Arterial Stiffness and Pulse Wave Velocity: Problems with Terminology

To the Editor:

It was with interest that we read the recent article by Safar et al. We fully agree with the authors’ emphasis on the importance of studying the mechanical properties of arteries and the potential for risk factor stratification provided by the derived information.

A number of points require clarification. The authors state, “arterial stiffness [is] usually expressed in the quantitative terms of compliance and distensibility.” Compliance (a change in volume or cross-sectional area for a given change in pressure) and distensibility (a fractional change in volume or cross-sectional area for a given change in pressure) are parameters that can be quantified and have units of measurement. Arterial stiffness, on the other hand, is a purely descriptive term that cannot be measured or quantified. Arterial stiffness cannot, therefore, be quantified in terms of compliance and distensibility, as implied in this article.

The authors also state that arterial stiffness is measured from aortic pulse wave velocity (PWV). PWV provides information on the time taken for a pressure or flow wave to travel a known distance. This value provides an indirect measure of a change in the mechanical properties of a vessel segment. Thus, an indirect assessment of the physical properties of arteries is being used to provide information about a mechanical descriptor, arterial stiffness, which, as stated, is neither measurable nor quantifiable.

Constructing the association between stiffness and PWV is unnecessary, as the latter is related to the intrinsic properties of arterial wall materials via the Moens-Kortweg formula, as follows: \( \text{PWV} = \sqrt{\frac{E h}{\sigma R}} \), where \( E \) is Young’s Modulus of the arterial wall, \( h \) is wall thickness, \( R \) is arterial radius at end-diastole, and \( \sigma \) is blood density. Using this formula, it can be appreciated that PWV is proportional to the square root of the elastic modulus, a recognized descriptor of the mechanical properties of arteries that can be quantified. However, the square root relationship also means that a change in PWV is not a particularly sensitive measure of change in physical arterial properties.

Clearly, determination of the mechanical properties of arteries has potential for targeting cardiovascular risk and guiding treatment intervention. Care must be taken when using terms that are used with respect to mechanical properties interchangeably, as they provide different information about the physical properties of the circulation. Consensus in this area is needed to avoid confusion and will help the future integration of these mainly research techniques into wider clinical practice.

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Response

We thank Dr. Hughes et al for accepting the idea that determination of the mechanical properties of arteries has the potential for targeting cardiovascular risk and guiding treatment intervention. This aspect, together with the role of wave reflections as signals enabling a cross-talk between macroand microcirculation, was the principal goal of our report.

The clarifications of Dr. Hughes et al on arterial stiffness, compliance, distensibility, and Young modulus are right. In fact, all these parameters have been well known and clearly defined for at least the second half of the 20th century. Excellent recent publications have even appeared on the subject. Our aim was not to define these parameters again but rather to discuss and promote their use in routine medicine.

Finally, we note that the discussion proposed by Dr. Hughes et al involves also a semantic aspect. None of the authors of the published report wrote in his own language. For instance, in French, the sentence “arterial stiffness (or elasticity) may be expressed quantitatively in terms of compliance and distensibility” makes sense. In contrast, the explanation of the Young modulus from the Moens-Kortweg equation is certainly a better approach but does not help to clarify the main message of the manuscript.

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