AN UNSUPERVISED METHOD TO DETECT THE LEFT ATRIAL APPENDAGES AND CLASSIFY THEIR MORPHOLOGIES

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Introduction

The left atrial appendage (LAA) is the site where the left atrial thrombi are most likely (90%) to develop [1]. Despite the increasing interest that LAA has attracted over the last decade, the methods currently used to classify its morphology are mainly based on cardiologists' judgment [2]. Given the remarkable improvement of imaging techniques, we propose an unsupervised quantitative method that can overcome the limits of the current classification systems. The resulting classification system is objective and reproducible.

Methods

Routinely acquired clinical computerised tomography (CT) dataset from control and atrial fibrillation cases have been segmented to obtain the 3D shape of the left atrium (LA) and LAA. The 3D surfaces were meshed with triangular elements of side ~0.5 mm.

Our method consists of three steps: i) LAA detection, ii) features extraction, and iii) classification.

i) The detection of the appendage (Figure 1) is performed by analysing the skeleton-surface distances. We obtain the model's skeleton by using the algorithm proposed by ref. [3]. Then we divide the 3D model into two groups using the distances threshold identified through the Otsu's method [4], and we recognise the appendage by analysing the skeleton's complexity. Finally, we cut the ostium of the appendage with a plane, consistently with the clinical imaging technique.

ii) The extracted features provide a quantitative characterization of the size and complexity of the LAA. We compute the appendage volume, and the ostium area and perimeter from the 3D models. The length of the main path of the appendage (representative of the main lobe), its complexity and the number of trabeculae are determined through a network analysis of the appendage's skeleton (Figure 1).

iii) The new classification is obtained by performing a cluster analysis using the complete linkage method [5] based on the features correlation matrix (Figure 3). We cut the dendrogram in correspondence of correlation $\rho = 0$, forming groups of morphologies that are positively correlated.

Results

The developed code was able to correctly identify all the twenty-nine analysed LAAs and to extract all above mentioned features. Our method is based on quantitative measures that lead to an objective and reproducible classification system (Figure 3) that does not require one to specify the number of the classification groups in advance. Five groups were identified by cutting the dendrogram correspondingly with null correlation.

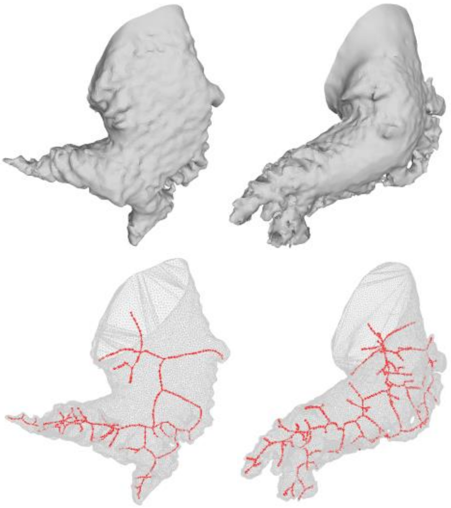

Figure 1: Two detected LAAs (top) and their corresponding skeleton (bottom).

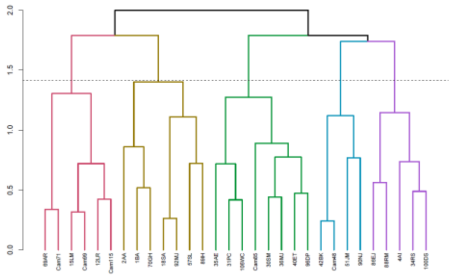

Figure 3: Dendrogram for hierarchical clustering by complete linkage.

Discussion

Our approach is able to overcome the limitations of the current classification systems. It could be improved by increasing the sample size and the number of features, including the haemodynamic analysis and providing a probabilistic classification.

References

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