Tool for Enhanced 3D Planning and Evaluation of AAA Procedures in Vascular Surgery

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Background/Problem Being Solved

Volumetric assessment of abdominal aortic aneurysms (AAA) offers precise pre- and post-endovascular aortic repair (EVAR) evaluation but is laborious. This study aimed to train and validate deep learning-based network facilitating automated segmentation and volume determination of pre- and post-EVAR infrarenal AAAs displayed on computed tomography angiographies (CTA) and to evaluate its role in accelerating clinical workflow.

Intervention(s)

A HIPAA-compliant study was performed investigating de-identified pre- and post-interventional CTAs of patients who underwent EVAR for management of infrarenal AAA at our institution. In research instance of our PACS (AI Accelerator, AIA, Visage Imaging, Inc.), ground truth volumetric segmentations of total aneurysm and lumen were performed from lowest renal artery to aortic bifurcation. nnU-Net model was trained and validated on this dataset. External validation was performed using multi-institutional datasets. Efficiency gains provided by model were tested against two attending vascular surgeons and one vascular surgery resident who performed semi-automatic AAA segmentation on both internal and external validation datasets using AIA. Baseline patient demographics were recorded.

Barriers/Challenges

Time consuming Manual adjustments
Ensuring the external datasets are sufficiently large, diverse
Ensuring that the trained nnU-Net model performs reliably across multi-institutional datasets with different imaging protocols and scanner settings.

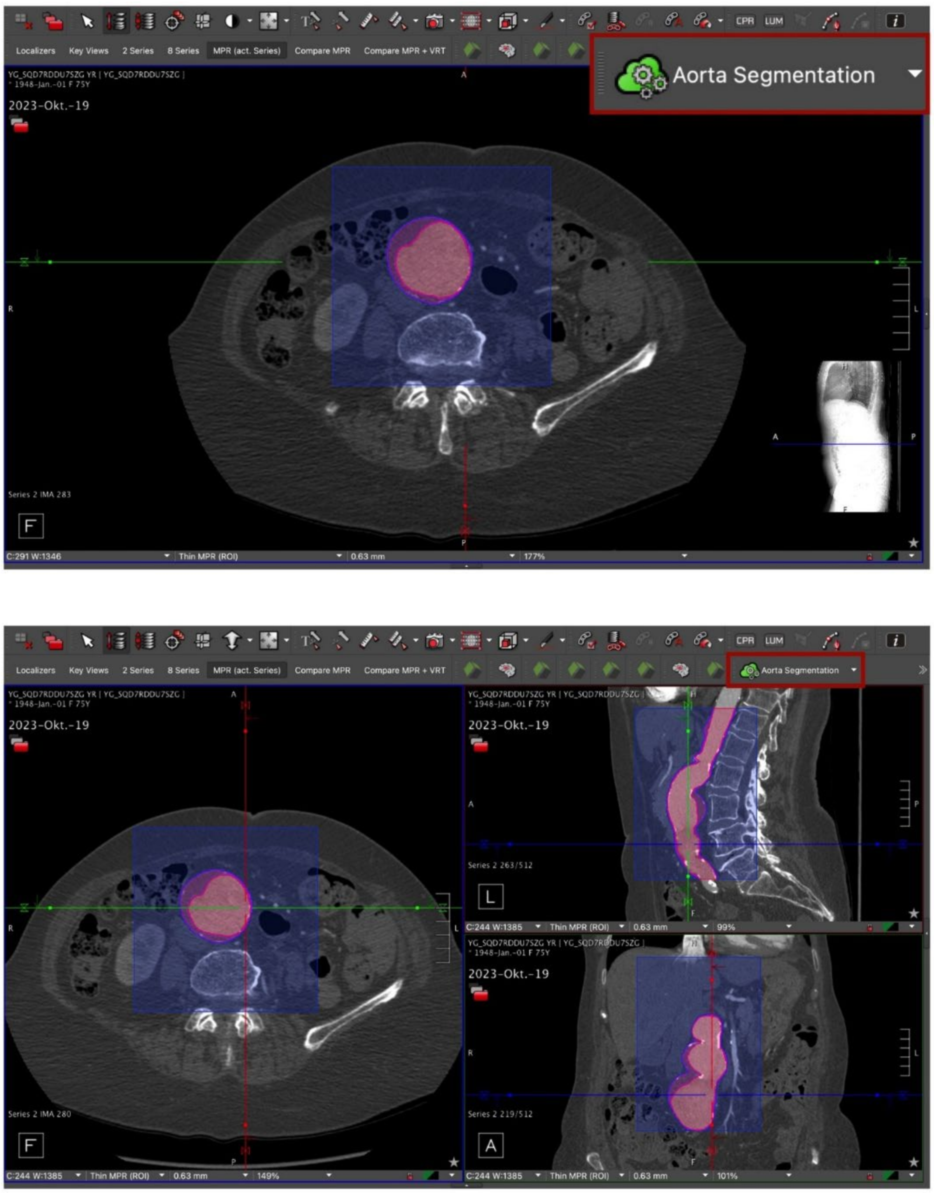
Outcome

A total of 110 patients with 84 (76.4%) males were included in internal dataset. Training and internal validation datasets comprised 176 and 44 pre- and post-EVAR CTAs; 60 validation studies from external institutions were included. For total aneurysm, mean Dice similarity coefficient was 0.972±0.013 and 0.960±0.035 in internal and external validation (Table1). AI-generated thrombus volumes showed a very strong correlation with ground truth in internal (r=0.996) and external validation (r=0.940). Mean algorithm-facilitated time savings of 117.1 seconds (56.0%) were demonstrated for total aneurysm.

Conclusion/Statement of Impact/Lessons Learned

Our PACS-based institution-agnostic network enables automated volumetric AAA analysis. Integration of an aorta segmentation algorithm into the model, including a manually adjustable bounding box for precise field-of-view selection, is being evaluated; the tool could be incorporated into routine clinical practice (Fig2).

Figure(s)



a

b

Figure 1. Aorta Segmentation tool implemented within research PACS showing automatic volumetric segmentations of total aneurysm and lumen in infrarenal aorta.

Characteristic	Mean ± SD	Range	Median	IQR
Total aneurysm				
Internal validation (44 CTAs)				
Dice Similarity Coefficient	0.972 ± 0.013	0.917 - 0.985	0.976	0.971 - 0.989
Hausdorff Distance/Slice (in mm)	2.053 ± 2.379	1.0 - 15.339	1.414	1.207 - 1.747
Jaccard Coefficient	0.973 ± 0.012	0.923 - 0.985	0.976	0.972 - 0.980
External validation (60 CTAs)				
Dice Similarity Coefficient	0.960 ± 0.035	0.747 - 0.983	0.969	0.962 - 0.975
Hausdorff Distance/Slice (in mm)	4.524 ± 16.436	1.0 - 114.952	1.207	1.0 - 1.414
Jaccard Coefficient	0.964 ± 0.015	0.912 - 0.986	0.970	0.960 - 0.974
Lumen				
Internal validation (44 CTAs)				
Dice Similarity Coefficient	0.963 ± 0.017	0.905 - 0.986	0.969	0.957 - 0.974
Hausdorff Distance/Slice (in mm)	1.772 ± 1.614	1.0 - 9.225	1.207	1.0 - 1.640
Jaccard Coefficient	0.962 ± 0.023	0.839 - 0.983	0.969	0.960 - 0.974
External validation (60 CTAs)				
Dice Similarity Coefficient	0.941 ± 0.122	0.809 - 0.979	0.961	0.955 - 0.968
Hausdorff Distance/Slice (in mm)	1.797 ± 3.105	1.0 - 21.108	1.0	1.0 - 1.414
Jaccard Coefficient	0.967 ± 0.024	0.839 - 0.996	0.966	0.959 - 0.988

Table 1. Mean Dice similarity coefficient in internal and external validation

Keywords

Applications; Artificial Intelligence/Machine Learning; Clinical Workflow & Productivity; Educational Systems; Emerging Technologies; Quality Improvement & Quality Assurance