Visualization in four dimensions of the left ventricle of the heart on a healthy patient

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Introduction The video film presented here concerns the preliminary results to visualize the left ventricle of the heart in four dimensions (volumic and temporal deformations) from ultrasound images obtained with a rotating probe developed specially for this application.

Material and method This study is carried out on an ultrasound image sequence of the heart acquired with a high resolution rotating probe. The innovative feature of this ultrasound scanning probe is the fast rotation of the piezoelectric sensor around the main axis of the probe. As the axis of the probe is practically aligned with the axis of the ventricle, each image represents a meridian cross section. About a hundred digital images are recorded at each examination. The first stage consists in segmenting manually these images with a specific software to extract the successive contours of the left ventricle. These 2D contours are then mapped onto fixed system coordinates which are the non-rotating parts of the probe. The deformations of the left ventricle are supposed to recur similarly during all the examination, thus permitting to group the contours in a single cardiac cycle. Visualization of the volume is obtained by interpolating then smoothing between all the contours. The deformations of the ventricular volume can then be observed during a cardiac cycle. The approximations are visualized by mapping the 2D contours onto the 4D volumes. This method allows to calculate directly the volume for each image acquisition and the ejection fraction on a cardiac cycle.

Results During the examination done on a healthy patient, the probe did four rotations per second with the direction inverted every other rotation. With images acquired at 42 frames per second, 106 images were stored during two and a half cycles ; the duration of each cycle was different. The volumes are correctly visualized and present results indicate that the volume variation curves associated to a cardiac cycle give an ejection fraction of 0.60.

Conclusion The results shown here will be improved by semi-automatic segmentation of the images, requiring only minor manipulations by the operator. In order to validate the data mapping over several cycles, similarity criteria of the deformations will be defined and included.