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Assessing Vascular Health via Applanation Tonometry

Jamie F. Burr[1]

Abstract

The purpose of this article is to give a brief background to the use of applanation tonometry for measuring arterial compliance from a health and research perspective. A methodological description for using automated applanation tonometry in a health care or research setting is provided.

Background

The assessment of blood pressure has long been included in medical screening with the understanding that high blood pressure, or hypertension, is a major cardiovascular risk factor. More recent advances in cardiovascular monitoring allow for the non-invasive quantification of the mechanical characteristics of the systemic vasculature, such as the distensibility of large arteries which effectively dampen the pressure difference between systole and diastole (the Windkessel function). Arterial compliance of the larger arteries can be measured by applanation tonometry using a peripheral artery and applying a generalized transfer function to estimate central artery distensibility.

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From the [1]Physical Activity and Chronic Disease Prevention Unit, and the Physical Activity Support Line, Vancouver, BC CANADA
email: j.burr@physicalactivityline.com

Applanation tonometry is a non-invasive method of measuring arterial compliance, most commonly at the radial artery. The term applanation tonometry comes from the words "applanate" which means "to flatten" and "tonometer" which is a device to measure tension or pressure.

Arterial compliance is associated with factors such as increasing age (Otsuki et al., 2006; Van Bortel and Spek, 1998), increasing blood pressure (Nichols and Edwards, 2001; O'Rourke, 1989) and propagation of atherosclerotic plaques (Giannattasio et al., 2001; Syeda et al., 2003). Poor arterial compliance, or arterial stiffness, leads to increased cardiac afterload with increasing systolic pressures (O'Rourke, 1990). It has been shown that stiff arteries result in a faster pulse wave velocity, and consequent return of waves that have been reflected by the periphery, which meet during late systole rather than early diastole (O'Rourke, 1990) and increase the work of the heart. Furthermore, increased stiffness has been shown to decrease coronary blood flow (Watanabe et al. 1993) and a combination of these factors pre-disposes to adverse cardiac events. However, regular aerobic physical activity (but not high intensity resistance training (Miyachi et al., 2004)) has been shown to be effective in the prevention of arterial stiffening and decreasing pulse wave velocity (Hayashi et al. 2005; Sugawara et al. 2004). Based on the accumulation of experimental and epidemiological data, it has been suggested that screening for large artery distensibility may be an important component of cardiovascular disease detection and prevention (Tsai and Yucha, 2001). It has been shown that the absolute numbers for arterial compliance measured using non-invasive applanation tonometry do not identically match arterial compliance values measured using invasive techniques; however, the general characterization of abnormality is suggested to be sufficient to warrant the widespread use of this technique (Cohn et al., 1995). Karamangolu and colleagues have shown use of a generalized transfer function to accurately (>90%) generate an aortic waveform from the radial artery (Karamanoglu, et al. 1993).

Methods

Today, there are multiple automated systems available (e.g. HDI CR-2000, Sphygmocor), which estimate central arterial compliance using differing methodologies. Nevertheless, the systems function similarly, with the tonometry measurement executed on the radial artery, and calibration pressures (if necessary) measured using brachial blood pressure measures from the other arm. The following methods provide a general description for use of an automated applanation tonometry device. For an in-depth review of methodological considerations, readers are referred to the Expert consensus document on arterial stiffness: Methodological issues and clinical applications (Laurent et al., 2006).

Preparation: Allow your participant (or patient) to lie supine on the examining table in a comfortable position avoiding awkward postures and crossing of the legs. Similar to other blood pressure measurements, the participant should be given a period of quiet relaxation (i.e 5-10 minutes) prior to measurement and the environmental conditions (i.e. temperature, humidity, ambient noise) should be controlled. Participants should be advised against the use of stimulants such as caffeine, nicotine, and exercise for at least 3 hr prior to the test.

Measurement: Locate the patient's radial artery by palpation of the wrist using your index or middle finger. The area with the strongest pulse within approximately 1 inch (2.54 cm) of the base of the thumb should provide the strongest signal. The head of the tonometer should be placed at this location, preferably over a portion of the artery not surrounded by excess soft tissue. The location and pressure of the sensor should be adjusted until a sufficiently strong signal is apparent (according to manufacturer guidelines) and a clear and consistent waveform is displayed. This should include a smooth systolic and diastolic contour and a clearly identifiable dicrotic notch (Figure 1). Due to the effects of aging on arterial mechanics, these features may be less obvious in older subjects compared to young; but a clean, consistent waveform and sufficient signal strength (typically >10%) should still be obtained.

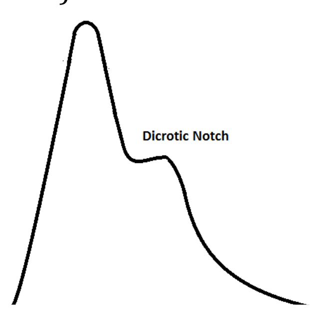

Figure 1. *Representation of a clear pulsewave with a plainly identifiable dicrotic notch.*

Once these conditions are met, you may initiate data recording. While collecting data, do not speak to the participant, avoid other excitatory stimuli and do not allow the participant to sleep as these factors can affect nervous tone and cardiovascular function. If possible, collect more than one measure, as you would for blood pressure, to help control for measurement error.

Conclusion

Automated applanation tonometry is a relatively simple and non invasive cardiovascular measure, which has the capacity to provide more insight into cardiovascular health than traditional measures alone. Especially considering the growing popularity of automated machines, it is likely that the widespread use of arterial compliance measurements will become a common component of cardiovascular screening batteries in the future. Many automated units also give estimates of related cardiovascular parameters (such as cardiac output, stroke volume, ejection time and systemic vascular resistance) and offer further easily obtainable cardiovascular function data at rest. However, the validity and reliability of such measures remains to be conclusively demonstrated. A greater understanding of cardiovascular health will allow researchers, physicians, health-care providers and exercise physiologists/therapists to further individually tailor investigations and interventions (i.e. exercise and pharmaceutical doses or rehabilitation programs) in a way that will target cardiovascular risk factors most effectively.

Qualifications

The author's qualifications are as follows: Jamie F. Burr Ph.D. CSEP CEP

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