other hand, PTT-eBP could enable BP analysis by allowing continuous measurement—for example, to determine BP variability associated with emotions, due to cold or sleep apnea, and during intravenous antihypertensive treatment for hypertensive emergencies, which change rapidly in minutes or seconds. Such data are expected to provide new insights into the mechanisms of BP regulation and optimization of hypertensive treatment. Importantly, the ability to measure PTT-eBP 24 h a day, 365 days a year, could enable the acquisition of completely new knowledge about human BP, potentially opening a new era for hypertension research.

Furthermore, by spectrally analyzing systolic BP fluctuation [9] estimated by PTT-eBP, we can analyze the beat-to-beat BP fluctuation caused by sympathetic vasomotor activity.

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Comprehensive analysis of heart rate variability and BP variability will allow a detailed investigation of how BP variability is generated by vasomotor activity and respiration, which is sensed by arterial baroreceptors and then transmitted to the central nervous system through the parasympathetic nervous system, causing a reflex. Signals are sent to the heart through the sympathetic and parasympathetic nervous systems, contributing to heart rate variability. The arterial baroreceptor cardiac reflex can be analyzed. Real-time analysis of the arterial baroreflex under various conditions could theoretically support the idea of systemic hemodynamic atherothrombotic syndrome (SHATS) or dynamic surge BP produced by synchronized resonance [10].

Thus, it is important for us to understand exactly how PTT-eBP works, its limitations, and the differences between the BP estimated by PTT-eBP versus that measured by the Riva-Rocci- Korotkoff method and the oscillometric method. Most importantly, we must clarify the relationship between PTT-eBP and prognosis, i.e., mortality and morbidity of cardiovascular disease, and the differences between existing BP measurement methods for these purposes. Researchers must carefully conduct studies on PTT-eBP, as it may be the savior for stagnant hypertension research.

Compliance with ethical standards

Conflict of interest The author declares no competing interests.

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