Virtual Angioscopy and 3-Dimensional Navigation Findings of the Aortic Arch After Vascular Surgery

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The anatomy of the aortic arch is variable, and its detailed analysis on computed tomography (CT) scan may be difficult. Indeed, its curvature, angulations, length of horizontal portion, and origin of supra-aortic trunks (SAT) may vary among individuals. Furthermore, drastic modifications of the patient’s anatomy may be observed after open or endovascular surgery and in case of congenital abnormalities. The 3-dimensional (3D) nature of the aortic arch is then difficult to assess on an axial plane. Current workstations have permitted the reconstruction in 2 dimensions of the aortic arch, and the volume-rendering technique or shaded surface display gives an external analysis of the structures. Virtual angioscopy, first described in 2001, allows the realization of an endoluminal navigation in 3 dimensions. It is based on the notion of active vision, in which only visual perception drives the motion of the virtual angioscope. The navigation mode allows manual analysis of the elements of the aortic arch under different viewing angles and dynamic localization of abnormalities in relation to SAT with high precision and better understanding. Here are examples of patients having undergone an aortic arch procedure and for whom the fly-through with the help of virtual angioscopy has permitted better understanding of abnormalities of the aortic arch.

Methods

A 64 Light Speed VCT multidetector-row CT was used (General Electric Medical Systems, Milwaukee, Wis), allowing maximal intensity projection and maximal projection-rendering imaging, as well as 3D rendering of images. Images were analyzed on a dedicated platform (Advantage Windows 4.2, General Electric Medical Systems). Angiography was obtained through the chest at 0.06-mm nominal thickness by intravenous injection of Visipaque (32 mg/mL, GE Healthcare SA, Velizy, France). Virtual angioscopy reconstruction was performed and volume-rendered thresholds and spatial rendering were applied (Volume Viewer, General Electric Medical Systems) that generated endoluminal views.

Results

Case 1

A 70-year-old patient was operated on for an aortic arch aneurysm with a hybrid technique consisting of prosthetic bypass from the ascending aorta to the SAT, then endografting of the thoracic aorta (Figure 1A). On control CT scan at 1 month, axial cuts revealed a dissection of the ascending aorta. However, precise localization of its entry site and surrounding anatomic structures (coronary ostia, aortic valves, prosthetic bypass, and endoprosthesis) was not possible with monoplanar imaging. (Figure 1B, top). Virtual angioscopy confirmed the dissection, and endovascular navigation showed its retrograde character beginning at the toe of the bypass near the suture line and extending retrograde down to the level of the right coronary ostium (Figure 1B, bottom, and online-only Data Supplement Movie I). The integrity of the anastomotic line was confirmed. Moreover, in contrast to conventional CT data, 3D visualization gave informations on the mechanism of the dissection, which seemed to be related either to aortic cross clamping or to the guide wire used for endoprosthesis placement. This patient is scheduled for a repeat aortic root replacement.

Case 2

An 82-year-old patient was operated on for acute type A dissection with aortic root replacement and en bloc reimplantation of the SAT. Conventional CT scan at 6 years follow-up showed a 70-mm dissecting aneurysm of the descending aorta with an intimal tear that could be approximately located within the aortic arch (Figure 2, top). Virtual angioscopy confirmed the dissection. Endovascular navigation precisely showed that the intimal tear was due to a rupture of the SAT block suture line under the Teflon felt near the left subclavian artery and that it fed the distal false lumen (Figure 2, bottom, and online-only Data Supplement Movie II). In comparison to conventional CT data, virtual angioscopy gave a better understanding of the genesis of the aneurysm of the descending aorta, which seemed to be related to the refeeding of the false lumen by the intimal tear. This case did not appear to be appropriate for endovascular treatment. On the other hand, the patient was not fit for a complex reintervention and was not scheduled for a new procedure.

Case 3

A 48-year-old patient was operated on for acute type A dissection with aortic root replacement. On control CT scan at...
6 years follow-up, axial cuts showed dissection of the aortic arch and more specifically the involvement of the supra-aortic ostia (Figure 3, top). Virtual angioscopy confirmed the dissection, and endovascular navigation precisely displayed the location of the dissection in the convexity of the arch near the ostia of the left subclavian and the innominate arteries (Figure 3, bottom, and online-only Data Supplement Movie III). In comparison to conventional CT data, virtual angioscopy gave a better understanding of the genesis of the dissection. The observed intimal tear was probably the exit site of the initial dissection, its entry site having been excised during the first procedure. No enlargement of the aortic arch was observed during follow-up.

Case 4
A 54-year-old patient with Marfan disease was operated on for acute type A dissection with aortic root replacement. On the control CT scan at 5 years follow-up, axial cuts showed an isolated dissection of the innominate artery with dilatation reaching 37 mm (Figure 4, top). Endovascular navigation confirmed the dissection and showed its entry site precisely by displaying a large intimal tear at 6.00 hours of the innominate artery (Figure 4, bottom, and online-only Data Supplement Movie IV). Thus, the patient was subsequently reoperated on for aortic arch replacement. Each finding of abnormality in virtual angioscopy is also shown in coronal or sagittal cuts to give a better understanding of the aortic arch and the SAT.

Conclusion
The analysis of the aortic arch after vascular surgery is sometimes confusing for the surgeon and the radiologist with conventional CT data. Virtual angioscopy and 3D navigation may help beyond the conventional method of diagnosis by demonstrating the final endoluminal configuration. Postgrafting information on the 3D relationship of the SAT ostia is provided. Abnormalities such as the precise location of entry sites of dissection and integrity of the suture line can be observed. This provides a better understanding of the aortic arch anatomy and may help indicate the optimal surgical strategy.3,4

Disclosures
None.

References
Figure 2. CT scan at 6 years of an acute type A dissection treated by aortic root replacement and en bloc reattachment of the SAT (case 2, online-only Data Supplement Movie II). Axial cut (top) shows dissection of the aortic arch. Virtual angioscopy (bottom) precisely locates the intimal tear just adjacent to the teflon felt.

Figure 3. CT scan at 5 years of an acute type A dissection treated by aortic root replacement (case 3, online-only Data Supplement Movie III). Axial cut (top) shows dissection of the aortic arch. Virtual angioscopy (bottom) precisely locates the origin of the retrograde dissection at the level of left subclavian artery.
Figure 4. CT scan at 5 years of a patient with Marfan disease operated on for an acute type A dissection by aortic root replacement (case 4, online-only Data Supplement Movie IV). Axial cut (top) shows the dissection of the innominate artery. Virtual angioscopy (bottom) precisely locates the intimal tear 2 cm after the origin of the innominate artery.
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