Engineering cardiac and aortic procedures

To the Editor:

We read with great interest the work by Okamoto and coworkers¹ that illustrates, using state-of-the-art 3-dimensional reconstruction and computational techniques, the mechanical properties of the dilated ascending aorta in various clinical settings.

With the objective of a more accurate prediction of rupture than methods on the basis of aortic diameter alone, once more² this group offered us the tools, the numbers, and the opportunity to reason in a new way about aortic wall stress.

The premise of the biomechanical approach is that aneurysm formation and enlargement are accompanied by an increase in wall stress in contrast to the ability of the aortic wall to withstand these stresses (failure strength). This is not new in the sense that the concept of "wall stress" already belongs to our decisional algorithms; however, studies such as the one of Okamoto and coworkers¹ illustrate that the law of Laplace, strongly implemented in our clinical reasoning, appears insufficient to provide estimates of complex stress distributions.³

Despite the intrinsic oversimplification of the problem, within definite boundaries, Laplace's law might still constitute a useful abstraction. However, when it represents the theoretic justification for major surgical procedures, these, in the light of recent biomechanical insights, require critical revisitations and new validations.

This is the case of reduction plasty, external reinforcement (wrapping), or plicature procedures (not only of the aorta) conceived with the goal to reduce wall stress by reducing the diameter according to Laplace's law.

As suggested by the findings of this study, the variations of strain-stress forces within the aortic wall vary also along its thickness in function of macroscopic geometric parameters; this is a further example of the complexity of the problem. It is easy to hypothesize, in the light of the presented data, that operations conceived to reduce aortic diameter and consequently the risk of aneurysm rupture might paradoxically favor acute dissection by increasing the wall stress at the level of internal aortic layers.

Clinical applications of finite element analysis therefore lead to the possibility to

simulate and test newly engineered surgical procedures.

We cannot foresee whether, in the future, biomechanical engineers will be actively involved in patient care or surgeons will be required to develop new clinical sensibilities related to cardiovascular mechanobiology. However, new tools are required to interpret structural conformations, to modify them by means of surgical procedures, and ultimately to support a renovated clinical awareness.

Despite some necessary model approximations, Okamoto and coworkers¹ superbly illustrate that to achieve clinically meaningful results, an engineering approach requires a comprehensive experimental knowledge of the material to be modeled, a physical model that captures the essential mechanical characteristics, and an efficient numeric model.

This is a nontrivial challenge: the mechanical properties of arterial walls are governed by a complex 3-dimensional network of structural proteins, making the aortic tissue an inhomogeneous, anisotropic, nonlinear viscoelastic material. New techniques, such as those shown in the study, enable the computation of meaningfully local stresses and strains in the wall. These are crucial for the understanding of the interaction of mechanical quantities with associated biologic responses.

However, the size and complexity of medical data sets resulting from 3-dimensional numeric simulations in computational biomechanics will make it increasingly difficult to understand, compare, analyze, and communicate the data. Representing complex material properties as a single image improves the perception of features and pattern in the data, enables the recognition of a relationship between different measures, and facilitates the navigation through and interaction with complex and disparate sets of data.

New scientific visualization tools constitute the interface between the computation specialists and medical professionals and represent the pentagram of a new clinical sensibility. It is realistic to imagine that, in the near future, each level of investigation, zooming from macroscopic organ geometry to elementary cellular biomechanics, will be organically modeled and synthetically visualized.

Extracting the more meaningful components from large datasets and generating

their representations provides an immense quantity of information in an intuitive way. Brilliant examples with tensor field visualization methods illustrate how this Copernican revolution regarding organ structure and function has already taken place.⁴

However, the prerequisite for the diffusion and user-friendly application of these techniques requires that medical professionals begin to feel the need to measure other things than aortic diameter or ventricular volumes, to think in a more complex manner, and to take full advantage of these major technology breakthroughs to find their answers.

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Lower lobe segments and pulmonary sequestrations

To the Editor:

We read with a great interest the article by Wandschneider and Illiasch entitled "Intralobar sequestration: a rare cause of severe hemothorax."¹ We thank you for the interesting subject. We have a comment about what you called the median segment of the left lower lobe. To the best of our knowledge and according to the Jackson and Huber classification of 1943, the Boyden classification of 1945, the ad hoc international committee meeting at the time of