Non TAVI post-treatment thoracic aorta: Findings at follow-up

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Purpose

• List common findings affecting thoracic aorta after treatment at follow-up.

• Identify various surgical and endovascular techniques for repair of thoracic aorta.

• Describe normal and abnormal findings to keep in mind for the radiologist when reporting with emphasizing those which can be prognostic factors for complications.
Methods and Materials

- 221 patients after treatment for thoracic aorta conditions are reviewed. Most of them were included at the Spanish Acute Aortic Syndrome Study (RESA).

- CT-angiography of all the patients and either PET-CT or MR when performed were reviewed. 209 patients had more than 2 exams. Evolutive findings were analyzed with focusing in those who could be important as prognostic factors for developing complications at follow-up.
Results

Open surgical and endovascular thoracic and abdominal aortic repair techniques (TEVAR/EVAR) can be used to manage aortic disorders, including aneurysms, acute aortic syndromes, and pseudoaneurysms (PSA) of all types.

Following aortic aneurysm repair, not only multidetector computed tomography (MDCT) but also magnetic resonance (MR) in selected cases may be used in documenting and assessing after-repair appearances as well as in routine follow-up and investigation of potential complications.

IMAGING TECHNIQUES AND PITFALLS

Following aortic aneurysm repair, the MDCT protocol should include triphasic CT angiography with unenhanced scans. When suspected complication involving the aortic valve or aortic root, a contrast enhanced thoracic acquisition should be obtained with retrospective ECG-gating. The follow-up protocol consists of MDCT performed before hospital discharge (baseline MDCT), at 3 and 12 months, and yearly thereafter.

Knowledge of the specific surgical procedure is often crucial to unambiguously interpret postoperative findings. When reconstruction of the aortic root and aortic valve is required, the options are either graft repair, usually with a Dacron tube, of the ascending aorta. The Dacron graft is visualized on non enhanced MDCT images as a high-density, thin-walled curvilinear tubular structure with a smooth and uniform appearance. Polytetrafluoroethylene (PTFE) felt material (felt pledgets) reinforce sites of arterial cannula placement from cardiopulmonary bypass. Pledgets are visualized on MDCT as small, paired, extraluminal densities that are spatially well-defined. The high-density felt material in these locations, a normal postoperative imaging finding, can mimic a PSA on MDCT, and unenhanced images must be used to confirm that these areas are surgical materials. (Fig. 1). Sometimes, the surgical technique include an "elephant trunk" portion of the graft protruding in the native descending aorta that can mimic a distal dissection. (Fig. 2).

TEVAR has become an accepted alternative to surgery for the treatment of aortic diseases. Most endovascular stents have an inner metallic skeleton made of nitinol, with a characteristic zigzag appearance causing only mild streak artifacts, surrounded by a covering of plastic (PTFE) or polyester graft membrane. The covering membrane component of the stent-graft is not seen on CT. Other devices such as the Candy-Plug
(Fig. 3) can be used together with regular TEVAR in order to occlude the false lumen. The Candy-Plug is a double tapered, tubular stent-graft. The Candy-Plug technique follows placement of a thoracic stent-graft into the true lumen to the level of the celiac artery. The Candy-Plug is then placed into the false lumen down to the distal end of the true lumen stent-graft thereby occluding the false lumen proximal to the renovisceral segment while preventing false lumen backflow to the thoracic segment.

Mild rim enhancement of fluid collections in the early postoperative period can be a normal finding, however, and often cannot be distinguished from low-grade infection in the acute and subacute postoperative period. Further investigation with biopsy, aspiration, re-do sternotomy, or even a PET-CT may be required for definitive diagnosis if a postoperative infection is suspected (Fig. 4). Although postoperative periaortic fluid collections used to resolve in 1-3 months, sometimes maybe persistent for a longer period and it does not necessarily mean a complication (Fig. 5).

**FINDINGS AT FOLLOW-UP: WHAT SURGEON NEEDS TO KNOW**

After treatment of a DeBakey type I aortic dissection either with a composite valve graft or valve-sparing surgery, the radiologist has to check the patency of false lumen and flow characteristics both at true and false lumen. The best way to do that is by MR imaging using MR-angiography and MR flow-sequences. Three scenarios are expected:

- Flows at true and false lumen are antegrade and quite symmetrical. (Fig. 6-8). We refer this scenario as **non dominance flow**.

- Flow at false lumen is antegrade but slowest than in true lumen (**proximal flow dominance**)

When in these two situations, there is dilatation of the aorta at follow-up, the recommended treatment is TEVAR.

- There is a false lumen backflow (**distal flow dominance**). In our series, this is the most frequent situation. The principle behind is a persistent backflow from distal entry tears. If the aorta dilates, the treatment in this case is EVAR. (Fig 9-12).

Thoracic endovascular aortic repair (TEVAR) has evolved as an alternative to open repair for a range of aortic pathology. Lifelong surveillance is obligatory following TEVAR to monitor the aortic morphology and detect associated complications. **The ultimate aim of TEVAR is to prevent aortic disease progression or rupture.** (Fig 13-14).
Endoleaks, defined as the persistent perfusion of the aneurysmal sac either after TEVAR or EVAR, are a very well-known complications after implantation. A less common complication is the development of endograft collapse. Although usually occurs shortly after the procedure, it is possible to diagnose it at follow-up. (Fig 15).

**Retrograde extension of the primary tear into the proximal aorta** is a rare event and is commonly an early complication. It is more common after TEVAR for aortic dissection compared with aortic aneurysm and it is associated with oversizing and possibly post-deployment balloon dilation of the endograft. (Fig 16).

**End organ ischemia** can occur post-TEVAR with spinal ischemia being the most investigated with an incidence of up to 7%. Vascular compromise can occur secondary to direct occlusion of vascular origins by the covered portion of the endograft. (Fig 17). Changes in flow dynamics in cases of aortic dissection can also reduce end organ perfusion, especially if the vascular supply is from the thrombosed false lumen.
**Fig. 1:** Pledgets visualized on MDCT. Figure (a) shows a felt pledget in ascending aorta that can mimic a PSA (arrow). Figure (b) shows the same image without contrast (arrow) and confirm that these areas is surgical material.
**Fig. 2:** Elephant trunk. Axial and sagittal MDCT angiogram show how the elephant trunk technique is depicted. A felt strip is seen at the distal aortic arc (arrow). The elephant trunk can simulate an aortic dissection flap.

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**Fig. 3:** Candy-Plug technique. Fig (a) shows a photograph of a Candy-Plug on the delivery system. Fig (b), MDCT, and fig (c), 3-D volume rendering, depict the Candy-Plug device (red and white arrow) placed in the false lumen with the corresponding occlusion.

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**Fig. 4:** Aortic graft infection. Fig 4a shows a peritube collection of uncertain significance (arrows). Fig 4b-c show the PET-TC correlation with intense, heterogeneous peritube FDG uptake (SUVmax 13,4)

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**Fig. 5:** Persistent perigraft collection. Seven months after Bentall-Bono surgery, a fairly stable fluid collection is present. The patient has no symptoms.

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Fig. 6: Non flow dominance. MR angiography shows a pretty symmetrical flow both at false and true lumen

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Fig. 7: Non flow dominance depicted by MDCT. There are both wide proximal and distal entry intimal dehiscence.

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Fig. 8: Non flow dominance. MR flow sequences at different levels of the aorta show that at diastolic phase (white box) there is no difference between true and patent false lumen regarding de flow volume.

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**Fig. 9:** Distal flow dominance. MR angiography shows a backflow false lumen at the delay phase.

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**Fig. 10**: Distal flow dominance. Fig 10(a) shows a proximal entry less than 5 mm at aortic arch and fig f10 (b) shows a wide distal entry at distal descendent aorta. Fig 10 c and d show two MR angiography images at early and delay phase that depict how the false lumen backflow.

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**Fig. 11:** Distal flow dominance. MR flow sequence at different levels of the aorta. The white box point out that at systole there is a flow volume at the false lumen going from bottom to the top (green bar) that reverse during dyastole (blue bar). This fact implies that the false lumen is "pressurized" and the probability of developing aneurysm is increased.

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Fig. 12: Distal dominance flow. Three months follow-up MDCT show a progressive dilatation of descending aorta in a case of distal dominance flow. Closure of the distal entry was ordered and good remodeling of aorta with almost normal diameter were found at follow-up.

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Fig. 13: Persistent false lumen perfusion with increase in the false lumen size and aortic diameter. Axial CTA images at the level of the right pulmonary artery (a,c) and diaphragm (b,d) following TEVAR for De Bakey type I aortic dissection. After 6 months, both the false lumen and aortic diameter have increased significantly.

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**Fig. 14:** Optimal EVAR result in a patient with type B dissection after surgical repair for type A dissection. Axial (a,b) and sagital (c,d) CTA images show near complete thrombosis and exclusion of the false lumen. This patient was treated with EVAR in order to occlude the distal entry since there was a distal flow predominance.

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**Fig. 15:** Endograft collapse. The maximum intensity projection (MIP) images clearly depict the fracture of the endograft.

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Fig. 16: Retrograde dissection. Sagital CTA image (a) shows a penetrating aortic ulcer (arrow) treated with TEVAR (b). Four months later, the patient developed a retrograde dissection (arrow)

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Fig. 17: End organ ischemia. 3D volume rendered image (a) of a patient treated with TEVAR and EVAR (arrows) for chronic aortic dissection. (b) show normal size of both kidneys. One year later an evident right renal atrophy is present (arrow).
Conclusion

- Surgical, endovascular and hybrid approaches to thoracic aortic conditions are increasingly complex. Imaging has an essential role in the postoperative evaluation of the thoracic aorta.

- According to clinical suspicion, a variety of CT-angiography, MR imaging sequences and PET-CT can be used. Knowledge of the original underlying disease and the repair techniques in use are essential for accurate postoperative imaging interpretation.

- Radiologists must be familiar with the imaging techniques indicators of vascular instability to consider either surgical or endovascular management and potentially avoid vascular rupture.
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