ASCENDING AORTIC ANEURYSM GROWTH PREDICTION BASED ON MACHINE LEARNING AND SHAPE FEATURES DERIVED FROM 3D SLICER

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Introduction

The ascending aortic aneurysm (AsAA) is a dilatation of a weakened part of the ascending aorta (AsA). The surgical decision for non-urgent cases is based on the maximum diameter assessment. The threshold is generally fixed at 55 mm [1]. Unfortunately, this does not seem to correctly reflect the AsAA patient’s risk of rupture [2]. In fact, patients with rapid growth of the aortic diameter (≥3 mm/year) should be considered for preventive surgical replacement [3]. In this regard, the research is now focused on determining new biomarkers able to predict the AsAA growth and developing user-friendly virtual environments for their detection.

In this work, we present a machine learning (ML)-based method of predicting the AsAA risk of growth using as input 4 local shape features computed on the AsA geometry through a dedicated 3D Slicer extension.

Materials and Methods

A retrospective dataset including 50 patients with at least two pre-operative acquisitions (CT-Scans and/or 3D MRI) was used. An extension in the 3D Slicer environment based on Python, VTK and VMTK was developed to automatically pre-process the geometry and compute the following shape features (Figure 1):

- the maximum AsA diameter D;
- the ratio DCR between D and the length of the ascending aorta centerline C;
- the ratio $EILR$ between the length of the external curvature line (ECL) and the internal curvature line (ICL);
- the tortuosity T defined as the ratio between the length of C and the length of the segment C_0 that connected the first and last points of C.

After, by exploiting the longitudinal acquisitions, a linear growth rate (GR) was calculated for each patient:

$$GR = \frac{D'' - D'}{\Delta t} \quad (1)$$

where Δt is the time interval between the first and second acquisition, D' is the diameter D related to the first exam and D'' to the second acquisition. The dataset was divided into two classes: the patients with $GR \leq 3$ mm/year composed the low-risk group (41 patients) while the others represented the class with rapid growth. Five different ML classifiers were trained with the shape features derived exclusively from the first exam as input and cross-validated to predict each patient’s belonging class. They were: decision tree (DT), logistic regression (LR), naive bayes (NB), support vector machine (SVM) and k-nearest neighbours (KNN). The classification performances were assessed reporting accuracy (ACC), sensitivity (SE) and specificity (SP).

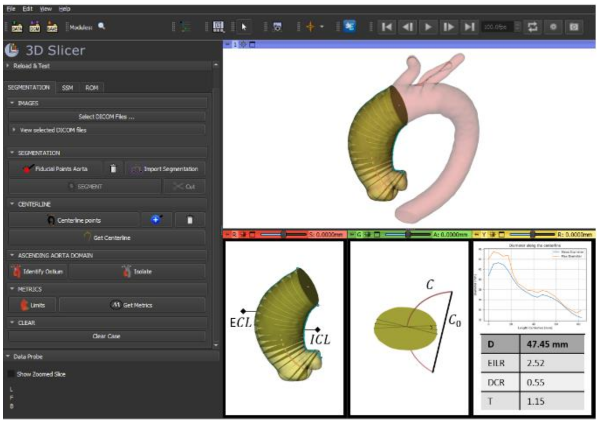

Figure 1: The 3D Slicer extension developed to compute the ascending aortic aneurysm local shape features.

Results

The classification performances are given in Table 1. SVM presented the best accuracy and specificity and together with LR and NB the best sensitivity.

	DT	LR	NB	SVM	KNN
ACC (%)	86	88	92	**96**	90
SE (%)	55.6	66.7	66.7	**66.7**	55.6
SP (%)	92.7	92.7	97.6	**100**	97.6

Table 1: Classification performances

Conclusions

The results show how the analysis of the AsA geometry could be crucial in predicting the aneurysm growth.
Integrating more patient data and results from numerical simulations could help to identify aortic shapes potentially at risk of rupture.

References

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