Artificial intelligence-based intraoperative endoleak visualization with completion digital subtraction angiography images during EVAR

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Disclosures

Speaker name:
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I have the following potential conflicts of interest to report:
  - Consulting
  - Employment in industry
  - Stockholder of a healthcare company
  - Owner of a healthcare company
  X Other(s)
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  - I do not have any potential conflict of interest
Completion angiography

- Performed at the end of every EVAR procedure
- Digital subtraction angiography (DSA)
- Inspection of:
  - Stent graft position
  - Patency of renal/visceral/iliac arteries
  - Endoleaks
Intraoperative endoleaks

- Types 1 and 3 endoleaks can be treated within the same procedure:
  - proximal/distal ballooning (1a/1b)
  - cuff extension (1a)
  - endoanchors (1a)
  - distal leg extension (1b)
  - relining (3)

- Current endoleak assessment is performed by ‘visual inspection’
  - subjective
  - limited by human interpretation
  - physician experience

Do we detect all endoleaks intraoperatively? If not → possible reintervention
Intraoperative endoleaks versus 30-day CTA detection by surgical team

- 54% no EL
- 31% EL during EVAR
- 15% EL on CTA
- 2% EL dissolved
- 10% EL not detected during EVAR

3% type 1
12% type 2
21%
Study aim

To perform **automatic analysis** of completion angiography imaging obtained during EVAR procedures with **artificial intelligence-based deep learning**
Methods

Patient cohort

All EVAR patients AUMC hospital
n=1260
2007-2021

Mobile C-arm
n=956
excluded

Fixed C-arm
n=304
screening

EVAR patient cohort
n=218
included

Excluded:
- F/BEVAR-TEVAR patients
- conversion to open repair
- missing data
Image preprocessing
perfusion parameters

DSA movie was converted

contrast density
time to peak
time of arrival
contrast volume
Manual labeling for model input

2 vascular surgeons
2 interventional radiologists
1 operating team

Scored the completion angiographies on:
  • Endoleak yes/no
    • Type
    • Location
Deep learning model

inputs:

- U-Net architecture
- Data:
  - 220 completion angiograms
    - Half with endoleak
  - Split in train (70%), validation (10%) and test set (20%)
- Data augmentation:
  - Vertical flipping
  - Z-axis rotation (15 degrees)
- MSE-loss, Adam optimizer
- Pytorch and Medical Open Network for AI (MONAI)
Results

Deep learning model

Training loss declining

ROI: 256x256 pixels, lr=0.001, tr batch size: 64, multitask factor: 0.3, MSELoss()
Results

Deep learning intraoperative endoleak visualization

<table>
<thead>
<tr>
<th>blue=prediction, red=label</th>
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<tbody>
<tr>
<td>2 TP</td>
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<tr>
<td>1 FP</td>
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<td>1 FN</td>
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Results

Receiver operating curve (ROC) with area under the curve (AUC)

Calculated AUC: 0.82

AUC of 0.82
Conclusion

We developed a fully automated endoleak visualization method, based on the completion digital subtraction angiography during EVAR.

The extraction of detailed imaging knowledge, can aid in intraoperative clinical decision making.

Future development will focus on better endoleak classification.
Al-team at Amsterdam UMC

Kakkhee Yeung - vascular surgeon
Jelmer Wolterink - assistant professor
Dieuwertje Alblas - mathematician
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