Blood Pressure With a Click of a Camera?

See Article by Luo, Yang, and Barszczyk et al

n this issue of the journal, Luo et al¹ investigate the feasibility of noncontact blood pressure (BP) measurement using a smartphone camera. The potential of this concept is fascinating. Each time a person uses a smartphone, an application controlling the camera could continually search for opportunistic moments (eg, when the person is still) to make BP measurements. Such passive and frequent BP monitoring during daily life with devices that are already in the pockets of many could help improve on the currently low hypertension awareness and control rates around the world.²

Noncontact cardiovascular monitoring with basic video cameras is actually not new. The measurement principle is the same as reflectance-mode photo-plethysmography (PPG, which is employed by pulse oximeters) except that ambient light rather than a dedicated light source serves as the illuminator. The external light is mainly absorbed by melanin in skin and hemoglobin in cutaneous blood vessels, and the residual light is reflected back to the camera. Each recorded video pixel of the skin, therefore, includes subtle color changes superimposed on the average skin color that are inversely related to the pulsatile arterial blood volume. Video PPG waveforms at various skin locations may then be extracted from the image sequence by way of signal processing. Early investigators focused on noncontact measurement of heart rate with video cameras,³ and the Philips Vital Signs Camera application for heart rate monitoring was introduced a few years later in 2011.⁴ A natural extension to this work, which has clinical application, is noncontact screening of atrial fibrillation via detection of irregularly, irregular pulse intervals in the video PPG waveforms.⁵ Although video camera BP measurement is less obvious and would seemingly require a leap of faith, previous investigators envisioned such an application via the popular pulse transit time principle⁶ and particularly the time delay between video PPG waveforms from the face and hand or 2 locations on the face.7-9

Luo et al¹ may have conducted the largest study to date on noncontact BP measurement with a video camera. These investigators specifically used a standard smartphone front camera to extract video PPG waveforms from 17 facial locations and a volume-clamp, finger-cuff device to measure reference BP from of 1328 normotensive subjects. The investigators then applied machine learning techniques to 85% of these data to identify video PPG waveform features that best correlate with the reference BP measurements and develop a formula to convert these features to systolic and diastolic BP values in units of mmHg (ie, cuff calibration). They finally tested the developed method on the remaining 15% of the data while blinded to the reference BP measurements. Their most intriguing finding is that the method was able to estimate systolic BP better than a model based on basic

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https://www.ahajournals.org/journal/ circimaging demographic features and heart rate alone (precision error of 7.3±0.02 versus 8.9±0.0 mm Hg), thereby indicating that facial video may indeed contain some BP information. Although diastolic BP was hardly improved in this regard, the results suggest that the method may at least offer added value in detecting early development of isolated systolic hypertension.¹⁰ Another interesting point is that the most important features related to the video PPG waveform shape, amplitude, and energy rather than pulse transit time between pairs of video PPG waveforms from different facial sites.

However, the reported results may not necessarily translate in practice. As acknowledged by the authors, the smartphone video camera was employed in a highly controlled setting in which the phone was placed on a tripod with 2 external light sources side-by-side at a fixed distance from still subjects for a 2-minute period (see Figure 2). Furthermore, the subject population was almost exclusively East Asian, and the BP of the cohort was restricted by design to the normotensive range (100–139 mm Hg for systolic BP and 60–89 mm Hg for diastolic BP). Room temperature was also fixed at one study site but not the other. In the wild, head and phone motion, variable position and orientation of the camera with respect to the user, poor lighting, cold temperature, and dark skin are all real concerns that can make it virtually impossible to extract meaningful video PPG waveforms. Moreover, even if the video PPG waveforms were of the highest fidelity, an accurate mapping from video PPG waveforms to BP values over the clinical BP range may not exist due to nonspecific signatures of BP in the PPG waveforms. For example, both pulse transit time and pulse amplitude not only change with BP (the latter by way of cardiac output) but can also vary independently of BP due to vasomotor tone.^{6,11}

Nevertheless, the study of Luo et al¹ represents an auspicious start for video camera BP measurement. In addition to including heterogeneous subjects, future studies should focus on extracting all potential BP-related information from facial video, including the imperceptible head movements with each heartbeat (head ballistocardiography)¹² and even facial expressions. Such rich information in facial video may render this video camera approach to be more promising for BP measurement than a contact measurement of the finger PPG waveform.¹³ Of course, privacy concerns would also have to be alleviated. Importantly, a video camera method must be tested rigorously, such as through the standard protocol for assessing the accuracy of automatic cuff BP measurement devices, which involves diverse subjects and expert-operated auscultation BP measurements as the reference.¹⁴ However, the method should not be simply dismissed if it does not meet the conventional 5 and 8 mm Hg bias and precision error limits.¹⁴ The reason is that it affords the possibility of making numerous measurements over time, which can be averaged to not only mitigate the error but also to eliminate natural BP variations that occur within a person in daily life.¹⁵ In this way, the method may be able to provide a reliable estimate of the actual underlying BP of the person despite large errors in any one of its measurements. A method that may not be sufficiently accurate in this regard may still have clinical value if it could, for example, distinguish very high BP from normal BP with good specificity. Perhaps BP with a click of a camera is not that far-fetched after all.

ARTICLE INFORMATION

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