ARVA
Augmented Radiology for Aortic Volume Assessment
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Project in Partnership with Incepto Medical

Disclosures
- No personal CI with INCEPTO
- HML/INCEPTO collaboration

Background
CT scans are analyzed to decide when to intervene, and during follow-up after treatment (open and endovascular). External aortic diameter measurements are performed.

State-of-the-art:
- 3D workstations accurate for lumen segmentation but not for thrombus segmentation -> time consuming process
- High inter-observer variability 87% >[-5; +5 mm] Mora et al. Eur J Vasc Endovasc Surg. 2014

Objective
Development of an artificial intelligence tool for automatic measurement of external diameters and volumes of each aortic segments in order to standardize the pre- and postoperative patients CT scan analysis.
ARVA State of the art (Deep Learning)

<table>
<thead>
<tr>
<th>Paper</th>
<th>Date</th>
<th>Data Source</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>[1]</td>
<td>19/11/2019</td>
<td>Contrast and non-contrast CT images</td>
<td>Dice = 0.89</td>
</tr>
<tr>
<td>[2]</td>
<td>19/11/2019</td>
<td>Contrast and non-contrast CT images</td>
<td>Dice = 0.82</td>
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<tr>
<td>[3]</td>
<td>19/11/2019</td>
<td>Contrast and non-contrast CT images</td>
<td>Dice = 0.96 (AA)</td>
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<tr>
<td>[4]</td>
<td>19/11/2019</td>
<td>Contrast and non-contrast CT images</td>
<td>Dice = 0.95 (DA)</td>
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</tbody>
</table>

ARVA Data

- 865 patients operate for thoracic and/or abdominal aortic aneurysm with available contrasted CT scans
- 2,674 CT scan examinations collected
- 400 manually segmented contrasted volumes

ARVA Database

- Nb of segmented volumes: 400
- % with aneurysms: 85%
- % with prosthesis: 80%
- % CT scan with contrast: 100%

ARVA Interactive tool

We use 5-fold cross validation to evaluate our algorithms.

ARVA Methodology

1. Database Creation
2. Aorta Localization
3. Aorta Segmentation
4. Centerline Computation

Results:
- Dice = 0.99 ± 0.01
- Mean error = 2.4 mm ± 1.7 mm

ARVA Diameter Measurement

Maximal diameter is obtained by computing the maximal aorta diameter in the perpendicular planes along the centerline.

Mean error on the test set is equal to 2.4 mm ± 1.7 mm.
**ARVA Result: segmentation**

Example of segmentation prediction with a Dice score equal to 0.92:

**Metric** | **State-of-the-art** | **ARVA**
---|---|---
DICE = \(\frac{2 \times TP}{TP + FP + FN}\) | 0.90 | 0.90 ± 0.01

**ARVA Results Illustration**

Example of good results:
- DICE = 0.93
- Diameter prediction error = 1.9 mm

Example of bad result:
- DICE = 0.85
- Diameter prediction error = 7.9 mm

**ARVA Data (Work In Progress)**

Ground truth: semi-manual measurements of the maximum external diameter of the 8 aorta segments by 2 expert surgeons.

Ground Truth

<table>
<thead>
<tr>
<th>Maximum external diameter in mm</th>
<th>20</th>
<th>30</th>
<th>50</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous maximum external diameter in mm</td>
<td>20</td>
<td>30</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>Evolution of the diameter in mm</td>
<td>+2</td>
<td>0</td>
<td>+6</td>
<td>20</td>
</tr>
</tbody>
</table>

| Volume of the zone in mm | 3 |
| Previous volume of the zone in mm | 3 |
| Evolution of the volume in mm | 3 |

Mean = 2.2 mm
Std = 2.6 mm

Without outliers (one measurement removed)
**ARVA**

**Product**

- **ARVA**
- **Conclusion**
  - Highest performance: DICE of 0.90
  - Biggest database: 400 segmented abdominal and thoracic aorta volumes with and without endografts
  - Clinically relevant: product in development

**ARVA**

**Perspectives**

- Validate segmentations by expert surgeons and radiologists to continue to improve performance
- Automatically delimit the 8 aorta segments

**ARVA**

**Team**

- **Vascular Surgeons**
  - Pr Stéphan Haulon
  - Pr Dominique Pabot

- **Clinical Science**
  - Dr Charlotte Pouchy
  - Dr Vincent Barrau
  - Dr Gaspard D'Assignies

- **Data Science**
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  - Léo Alberge
  - Dr Roberto Anton