Letter to the Editor

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Wall Viscosity of the Stented Arteries

To the Editor:

In the November 2003 issue of Stroke, Vernhet and colleagues reported a clinical analysis of wall mechanics in stented extracranial carotid arteries, and they concluded that stenting of these arteries induces a compliance mismatch between the native and the stented artery. Additionally, the authors observed a significant decrease in the distensibility coefficient of the stented region.1 These are remarkable findings and are in accordance with others, in which the mismatch observed between the mechanical properties of the prosthetic graft and that of the adjacent native artery is conducive to the development of distal anastomotic intimal hyperplasia.2

However, the study of Vernhet and coworkers did not reflect wall mechanics of stented carotid arteries as is suggested in the title. A complete mechanical study involves a characterization of geometric, elastic, and viscous properties of the arteries that can be performed in patients on the basis of noninvasive recordings of pressure and diameter pulses as previously reported.3 Actually, viscoelastic properties of the arterial wall play a significant role both in normal and pathological vessels, and are better characterized by indices such as the incremental elastic modulus (Einc) and Peterson modulus (Ep), because these are not affected by dimensional changes.4

As published, pressure wave propagation in arteries depends on both elastic and viscous parameters counterbalancing possible instability phenomena.5 Arterial wall elasticity is found to be related to the amplitude of oscillations whereas viscosity attenuates high frequency pulsations. Consequently, the mechanical response of a viscoelastic material depends both on the force applied (elastic response) and on the time it acts (viscous response).

To the best of our knowledge, arterial wall viscosity and elasticity have mutual dependence. In fact, in 1961, Bergel found that the relation between arterial wall elasticity/viscosity was remarkably similar within the studied frequencies (5 to 18 cycles/second) in an in vitro study.6 This is in accordance with our unpublished results obtained in ovine arteries. We calculated arterial wall viscosity using the hysteresis of the pressure-diameter loop and arterial wall elasticity using Einc and Ep. In these studies cross-sectional compliance did not appear to be a good marker of mechanical properties of the arterial wall. Because arterial compliance could yield spurious results, as it is highly dependent on pulsatile cross sectional area, the elastic mismatch should be characterized using a dimension independent elastic index such as the Einc or the Ep.

Arterial wall viscosity has been demonstrated to be related to vascular smooth muscle activation.5 In stented arteries, smooth muscle activity is inhibited. This is not a minor subject, because the decreased elasticity together with the lack of viscosity in the stented region might enhance the reported mismatch, avoiding the counterbalancing effect.

Finally, we agree with the authors, that compliance mismatch is often reported in the literature to characterize vascular dynamic behavior. Although they insist in this article on considering their study as a mechanical analysis, our reports and many others have stated that arterial compliance is only one of the many indices. Furthermore, some indices (like Ep) can be obtained noninvasively.

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Response:

First of all, we must thank the authors of this letter for their very clever and constructive comments. Of course, we do agree with them when they state that ours was not a (comprehensive) mechanical analysis of the stented artery. We could only assess some relevant if not fully descriptive parameters, and confirm the compliance mismatch that had been previously demonstrated in more or less comparable situations. By the way, we relied on the distensibility coefficient rather than on compliance only. On the other hand, only a few parameters can be noninvasively assessed in patients, and the stented carotid artery is not easily accessible for accurate and complete measurements. Direct blood pressure measurement should be essential here but could not be performed, for obvious ethical reasons. That is why we used alternative (experimental, on the rabbit aorta, and mathematical) models to investigate such complex and intricate problems. In some other clinical settings, for instance, pulse wave velocity is a useful, although “old” parameter, since it is viscosity- and therefore frequency-dependent. We were aware that stenting would also affect viscosity and that this change would not lead to any counterbalancing effect.

We will certainly take a deeper look at the authors’ work and reports, and keep in touch for further discussion.

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