U-Net neural network for locating midpoint of insertion zone of transcatheter aortic valves in CTA images

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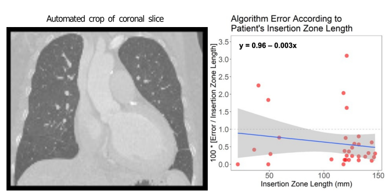
Introduction: Precise anatomic assessment of the aortic valvular complex using computed tomography angiography (CTA) is crucial for optimal sizing of transcatheter heart valves (THV) and identification of patients presenting aortic stenosis (AS) with increased anatomical risk for post-procedure adverse events, such as paravalvular leakage and conduction abnormalities. However, identification and positioning of the THV insertion zone (IZ) can be time-consuming and suffers from variability and reproducibility problems. We present a deep leaning approach in CTA images to locate the axial midpoint of IZ as a step towards complete automated assessment.

Method: We included (132+32 training and test set) patients with symptomatic severe AS who underwent CTA before transcatheter aortic valve replacement. A radiologist manually segmented the IZ (gold standard). Images were preprocessed then trained with a 2D U-Net model with batch normalization in axial projections: Hounsfield units mapped to [1000,400]; images resized to 256×256 pixels; augmentation with random rotations and Gaussian noise; pixels normalized to [0,1]; shuffled batches of 16 images (8 showing the valve and 8 not showing); Dice similarity coefficient as loss function; stochastic gradient descent as optimizer.

A density vector was created from predicted masks to locate the IZ, with elements representing the count of detected pixels per slice. It was split into unbroken stretches of non-zero values, and the most dense used to define start and end slices of the IZ, from which the midpoint of the IZ was computed as the average. The figure shows a coronal image projection, cropped ±10cm from our computed IZ midpoint.



Results: We found a very low systematic error for the recognition of the midpoint with a median computed error of 0.38mm (interquartile range 0.15 – 0.79mm). All percentage errors (error divided by insertion size) were 5% or less (Figure), with the vast majority below 1%. There was no evidence of a significant proportional error across different IZ lengths.