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The architecture of the mammalian left ventricle: Similarity with a bird's nest?

In order to demonstrate the hierarchically ordered connectivity of the left myocardium, gentle inflation by compressed air and subsequent CT-based analysis was performed on excised pig hearts. Perimysial spaces become thereby visible and allow demarcating lamellar segments. In addition to the well-known global helical pattern of the spatial direction field, a quite inhomogeneous arrangement with respect to lamellar segment orientation manifests itself. In particular, up to 30% of the lamellar segments deviate significantly, by more than 10° (up to 45 and more degrees) from a surface-parallel direction. Visual impression might in fact suggest some similarity with a bird's nest. These findings along with force measurements made in the ventricular wall can be interpreted as follows. First, constrictive units with a primarily transmural orientation counteract to some extent systolic constriction and act in an antagonistic fashion. This feature may on the one hand be protective (excessive deformations are avoided), on the other, modulation of wall thickening according to local conditions is enabled. Second, architectural variations are expected to be such as to prohibit local stress concentrations and equalize overall loading conditions. Geometrically regular fiber architectures were examined in the form of mathematical models that showed, among other, that even slight disturbances of a regular pattern lead to a significant loss of cardiac performance. In contrast, in case of architecture involving appreciable stochastic local aberrations, even large changes seem to have a minor effect on the ejection fraction thereby stabilizing ventricular function over a wide range of physiological conditions.

Biography

Peter F Niederer is an Emeritus Professor at the Institute of Biomedical Engineering, ETH Zurich, Switzerland. He is also the President of the IT'IS Foundation.

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