
C-19 The Role of Imaging and 3D Models in the Treatment of Abdominal — Aortic Aneurysms —

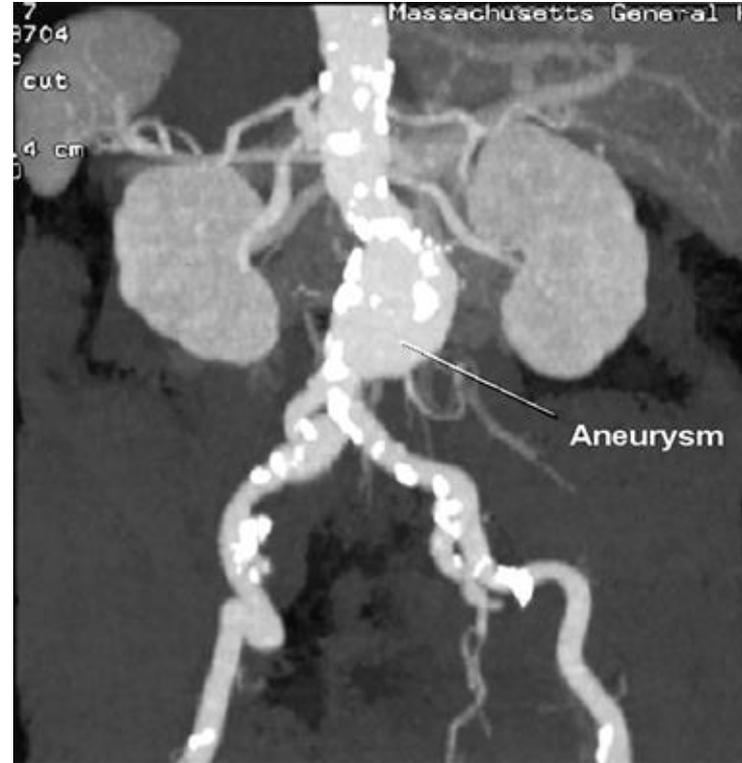
Objectives:

- Define an abdominal aortic aneurysm (AAA).
 - Describe how AAAs are diagnosed using medical imaging.
 - Discuss current Interventional Radiology (IR) treatment options for AAAs.
 - Explain how patient-specific 3D models enhance AAA treatment planning.
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Thesis:

- The incorporation of 3D models enhances surgical planning and optimizes patient outcomes in AAA treatment within Interventional Radiology.

Figure 11. Contrast-enhanced CT scan with 3-dimensional reconstruction demonstrating a 5.6-cm infrarenal abdominal aortic aneurysm. The image has been rotated in space so that one is viewing the posterior aspect of the aneurysm. The kidneys, spleen, and liver are also visualized.



Isselbacher, E. (2005). CT scan demonstrating an abdominal aortic aneurysm [Picture]. *American Heart Association*.
<https://www.ahajournals.org/doi/10.1161/01.cir.0000154569.08857.7a>

Definitions:

- **Gating**: A scanning method that takes images at a specific time in the heartbeat cycle to reduce motion and improve image quality (Murphy, 2025).
- **Abdominal Aortic Aneurysm (AAA)**: A bulge in the main artery of the abdomen caused by a weak spot in the vessel wall (Abdominal Aortic Aneurysm, 2025).
- **Atherosclerosis**: A condition where fatty plaque builds up inside the arteries, making them narrow and harder for blood to flow through (National Heart and Lung Association, 2024).
- **CT Angiography**: A scan that uses contrast dye and CT imaging to look at blood vessels and find problems like blockages or aneurysms (Radiological Society of North America, 2025).

Causes of AAA:

- Atherosclerosis
- Family history
- High blood pressure
- Trauma to the aorta
- Infection in the aorta
- Blood vessel disease

(Mayo Clinic, 2025)



Turkey, A. (2021). Chest Pain [Picture]. Hill Regional Hospital.
<https://www.hillregionalhospital.com/blogs/sharp-chest-pain/>

Signs/Symptoms of AAA:

- Confusion or dizziness
- Fatigue
- Headache
- Nausea or vomiting
- Pain in abdomen, chest, or back
- Rapid heart rate
- Vision changes

(Cleveland Clinic, 2025)

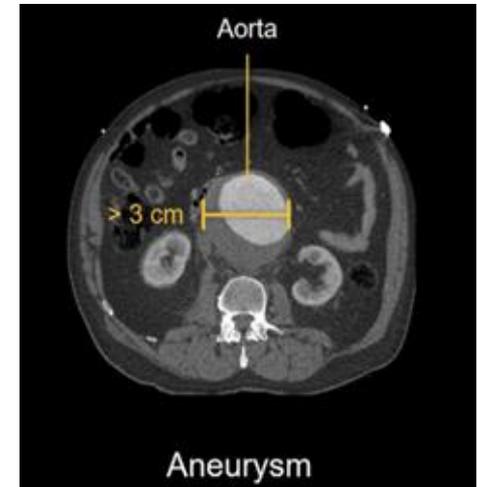
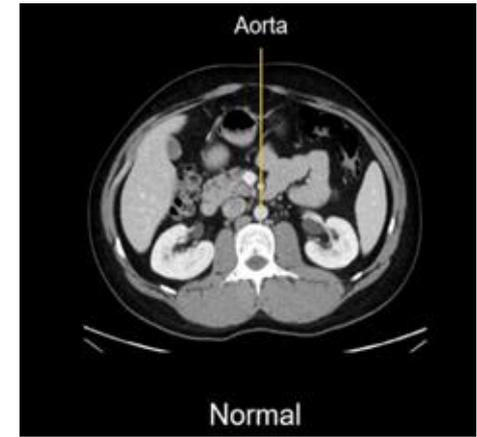
Role of Diagnostic Imaging in AAA Diagnosis:

- Diagnostic imaging is essential for detecting, characterizing, and monitoring abdominal aortic aneurysms.
- Imaging helps determine the aneurysm size, shape, location, and involvement of branch vessels, which are crucial factors for treatment planning.
- Plays a major role in early detection before rupture and in guiding treatment decisions between endovascular repair (EVAR) and open surgery.

(Ricco, 2025)

Imaging Modalities Used to Diagnose AAA:

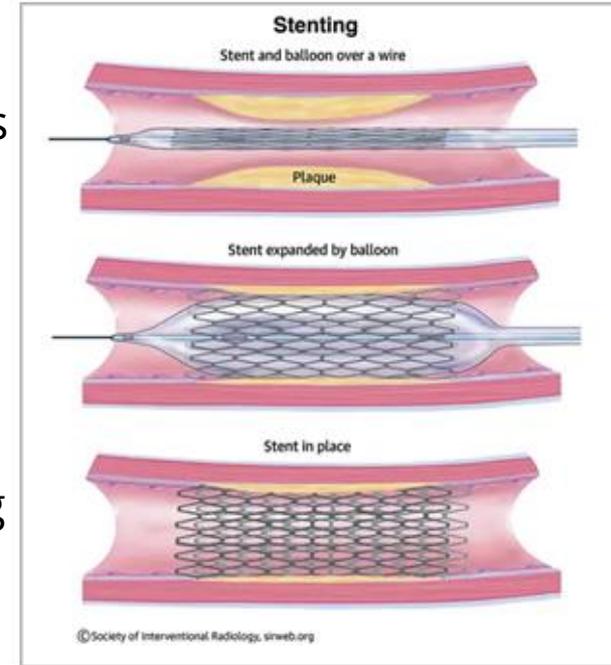
- Abdominal CT Scan
 - CT scans are beneficial in creating detailed cross-sectional images of internal structures within the abdomen, providing clear views of the aorta. Scans also provide valuable information on the size and shape of an AAA (Mayo, 2025).
- Abdominal MRI
 - This test uses magnetic fields and radio waves to generate detailed images of the organs and structures within the abdomen (Mayo, 2025).



Hartung, M. & Brown, A (2024). CT scan of Normal aorta vs aneurysm [Picture]. Life in the Fastlane. <https://litfl.com/abdominal-ct-aortic-aneurysm/>

Imaging in Treatment Planning (IR):

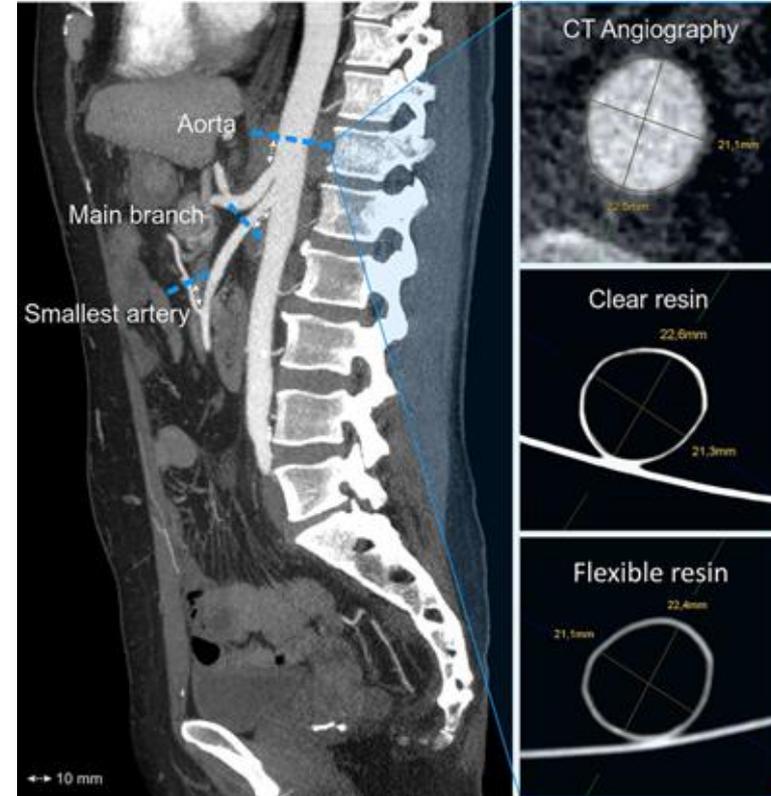
- Radiologic imaging plays a fundamental role in the diagnosis, follow-up, and treatment planning of patients with abdominal aortic aneurysms (AAAs).
- EVAR: is a minimally invasive procedure in which an interventional radiologist inserts a stent graft into the aorta. This stent allows blood to flow normally through the vessel while diverting it away from the weakened aneurysm wall, thereby reducing pressure and lowering the risk of rupture (CIRSE, 2024).
- Open surgery: Major surgical procedure in which the surgeon removes the weakened section of the aorta and replaces it with a graft that is stitched into place (Cleveland Clinic Medical, 2022).



Abdominal aortic aneurysm and IR treatment options. Society of Interventional Radiology. (n.d.). <https://www.sirweb.org/for-patients/conditions-and-treatments/abdominal-aortic-aneurysm/>

How are 3D Models Created in IR?

- Perform a CT angiography to ensure optimal contrast enhancement of the arteries during the arterial phase (Kaufmann, 2022).
- Reformat the images in the axial plane with a 1-mm slice thickness (Kaufmann, 2022).
- Import the reformatted images into a 3D visualization software to generate a printable 3D model (Kaufmann, 2022).
- Transfer of the finalized 3D model file for printing, ensuring all supporting structures—from the largest to the smallest—are accurately included for anatomical precision (Kaufmann, 2022).



Kaufmann, R. (2022). *Diameter measurements of the CT-scanned vascular model* [Picture]. *Journal of digital imaging*. <https://pmc.ncbi.nlm.nih.gov/articles/PMC8854516/>

CT vs MRI in 3D Image Reconstruction

CT

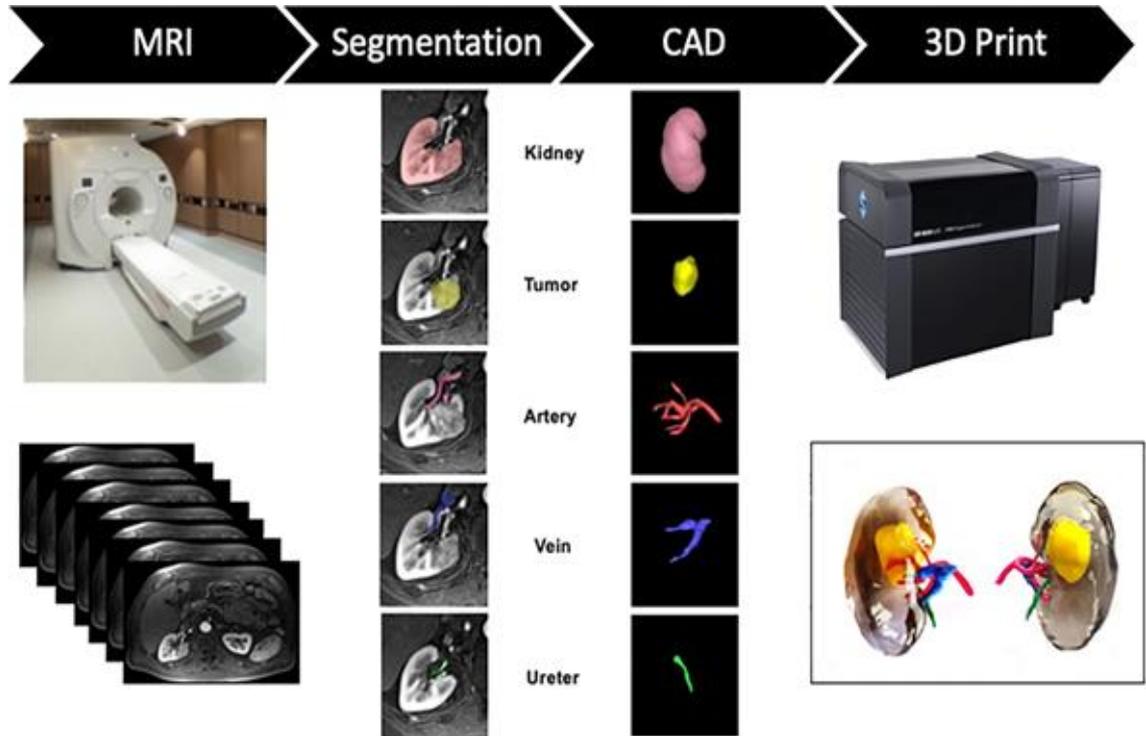
- High image quality is pivotal in creating detailed 3D models (Magagna, 2022).
- Specific protocol and gating techniques are used to minimize artifacts such as breathing and cardiac motions (Magagna, 2022).
- Artifact from CT directly impacts segmentation and the printed volume of 3D models (Magagna, 2022).
- A dedicated software is used to compile axial, coronal, and sagittal slices to create a 3D image (Magagna, 2022).

MRI

- Data sets obtained utilizing MRI are difficult to standardize due to complex sequences of scans (Talanki, 2021).
- MRI scans are more desirable because they provide improved visualization of soft tissue structures without the use of contrast (Talanki, 2021).
- Often, image segmentation and computer programs are unsuccessful in creating 3D models from MRI data sets (Talanki, 2021).
- Edge detection and masking techniques are inadequate to visualize detailed structures (Talanki, 2021).

Full Workflow From Imaging to 3D Printing:

- The image demonstrates the entire clinical workflow used to create a patient-specific 3D anatomical model—from the initial MRI exam all the way to the final printed object (Talanki, 2023).



Talanki, R. (2023). *General workflow for 3D printing* [Picture]. National Library of Medicine. <https://pmc.ncbi.nlm.nih.gov/articles/PMC10326907/>

Clinical Benefits of Using 3D Printed Models

Preoperatively

- Surgeons are able to familiarize themselves with patient specific anatomy to ensure best surgical outcomes possible (Sharma, 2022).
- Delicate tissues are visualized and taken into account when creating a preoperative plan (Sharma, 2022).
- Creation of 3D models is inexpensive and a low risk training method (Sharma, 2022).
- 3D models are invaluable, as they allow young surgeons hands-on training (Sharma, 2022).
- New surgical techniques can be practiced in a low-risk environment (Sharma, 2022).



Polanczyk, A. (2019). *Front and back 3D model of an abdominal aortic aneurysm*. [Picture]. BioMedical Engineering OnLine. https://www.researchgate.net/figure/An-example-of-3D-reconstruction-of-abdominal-aortic-aneurysm-AAA-a-AngioCT-data-AAA_fig7_333097349

Clinical Risks of Using 3D Printed Models

- 3D models provide satisfactory results, however they could be further improved to provide minor anatomical defects and variations of tissue density (Bonvini, 2024).
- When 3D printing is utilized, the process of reconstruction, post-processing, and printing can take over 24 hours to complete (Bonvini, 2024).
- 3D models may not perfectly replicate the physical properties (flexibility, wall thickness, and compliance) of an actual aortic tissue (Bonvini, 2024).
- The most common source of errors in 3D models are the image acquisition and tissue segmentation. Errors in this portion of the process can skew the result and force the surgeon to make on the spot changes to intraoperative plans (Bonvini, 2024).

Conclusion:

- Patients felt they understood their disease and treatment plan better when shown the model.
- Improved surgical outcomes (shorter procedure times, fewer procedural complications).
- Surgeons had a better understanding of complex anatomies and pathologies, which allowed for more in-depth preoperative planning.

Figure 1: The 3D printed abdominal aortic aneurysm model as viewed from different angles



Khural, M. et al. (2020). *3D printed AAA [Picture]*. Cureus Journal of Medical Science.
<https://www.cureus.com/articles/28962-evaluating-the-use-of-a-generic-three-dimensionally-3d-printed-abdominal-aortic-aneurysm-model-as-an-adjunct-patient-education-tool#!/>

Article References:

Aneurysm: What it is, types, symptoms, diagnosis & treatment. Cleveland Clinic. (2025b, September 26).

<https://my.clevelandclinic.org/health/diseases/22769-aneurysm#signs-and-symptoms>

Bonvini, S., Raunig, I., Demi, L., Spadoni, N., & Tasselli, S. (2024, February 9). *Unsuspected limitations of 3D printed model in planning of complex aortic aneurysm endovascular treatment.* *Vascular and Endovascular Surgery.*

<https://pubmed.ncbi.nlm.nih.gov/38335135/>

Cleveland Clinic Medical. (2022, April 25). *Aneurysm Surgery: Procedure Details and Recovery,* Cleveland Clinic.

<https://my.clevelandclinic.org/health/treatments/16735-aneurysm-surgery-traditional-open-surgery>

Endovascular treatment of abdominal aortic aneurysms (EVAR). CIRSE. (2024, June 12). <https://www.cirse.org/patients/general-information/ir-procedures/endovascular-treatment-of-abdominal-aortic-aneurysms-evar/>

Kaufmann, R., Zech, C. J., Takes, M., Brantner, P., Thieringer, F., Deutschmann, M., Hergan, K., Scharinger, B., Hecht, S., Rezar, R., Wernly, B., & Meissnitzer, M. (2022, February). *Vascular 3D printing with a novel biological tissue mimicking resin for patient-specific procedure simulations in interventional radiology: A feasibility study.* *Journal of Digital Imaging.*

<https://pmc.ncbi.nlm.nih.gov/articles/PMC8854516/>

Magagna, P., Xodo, A., Menegolo, M., Campana, C., Ghiotto, L., Salvador, L., & Grego, F. (2022, December 20). *Applications of three-dimensional printing in the management of complex aortic diseases.* *Aorta (Stamford, Conn.).*

<https://pmc.ncbi.nlm.nih.gov/articles/PMC9767784/>

Article References Continued:

Mayo Foundation for Medical Education and Research. (2025, April 3). *Abdominal aortic aneurysm*. Mayo Clinic.

<https://www.mayoclinic.org/diseases-conditions/abdominal-aortic-aneurysm/symptoms-causes/syc-20350688>

Ricco, J.-B., Hostalrich, A., & Chaufour, X. (2025, August 13). *Aorta unveiled: The crucial role of imaging in diagnosing and managing aortic disease-A Review*. European Heart Journal. Imaging methods and practice.

<https://pmc.ncbi.nlm.nih.gov/articles/PMC12448707/#:~:text=CTA%20remains%20the%20cornerstone%20for,of%20disease%20progression%20or%20complications.>

Sharma, V., Garg, M., Bhaskar, S., Tiwari, S., Bhatia, P. K., & Jha, D. K. (2022, December 9). *Handmade models for aneurysm surgery: A useful tool for training*. Surgical Neurology International.

<https://pmc.ncbi.nlm.nih.gov/articles/PMC9805621/#sec1-7>

Sklar, S. (2024, September 3). *The role of imaging and interventional radiology in aneurysm treatment*. Charlotte Radiology.

<https://www.charlotteradiology.com/blog/the-role-of-imaging-and-interventional-radiology-in-aneurysm-treatment/>

Talanki, V. R., Peng, Q., Shamir, S. B., Baete, S. H., Duong, T. Q., & Wake, N. (2021, May 27). *Three-dimensional printed anatomic models derived from magnetic resonance imaging data: Current State and image acquisition recommendations for appropriate clinical scenarios*. Journal of magnetic resonance imaging : JMRI. <https://pmc.ncbi.nlm.nih.gov/articles/PMC10326907/>

Definition References:

Abdominal aortic aneurysm and IR treatment options. Society of Interventional Radiology.

(n.d.). <https://www.sirweb.org/for-patients/conditions-and-treatments/abdominal-aortic-aneurysm/>

Murphy, A. (2025, July 15). *Cardiac gating (CT) | radiology reference article | radiopaedia.org.*

Cardiac Gating. <https://radiopaedia.org/articles/cardiac-gating-ct?lang=us>

Radiological Society of North America (RSNA) and American College of Radiology (ACR).

(2025, January 30). *CT angiography (CTA).* Radiologyinfo.org.

<https://www.radiologyinfo.org/en/info/angiact>

U.S. Department of Health and Human Services. (2024, October 28). *What is atherosclerosis?.*

National Heart, Lung, and Blood Institute.

<https://www.nhlbi.nih.gov/health/atherosclerosis>

Image References:

- Abdominal aortic aneurysm and IR treatment options.* Society of Interventional Radiology. (n.d.). <https://www.sirweb.org/for-patients/conditions-and-treatments/abdominal-aortic-aneurysm/>
- Hartung, M. and Brown, A. (2024). CT scan of Normal aorta vs aneurysm [Picture]. Life In the FastLane. <https://litfl.com/abdominal-ct-aortic-aneurysm/>
- Isselbacher, E. (2005). CT scan demonstrating an abdominal aortic aneurysm [Picture]. American Heart Association. <https://www.ahajournals.org/doi/10.1161/01.cir.0000154569.08857.7a>
- Kaufmann, R., Zech, C. J., Takes, M., Brantner, P., Thieringer, F., Deutschmann, M., Hergan, K., Scharinger, B., Hecht, S., Rezar, R., Wernly, B., & Meissnitzer, M. (2022, February). *Vascular 3D printing with a novel biological tissue mimicking resin for patient-specific procedure simulations in interventional radiology: A feasibility study.* Journal of Digital Imaging. <https://pmc.ncbi.nlm.nih.gov/articles/PMC8854516/>
- Khural, M., Gullipalli, R., & Dubrowski, A. (2020, June 9). *Evaluating the use of a generic three-dimensionally (3D) printed abdominal aortic aneurysm model as an adjunct patient education tool.* Cureus Journal of Medical Science. <https://www.cureus.com/articles/28962-evaluating-the-use-of-a-generic-three-dimensionally-3d-printed-abdominal-aortic-aneurysm-model-as-an-adjunct-patient-education-tool#!>
- Polanczyk, A. (2019, May 14). (PDF) *A novel vision-based system for quantitative analysis of abdominal aortic aneurysm deformation.* BioMedical Engineering OnLine. https://www.researchgate.net/publication/333097349_A_novel_vision-based_system_for_quantitative_analysis_of_abdominal_aortic_aneurysm_deformation
- Talanki, V. R., Peng, Q., Shamir, S. B., Baete, S. H., Duong, T. Q., & Wake, N. (2023, July 7). *Three-dimensional printed anatomic models derived from magnetic resonance imaging data: Current State and image acquisition recommendations for appropriate clinical scenarios.* Journal of magnetic resonance imaging: JMRI. <https://pmc.ncbi.nlm.nih.gov/articles/PMC10326907/>
- Thoracic and abdominal aortic aneurysms | circulation.* Thoracic and Abdominal Aortic Aneurysms. (2005, February 15). <https://www.ahajournals.org/doi/full/10.1161/01.cir.0000154569.08857.7a>
- Turky, A. (2021, July 14). *Sharp chest pain: Hill Regional Hospital.* Sharp Chest Pain | Hill Regional Hospital. <https://www.hillregionalthospital.com/blogs/sharp-chest-pain/>