# Predicting High-Risk Patients: A Biomechanical-Based Machine Learning Approach for Coronary Vulnerable Plaques Detection

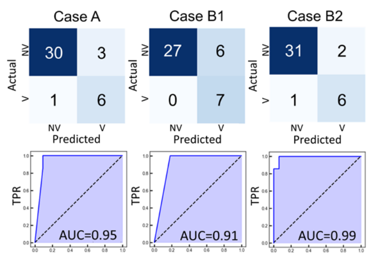
Anna Corti, Marco Stefanati, Matteo Leccardi, Ovidio De Filippo, Alessandro Depaoli, Pietro Cerveri, Francesco Migliavacca, Valentina DA Corino, José F Rodriguez Matas, Luca Mainardi, Gabriele Dubini

Politecnico di Milano, Milan, Italy

Detecting coronary vulnerable plaques is crucial for preventing major adverse cardiac events. Biomechanical indicators, though promising, are underutilized in vulnerability machine learning prediction models, and accurate biomechanical-based patient stratification remains elusive. Our study proposes a machine learning pipeline to predict vulnerable patients using biomechanical markers from finite element analysis (FEA), while also considering the variability in mechanical properties.

The dataset included 40 patients (7 vulnerable, 33 non-vulnerable patients), who underwent coronary computed tomography angiography (CCTA) and optical coherence tomography (for vulnerable plaque detection) at the “Città della Salute e della Scienza” hospital of Torino, Italy. Coronary artery cross-sections with details on medial, fibrous, fibrous fatty, lipid, and calcific tissues, were segmented from CCTA. To explore the impact of mechanical properties variability in patient stratification, FEA was performed by modelling arterial components as linear isotropic with: (A) average mechanical properties, resulting in one peak stress/strain value per plaque; and (B) 200 combinations of tissue mechanical properties, resulting in 200 peak stress/strain values for each plaque. For scenario B, two cases were explored: (B1) averaging over the 200 instances, obtaining one peak stress/strain value per plaque; (B2) considering 200 instances per plaque for data augmentation. Plaque structural stresses and strains and patient’s pressure data were used to train decision tree classifiers, within a leave-one-out cross-validation scheme.

Good stratification performances were achieved by all methods (Figure). While A identified 6 out of 7 vulnerable patients, B1 detected all the 7 vulnerable patients, but decreased the specificity. Differently, B2, identified 6 out of 7 vulnerable patients, as A, but improved the specificity.




Results of cases A, B1 and B2.

This investigation underscores the promise of biomechanical plaque phenotyping for patient stratification and demonstrates the effectiveness of considering the material parameter variability to improve classification performances.