P2-11

Statistical Analysis of Volume Time Curves for Multiple Imaging Methods

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Introduction: Real-Time-3D-Echocardiography (RT3DE) offers the opportunity to determine cardiac volumes non-invasively and display their behaviour during the cardiac cycle. Volume time curves (VTC) express volume trends over time and comprise important information about systolic and diastolic function. However, data interpretation and statistical comparisons of VTCs derived from different devices such as cardiac magnetic resonance imaging (CMR), RT3DE or conductance technology and comparison between different software tools is complex. Standard statistical methods have not been developed so far. Objective of our study is to develop a mathematical approach to analyse, characterise and compare VTC. Methods: First, we want to apply pattern recognition and statistical algorithms to compare different VTC. We use a cluster analysis to detect similar VTC and group them into clusters. Subsequently, they are compared using the Euclidean distance and the dynamic time warping (DTW) algorithm. Each of the resulting clusters will be analysed with respect to the patients' data, such as heart size and anatomy. Additionally, a discrete Fourier transform decomposes the VTC into complex sinusoids, which are resembled by a list of coefficients. These coefficients are features of the VTC, which are easy to compare quantitatively. For the investigation of the coefficients, classification and filtering algorithms can be applied to group VTC regarding their frequencies. Results: A first clustering with a set of 16 different VTC derived from RT3DE has been established. Furthermore, the DTW algorithm has been used to detect the optimal non-linear alignment between two VTC and calculates a cost matrix and warp path, which are shown in the figure. Conclusions: This approach for data analysis can be used to recognize patterns and features of VTC. Characterization of systolic and diastolic functionality can be used to described and assess pathologies or dysfunctions of the heart. Furthermore, it could allow to compare different measurements from CRT, RT3DE or conductance technology to evaluate the quality of each device. In terms of "big data" it paves the way for modelling of heart failures based on non-invasive methods and provides a fast data analysis.