The Measurement of Arterial Properties In Hypertension

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This issue of the Journal contains an article comparing the usefulness of differing methods of measuring arterial compliance in predicting changes in the heart. More such articles are on the way, and therefore, it seems timely to briefly consider the growing role of arterial compliance as a marker or surrogate for vascular involvement in hypertension and other conditions affecting the cardiovascular system.

The discipline of Hypertension traditionally has been based on the concept that high blood pressure, at least on a population basis, is predictive of an increased probability of major cardiovascular and renal events. Not only do epidemiologic data support this view, but clinical trials have indicated that the therapeutic reduction of blood pressure decreases the incidence of adverse outcomes and improves survival in hypertensive patients. On the basis of these observations, guideline committees have been able to propose specific levels of blood pressure at which hypertension should be diagnosed, and have also advocated specific blood pressure targets that should be achieved during the treatment of hypertension.

Recently, it has become clear that systolic blood pressure may be a better predictor of prognosis in hypertension than diastolic pressure, and the pulse pressure, obtained by subtracting the diastolic from the systolic values, may be the best of all. The explanation for the importance of pulse pressure is that a high systolic pressure coupled with a low diastolic pressure is indicative of stiffening of major arteries and the presence of ongoing vascular disease. This measurement, however, appears to be of greatest value in older people and may not identify early stages of disease when intervention may be most effective in preventing or modifying hypertension.

Focus on the Arteries

Direct measurements of the structure and function of key arteries appears to be an attractive way of evaluating hypertension. After all, although blood pressure in broad terms helps to define risk, it is not always a reliable predictor of cardiovascular events in the individual. In addition, high blood pressure often is found as part of a risk cluster. For example, lipid abnormalities, changes in insulin metabolism, and even increased thrombotic tendencies are frequent associations of high blood pressure and can also produce or exaggerate the progress of arterial disease. Smoking is another common finding with adverse vascular effects.

For this reason, a measurement that reflects the state of the arteries potentially could represent the common factor that includes these and other findings that predispose to cardiovascular disease. It is not clear how these various stimuli can produce stiffening of arteries or—to use the more common expression—reduced arterial compliance, but it is likely that a key mechanism may be the endothelial dysfunction with which these changes are commonly associated.

Arterial Compliance

The concept of using arterial compliance as a marker for cardiovascular changes is still evolving, and therefore it is of no surprise that there are still disagreements as to the optimal methods for measuring this index. There are some obvious difficulties. For example, the arterial circulation is not uniform; there are clear differences in structure and function between large conduit arteries, mid-sized arteries, and the small precapillary vessels. Indeed, although the aorta and small caliber arteries tend to stiffen with hypertension, there is actually an increase in compliance or distensibility of some mid-sized vessels.

Unfortunately, definitions of compliance can get complicated. Strictly speaking, the measurement of arterial compliance depends on volume:pressure relationships, and normal compliance is associated with the ability of vessels to distend and contract appropriately in response to these changes. What adds further complexity, however, is that these relationships within arteries differ according to the level of the blood pressure, and so, it is difficult to fully interpret a compliance value without at the same time adjusting for the pressure within the vessel.
Clinical Relevance

Given the technical nature of the concepts surrounding compliance, and the varying methods used to measure it, it may be illustrative to link compliance measurements to other indices of cardiovascular risk. But the article in this issue of the American Journal of Hypertension has demonstrated that even this approach can be complex. This new study has evaluated the relationships between three different methods of accessing arterial compliance and risk markers such as age (which is known to increase arterial stiffness), serum creatinine (an index of renal function), HDL-cholesterol, and tobacco consumption. Interestingly, these known determinants of cardiovascular outcome were found to be clearly associated with such simple compliance indicators as pulse pressure and pulse wave velocity (which increases as a function of arterial stiffness, and thus is a useful measure of arterial change). On the other hand, a different but well-respected method of assessing the arteries, namely carotid wave reflections that depend primarily on the degree of stiffness of the peripheral arterial circulation, did not appear to be associated with the other cardiovascular risk factors.

Another very recent article that looked at pressure-dependent and pressure-independent measures of arterial stiffness found that these differing approaches were clearly not equally predictive of echocardiographic measurements of the left ventricle. Surely it should not be surprising that separate techniques that examine such diverse parts of the circulation as the carotid arteries, the aorta, the brachial, and the radial arteries provide different and apparently inconsistent measures of compliance. And, yet again, the more simple systemic approaches like pulse pressure or the ratio of cardiac stroke volume:pulse pressure (sometimes termed total arterial compliance) appear to provide insights into completely different aspects of the circulation. It is obvious that this multiplicity of methods can cause confusion; but, at the same time, it provides exciting evidence of the rapidly growing interest in the concept and relevance of arterial compliance.

It is important to note that arterial compliance is related to key physiologic determinants. For example, a compliance method known as pulse contour analysis, which is predicated on the Windkessel model of the circulation, relies on an advanced mathematical analysis of the diastolic decay portion of the arterial pulse wave. This approach separately estimates the compliance of the large proximal circulation and the small distal circulation, and has linked these findings to plasma measurements of catecholamines, renin, lipids, and insulin and to blood pressure. Such conditions as congestive heart failure and diabetes mellitus, or the administration of hormone replacement therapy, also influence these compliance measurements. Moreover, in healthy volunteers this technique has demonstrated a reduction in compliance in those individuals with a family history of hypertension, suggesting that this technology might be able to identify patients at risk of cardiovascular events even before conventional clinical abnormalities can be detected.

Recently, the total arterial compliance approach (stroke volume:pulse pressure) was the first compliance method shown to be predictive of long-term cardiovascular prognosis. This method has also helped point out other interesting findings. For example, in obese patients it was noted that a primary determinant of arterial compliance was the plasma insulin concentration, whereas in lean hypertensive patients norepinephrine was more important. Using other methodologies, it has also been possible to study the differential effects of cardiovascular drugs on arterial compliance.

Are we Ready for Routine Compliance Measurements?

We should not be discouraged by the diversity of methods currently being offered for measuring arterial compliance, nor should we be discouraged by apparent inconsistencies among these approaches. As we become more sophisticated in our understanding and use of these methods we will learn how each of them can teach us something different and potentially valuable about the cardiovascular system.

Two conclusions are already possible. First, that arterial compliance is a physiologically and clinically relevant approach to the assessment of the cardiovascular system. Whether we choose to use measurements of arterial compliance as indicators of cardiovascular risk or as indicators of ongoing cardiovascular damage, or both, it is evident that these simple and inexpensive technologies could be of considerable value to the clinician. It is already easy to see how measurements of arterial compliance can help with the diagnosis of such conditions as hypertension and, perhaps more important, in providing a staging system for determining the degree of vascular involvement.

The second major potential for this approach lies in gauging the progress of therapy. It would be helpful and reassuring to know that the treatment of such conditions as hypertension, lipid disorders, or diabetes mellitus in individual patients is associated with improvements in arterial compliance. And, as soon as possible, it would be highly desirable to measure arterial compliance as part of controlled clinical trials with major cardiovascular end points so that we can determine whether monitoring compliance provides a reliable indicator or surrogate for clinical events.

References


