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An Application of Mathematical Physiology to the Study of Heart Failure

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Based on the theory of large elastic deformation, a mathematical expression describing a non-linear model of the end-systolic pressure-volume relation (ESPVR) in the heart ventricles has been derived. Relations between ejection fraction (EF) and the parameters describing the ESPVR were used to obtain new indexes that can be used to assess the performance of the heart ventricles, those indexes offer a new approach for the understanding of the problem of heart failure with normal or preserved ejection fraction (HFpEF). The new indexes are based not only on the calculation of the change of the geometry of the ventricles, but also on the pressures acting on the myocardium and the areas below the ESPVR that have units of energy. Calculation can be performed in a non-invasive way when ratio of pressures is used. Applications published in the literature to a wide range of clinical data show consistent results that can be used for prognostic, diagnostic and monitoring of patients. Results show that the EF is just one of several indexes that can be used to assess the ventricular contraction, and that bivariate (or multivariate) analysis of indexes is superior to univariate analysis for the purpose of segregation between different clinical groups. The work is an example that shows the impact that mathematical physiology has on medicine, similar to the impact that mathematical physics had on the advancement of experimental physics.

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