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

Complex tortuositities and angulations

Entry points: Radial and Femoral

Difficulty in accessing the supra-aortic trunks

2. Technical background

Task | Studies
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**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 [1].
- 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; BolaTrack injection technique.

- **Data labeling**

Maturализа mimics care suite

Semi-automatic segmentation

3D slice

Aortic arches only

Validation and correction

Aorta (arches + supra-aortic trunks)

Semi-automatic measurements

- Artery lengths
- Vessel tortuositities
- Angulations

4. Segmentation and characterization pipeline

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

**Post processing**
- 3D reconstruction
- Arch type (I, II or III)
- Lengths and tortuositites
- Radii, take-off angles and reverse curves
- Vertical distance to first major curvature

**Geometric characterization module**
- Geometry and tortuosity
- 3D reconstruction

5. Results

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

**References**


6. Conclusion and perspectives

- Complete analysis pipeline, from MRA images to high-level features: arch type, tortuositities, 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).

- Clinical validation of our features on a diversified dataset in terms of demographic, pathological and imaging data of different modalities.

- 3D extension of our CNN pipeline to better capture vessels of different diameters.

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1) and 2) 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.