Segmentation and characterization of the aorta and supra-aortic trunks for neuroradiology procedure planning

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1. Clinical background

Obstacles: aortic arch and carotid arteries
Entry points: Radial, Femoral
Complex tortuosities and angulations
Difficulty in accessing the supra-aortic trunks

2. Technical background

Task Studies

SEGMENTATION
- Studies are oriented towards the use of CTA volumes.
- U-Net variants are the most used architectures.
- Approaches like multi-view 2D CNNs [2] and multi-stage pipelines were used [3].
- Segmentation is often pathology oriented e.g. segmentation of type B aortic dissection [3].

CHARACTERIZATION
- Generic frameworks with sets of functions for geometric quantification of anatomical features and vessel characterization [4, 5]. These frameworks are suitable for engineers for research but not relevant for clinicians to use in a medical setting.

3. Data


Acquisition parameters: coronal plane covering: 250 slices; active TR/TE = 5.5/2.2 ms; flip angle = 27°; number of excitations = 1; acquisition bandwidth = 476.7 Hz; FOV = 380 x 321; voxel size = 0.5 x 0.5 x 1.0 mm; imaging time = 69 sec; Bolus track injection technique.

Data labeling

Matalase mimics care suite
Semi-automatic segmentation

Validation and correction

Aortic arches only
Semi-automatic measurements

- Artery lengths
- Vessel tortuosities
- Angulations

4. Segmentation and characterization pipeline

Segmentation module
- Volume refocusing
- Localization CNN
- Resampling
- Normalization
- Segmentation CNN

Post processing
- 3D reconstruction
- Centerlines

Geometric characterization module
- Arch type (I, II or III)
- Lengths and tortuosities
- Radii, take-off angles and reverse curves
- Vertical distance to first major curvature

5. Results

- Dice score = 88.07%
- Precision = 84.10%
- Recall = 93.80%

3D reconstruction

Geometric characterization

Artery Length Torquity
Pearson RMSE MAPE Pearson RMSE MAPE
RCCA 0.97 5.97 1.75 0.93 0.06 3.32
LCCA 0.92 6.80 1.14 0.95 0.04 2.30

6. Conclusion and perspectives

- Complete analysis pipeline, from MRA images to high-level features: arch type, tortuosity, reverse curves, take-off angles and access difficulty after engaging an artery.
- Quantitative and qualitative validation by comparison to the medical reference (manual measurements and segmentations).
- Validation of our features on a diversified dataset in terms of demographic, pathological and imaging data of different modalities.
- Clinical validation of our features on a diversified dataset in terms of demographic, pathological and imaging data of different modalities.
- Aortic arch and supra-aortic branches, 3) and 4) intracranial vessels. Vascular structures of different anatomical characteristics: vessels become more tortuous, and their diameter decreases as they ascend to the brain.
- 3D extension of our CNN pipeline to better capture vessels of different diameters.