experience, LRVD without reconstruction is only indicated during emergency aortic surgery. Re-anastomosis of the LRV is a relatively simple procedure and we think that except in the previously mentioned situation (emergency) there should be no reason not to reconstruct it. If we cut something, we are obliged to repair it. However, reconstruction is necessary, especially in patients with signs of chronic renal insufficiency and in cases of intraoperative huge renal vein finding, which suggests compensatory enlargement due to venous drainage problems. If reconstruction is not possible it’s of huge importance to preserve the gonadal or suprarenal vein. At the same time, these procedures do not affect early and late renal function. We found that LRV temporary transection and re-anastomosis did not have any influence on early and mid-term renal function.

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Re ‘How Should We Measure and Report Elasticity of Aortic Tissue?’

We read with interest the article by Khanafer et al. but found that it contains many incorrect or misleading statements, interpretations, and conclusions concerning stress, strain, and elastic modulus measures that are used to analyse the elasticity of aortic tissue. Because of limited space we quote only one example, from the Abstract: “We found that the Almansi-Hamel strain definition exhibited the highest non-linear stress-strain relation and consequently may overestimate the elastic modulus …”. This is misleading because there are simple connections between the elastic moduli associated with different stresses and strains. They all carry the same information.

The strain measures used in Khanafer et al. are members of the family \((\lambda^m - 1)/m, m = 1,2, -2,0\). The stresses \(\sigma_y, \sigma_x\), and \(S\) are related by \(\sigma_y = \lambda \sigma_x = \lambda^2 S\). For the engineering strain the elastic moduli associated with these stresses are \(d\sigma_y/d\lambda, d\sigma_x/d\lambda\) and \(dS/d\lambda\), respectively, and they are simply related by

\[
\frac{d\sigma_y}{d\lambda} = \lambda \frac{d\sigma_x}{d\lambda} + \sigma_x = \lambda^2 \frac{dS}{d\lambda} + 2\sigma_x. \tag{1}
\]

Equation (1) scales by a common factor \((\lambda^{-1}, \lambda\) or \(\lambda^2\)) for each of the other strain measures. As \(\sigma_x\) is positive, it follows from Equation (1) that the patterns shown in Fig. 5 are immediately obvious. A similar pattern to that in Fig. 5 appears in the first two panels of Fig. 4, which relates to the so-called hypertensive elastic modulus (not defined), although it has been stated that the differences in the elastic moduli are not significant. They are, but those in the third panel of Fig. 4 are not. However, the data therein are not consistent with Equation (1) and cannot be correct (the true stress modulus must be larger than the engineering stress modulus by definition). The “errors” referred to in Table 3 are not errors. The differences are merely manifestations of the connections (Equation (1)).

The stress—strain plots in Fig. 3 are substantially redundant and also misleading as, for example, each of the 12 plots in (a) contains the same information; the changes from engineering stress to the true stress and the second Piola-Kirchhoff stress merely involve scaling of the vertical axis by \(\lambda\) and \(\lambda^{-1}\), respectively, and the four curves in each panel of Fig. 3 are equivalent because they simply translate from one to the other by a change of the strain, that is by a nonlinear scaling of the horizontal axis. The figures in Fig. 3 are not needed to elaborate the obvious fact that the stress—strain curves and “the elastic modulus” are very dependent on the choice of variables.

Contrary to the assertion of the authors, the choice of stress, strain, and elastic modulus measures is not important for the analysis because there are simple connections between them. In any case, the concept of elastic modulus is not useful in nonlinear mechanics. What is really needed is an explicit nonlinear relation between stress and strain, that is a constitutive equation, that characterizes the material properties of the soft tissue in question. Also, one-dimensional tests yield very limited information about tissue mechanical properties. To assess more fully the elastic properties of, for example, aortic tissues, multi-dimensional
tests are required. Importantly, these can determine, in particular, whether anisotropy is present.

Any measure of stress has to be calculated from the measured force. The most common stress used in experiments in nonlinear mechanics is the engineering stress as it requires knowledge of the undeformed cross-sectional area of a specimen, which is usually accessible (unlike the deformed cross-sectional area required for the true stress favoured by the authors). The measure of deformation that is determined directly from experiments (in one dimension) is the stretch (not the true strain), and experimental results plotted on the basis of engineering stress and stretch are the easiest to interpret, as is well known in the biomechanics community.

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Response to ‘Re. How Should We Measure and Report Elasticity of Aortic Tissue?’

Several investigations have been conducted to measure the mechanical properties of human tissues in vitro both uni- and biaxially. In reviewing the existing results on the mechanical property measurements in these studies, we noticed that different stress—strain definitions were used by many authors to determine the elasticity of the wall of aneurysms without any explanations. Such definitions include “engineering stress-engineering strain”, “true stress-engineering strain”, “true stress—Almansi-Hamel strain”, “2nd Piola Kirchhoff stress—Green St. Venant strain”, and “true stress—Green St. Venant strain”.

It can be noted from above that there is no agreement as to which stress—strain definition should be implemented. The conclusions of our study apply whether uniaxial or biaxial is used when reporting elastic values of aortic tissues. Our study focused on comparing different stress—strain definitions, and it applies to both uni- and biaxial tests. Although constitutive equations are important in numerical models to describe correctly the behavior of tissues under various loads, they cannot be used when working on a bench top model.

It would be useful for clinicians to have an agreed definition of the stress—strain model in order to interpret the reported results of measurements of elasticity by different researchers. The purpose of our study was to show how the various definitions of stress—strain used provide different results, and to recommend a specific definition when testing aortic tissues.

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