Identification of subclinical cardiac amyloidosis in aortic stenosis patients undergoing transaortic valve replacement using radiomic analysis of computed tomography myocardial texture

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Introduction

Clinical presentation associated to cardiac amyloidosis (CA) shows an increased biventricular wall thickness, myocardial stiffening and ventricles restrictive physiology caused by amyloid myocardial deposition [1]. Similar myocardial remodeling processes affect patients with aortic stenosis (AS), that is the most common cause of valvular heart disease [2]. As CA shares several common phenotypical features with AS and considering the high prevalence of subclinical CA among AS undergoing transcatheter aortic valve implantation (TAVI), the differential diagnosis of these two entities has important prognostic and therapeutic implications.

In this framework, radiomics can be a non-invasive tool useful to perform differential diagnosis from medical images such as cardiac computed tomography (CCT) usually used for interventional planning of AS patients undergoing TAVI.

The aim of this study is to identify a set of stable and discriminative myocardial CCT radiomic features differentiating left ventricle (LV) hypertrophy due to CA versus AS.

Materials and methods

Twenty-one patients with CA and 44 with AS were randomly extracted by our database. All patients underwent CCT scans (Revolution CT; GE Healthcare, Milwaukee, WI or Aquilion ONE Vision^{TM} or Canon Medical Systems Corp., Tokyo, Japan). The institutional Ethical Committee approved the study, and all the patients signed the informed consent.

After image preprocessing, 107 radiomics features pertaining to shape and size (14 features), first-order statistics (18 features) and textural (75 features) classes, were extracted using Pyradiomics 3.0 [3] on the LV wall 3D-volume. Radiomic feature selection was based on i) stability; ii) non-redundancy; iii) relevance based on the Wilcoxon test followed by LASSO algorithm. All these steps were performed on the training set and then applied on the validation and test set. A nested cross-validation, composed of a 7-fold outer cross-validation and a 7-fold inner cross-validation, was performed, using five classifiers (k-nearest neighbors, support vector classifier, decision tree, logistic regression and gradient boosting). To deal with the unbalanced dataset, SMOTE (Synthetic Minority

Over-sampling Technique) algorithm was applied on the inner sets. Four additional ML models were implemented including: i) age and sex; ii) age, sex, body mass index, LV end diastolic and systolic volume index (ml/m^2), LV ejection fraction and interventricular septum thickness (mm); iii) radiomic features, age, and sex; iv) radiomic features and variables included in ii).

Results

Feature selection steps reduced the number of features to 10. As logistic regression showed the best performances in the validation set, it was selected for test set prediction obtaining an AUC of 0.92, sensitivity and specificity of 0.857 and 0.864 respectively. ROC curves for the test set, were computed using radiomic features (Figure 1a) and/or clinical variables (Figure 1b). The greatest performances were observed in model iv) (AUC=0.96).

Discussion:

The main finding of our study is that a CCT acquired for the usual planning of TAVI in AS patients can be used to extract radiomic features to diagnose CA.

As compared with the previous experience, several points of strength could be considered in our study. First, our results based on CCT radiomics obtained a balanced accuracy of 86% in the test set, higher as compared previous studies. Second, to the best of our knowledge, this is the first study to employ CCT for amyloidosis identification. Indeed, several studies showed that CA is frequent (11.8%) in patients with severe AS referred for TAVI and the challenge, in this context, is to differentiate a wooden horse (lone AS) from a Trojan horse (AS with CA) [4].

Having high values of sensitivity represents a promising result from the clinical viewpoint as recognizing CA, whose prognosis results worse compared to AS, is the main interest of this study.

Several study limitations should be considered. First, the sample size employed in the study is limited thus these results are preliminary and should be confirmed by a larger dataset. In addition, the considered patients were randomly extracted from a cohort of AS and CA patients referred for CCT.

Finally, CA and AS were explored separately without including patients affected by both pathologies who might be included in a further study.

Reference list

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Figure 1: ROC curve computed for the test set using LR with (a) radiomic features, (b) age and sex (yellow line), clinical variables (orange line), radiomic, age and sex features (red line), and radiomic-clinical features combination (dark red line).