# Benefits of Immediate Cone-Beam CT After EVAR

Assessing technical success after standard and fenestrated EVAR.

**WITH ROBERT Y. RHEE, MD**

## What can you tell us about your practice?

I am the Chief of the Vascular Surgery Division of the Heart and Vascular Institute at Maimonides Medical Center, a 740-bed tertiary care center located in the heart of Brooklyn, New York, which draws from more than 2.5 million patients within a radius of 5 square miles. Within the Institute, I also direct and lead the comprehensive aortic center, which treats patients with the full range of aortic pathologies from acute aortic dissections to complex aneurysms. Our aortic center team includes vascular surgeons, cardiac surgeons, cardiologists, and nurse practitioners. We offer patients access to the latest advancements in aortic therapies by leading or participating in clinical trials, the only way to offer a truly comprehensive approach to managing complex aortic diseases.

## What types of aortic cases do you typically see at your referral center, and what is your treatment philosophy?

At our aortic center, surgical and endovascular repair of abdominal and thoracic aortic aneurysms is performed utilizing the latest imaging technologies so that patients are treated using the safest and most effective approach. Our surgeons and interventionists attempt to provide the least invasive solution to any patient's aortic disease, which is possible because we perform all of our complex aortic procedures in two state-of-the-art hybrid operating rooms (ORs). Each aortic repair is carefully planned and tailored to the patient's anatomic characteristics. We utilize the most advanced imaging technology such as computer simulation and real-time three-dimensional (3D) fusion imaging to plan and guide the aortic procedures. We often combine this approach with virtual reality software that allows our vascular surgeons to "rehearse" the procedure in advance in our state-of-the-art center for clinical simulation.

## What are the current challenges of patient follow-up after endovascular aneurysm repair (EVAR)?

Although endovascular treatment of aortic diseases is extremely effective in preventing disease progres-

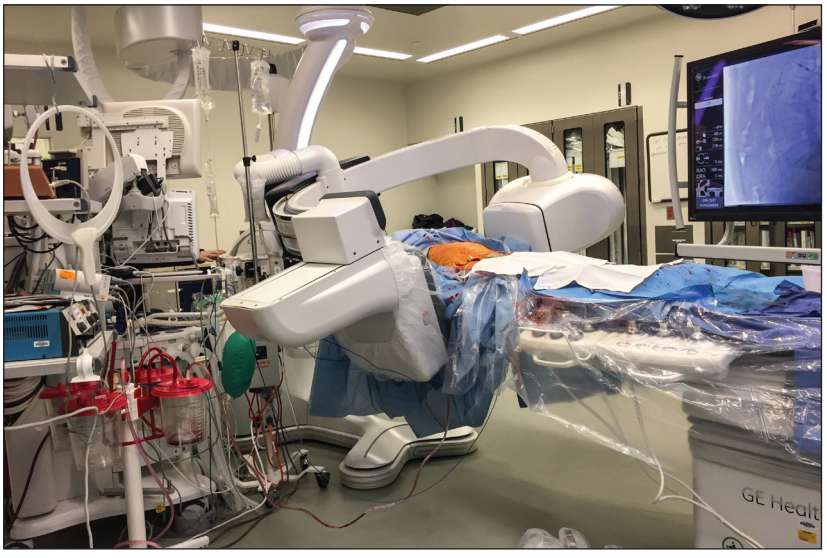
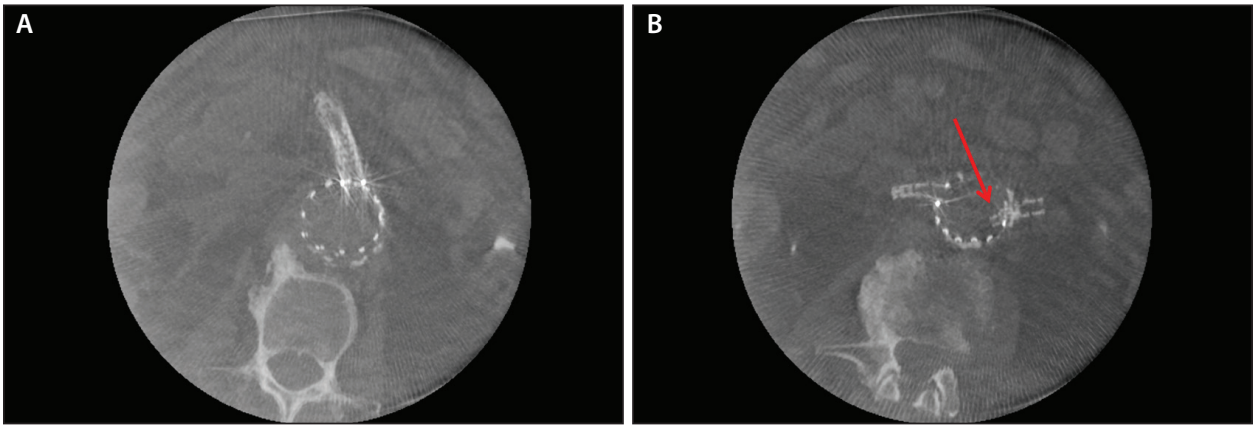



**Figure 1. The CBCT layout of the hybrid OR.**




Courtesy of Stéphan Haulon, MD, PhD.

**Figure 2. The superior mesenteric artery branch showing 3D patency and integrity of the stent (A). CBCT shows a kink in the left renal stent graft, which is subsequently treated before completion of the FEVAR procedure (B).**

sion and death, follow-up is often a challenge due to the need for serial imaging studies. Even though post-EVAR/thoracic EVAR (TEVAR) mortality rates are quite low, the increasing volume and complexity of aortic endovascular procedures leads to a well-defined rate of stent graft–related complications, which often requires reintervention. A second concern is related to the prevailing question regarding the long-term durability of endografts in general. Therefore, regular follow-up with CTA or duplex ultrasonography (DUS) is still required. This need for close follow-up for post-EVAR/TEVAR patients has raised serious concerns regarding radiation exposure over the long term. During endovascular aortic treatment, patients must undergo several repeated exposures to radiation: before (preoperative CTA), during (perioperative fluoroscopy and angiography), and after the procedure (postoperative CTA).

## What was your previous standard protocol for EVAR assessment and follow-up?

Historically, we performed standard digital subtraction angiography (DSA) to detect type I or type III endoleaks, which are then mostly treated immediately in the hybrid OR. Elective patients were discharged the day after the procedure. Patients were then brought back to the medical center for a 1-month follow-up CTA and DUS. If a type I or type III endoleak was detected at this point, they were treated immediately. If a type II endoleak was detected, follow-up CTA or DUS would be performed every 6 months to assess the aneurysm sac size. Once the aortic sac stabilizes, we change to yearly follow-up going forward.

Unfortunately, the two-dimensional (2D) nature of the DSA used for immediate assessment can lead to missed endoleaks, which could have been treated at the time of the original implantation. Occasionally, inadequate visualization of the actual structure of the endograft device leads to early reintervention within the first few months after the initial procedure. In such cases, complications are detected at the 1-month follow-up CTA, requiring the patient to undergo additional radiation exposure and face the risks associated with a second invasive endovascular procedure.

## How has the hybrid OR changed your workflow after EVAR?

Our hybrid ORs allow us to smoothly combine surgical and minimally invasive catheter techniques to treat our patients. Modern hybrid ORs enable the acquisition of cone-beam CT (CBCT) scans intraoperatively (Figure 1). The Discovery IGS 740 (GE Healthcare) wide-bore offset C-arm allows fast and easy CBCT acquisi-

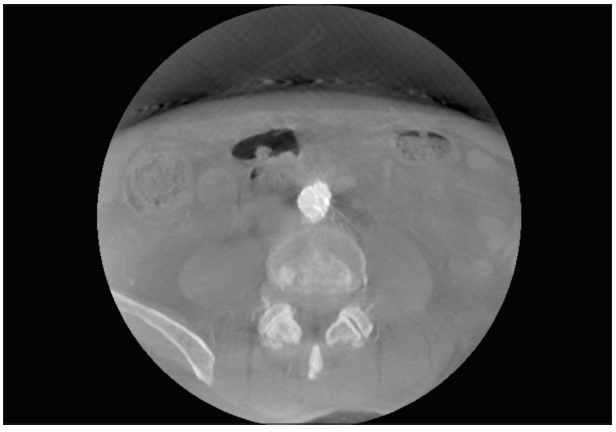


**Figure 3. The left limb of an EVAR device is compressed on CBCT, but this is not apparent on 2D completion angiography. The limb was treated immediately while the patient was still in the hybrid OR.**

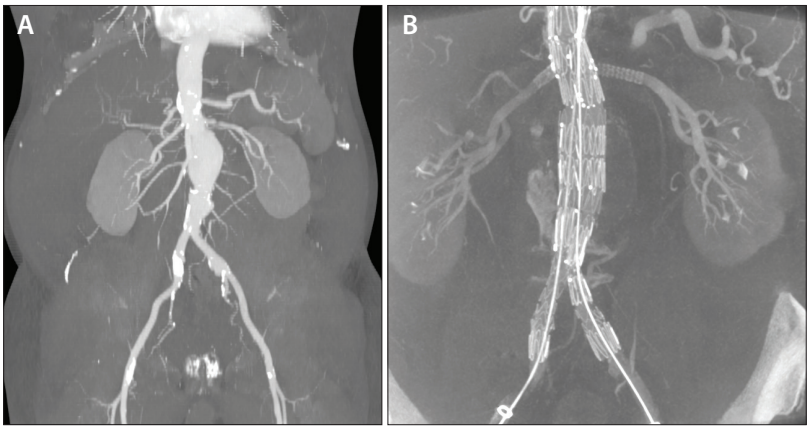



**Figure 4. Preoperative CTA before FEVAR (A). Postprocedure CBCT of the same patient showing the 3D details and full evaluation of the endograft configuration (B).**

tion even for patients under general anesthesia. Three-dimensional cross-sectional images are reconstructed in less than a minute and can be immediately reviewed to check for type I, II, or III endoleaks; patency and integrity of the endograft; direct 3D assessment of the visceral branch stent grafts (Figure 2); and patency of the iliac arteries (Figure 3).

After we initiated a contrast-enhanced CBCT protocol, we directly compared immediate post-EVAR CBCT with 1-month follow-up CTA in 12 EVAR patients over a 3-month period. CBCT provided good image quality and detected all significant endoleaks, problems with the main device, or branch graft integrity as compared with standard CTA. The routine completion DSA is also not needed due to the sensitivity of CBCT for detecting endoleaks and endograft integrity issues. After this lead-in period, we completely eliminated the use of the routine 1-month follow-up CTA.

## How do you actually perform a CBCT in the new hybrid OR?

The setup for CBCT is essentially the same as the layout for performing the EVAR/TEVAR procedure. The contrast-enhanced CBCT is performed at the end of the endovascular aortic procedure and consists of a 5-second rotational acquisition > 200° centered on the anatomy of interest with injection of 35 mL of contrast media mixed with 35 mL of saline solution. Patients are asked to hold their breath (or the ventilator is temporarily paused if they are under general anesthesia) during the acquisition for image quality optimization. An x-ray delay of 2 seconds allows for good filling of the vessels prior to the start of the acquisition, and the total volume allows opacification throughout the length of the rotation. The 2D projections are automatically pushed to a workstation (Advantage Workstation, GE Healthcare), and 0.45-mm X 24.4-cm axial slices are reconstructed in a 512 X 512 matrix size. We review both the multiplanar and 3D images at all angles to visualize the endograft within the patient's anatomy immediately after the procedure.

## How has your practice evolved for postoperative EVAR assessment and follow-up with the hybrid OR?

The main difference in our current practice with the addition of the hybrid OR is the utilization of completion contrast-enhanced CBCT to detect endoleaks and ensure endograft/stent integrity. CBCT is particularly useful and sensitive to fenestrated and branched endografts (Figure 4). The patient is usually discharged the day after the procedure (elective EVAR), and initial follow-up is now performed at 1 month with DUS only and then every year thereafter. Patients with type II endoleaks (Figure 5) are followed every 6 months to measure aneurysm sac growth, and if needed, they undergo reintervention. We no longer perform 1-month follow-up CTA.

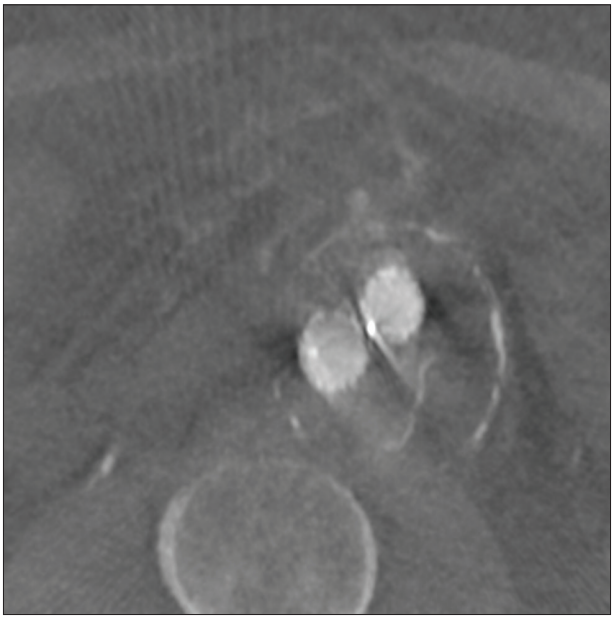


**Figure 5. CBCT showing a large type II endoleak not detected on standard DSA.**

## What are the benefits and outcomes with this new protocol?

The obvious main benefit is the ability to immediately reintervene and correct a defect while the patient is still on the angiography table (Figure 2B and Figure 3), problems that may have only been detected at the 1-month follow-up CTA. In complex fenestrated EVAR (FEVAR) cases, it allows a precise assessment of endograft positioning and branch stent integrity within the patient's anatomy. I believe that this is a huge improvement in the quality of patient care and safety. The number of secondary reinterventions in < 30 days could potentially be reduced, which in turn could increase patient satisfaction.

Repeated radiation exposure for patients who undergo EVAR is a growing concern, and most aortic centers have adopted some form of follow-up schedule, which has reduced the number of radiation-emitting imaging studies during the immediate and long-term postoperative period. According to previously published data, the effective dose from a CBCT is 2.03 mSv (for the Discovery IGS 730) or 3.36 mSv (for the Discovery IGS 740) compared to 4.4 to 5.6 mSv for a standard low-dose CTA. The use of CBCT may ultimately reduce the overall radiation-associated complications after EVAR/FEVAR.

Contrast-induced nephrotoxicity is a major concern for high-risk patients undergoing repeated CTA exams. We have been able to lower the contrast volume to 70 mL of diluted 50% contrast media for injected CBCT versus 125 mL of full-strength contrast for a typical follow-up CTA at our center.

## Are there any economic benefits with this new protocol in your experience?

The protocol for EVAR assessment and follow-up may vary from center to center. In our center, we perform the immediate assessment with CBCT, which is reimbursed similarly to CTA. We utilize the codes for CTA (74175 including 76377 for 3D). While improving the safety and quality of care for our patients with abdominal aortic aneurysms, we're able to show that this approach is cost-effective. ■

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