ASK THE EXPERTS

What Is Your Protocol for Following Patients After TEVAR?

Expects comment on their approach to surveillance for patients with aneurysmal disease versus aortic dissection.

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Thoracic endovascular aortic repair (TEVAR) has become the modality of choice for treating thoracic aortic pathology, with reduced morbidity and mortality as compared with open surgery. Over the past few years, this technology has been increasingly adopted for aortic dissection. With all endografts, there is a long-term failure rate attributable to endoleaks, and therefore long-term surveillance is mandatory. There has been no clear consensus as to the frequency and imaging modality of choice for surveillance. Most practitioners follow a schedule utilized in some pivotal studies that have evaluated endografts, which involves CTA at 1, 6, and 12 months and then yearly thereafter. Of late, there has been concern about radiation exposure and contrast usage during such long-term follow-up.

It is important to understand what the long- and short-term endpoints are to treating both aortic aneurysmal disease and the spectrum of aortic dissection. In aortic aneurysmal disease, we are evaluating for the presence of endoleaks and sac enlargement. In patients with dissection, there is almost always filling of the false lumen, and we are essentially concerned with long-term aortic remodeling and prevention of aneurysmal degeneration.

In my practice, patients with endografts for aneurysms are followed using CTA at 1 month, and if there is no endoleak identified, then they are followed with a combination of either CTA or noncontrast CT on a yearly basis depending on the patient's renal function. If an endoleak (specifically type II) is identified at the 1-month CTA, then I reevaluate them with CTA at 6 and 12 months. If the aneurysm sac remains stable with an endoleak, then I continue to follow them with a combination of either CTA or noncontrast CT yearly.

Patients who have endografts placed for aortic dissection are followed slightly differently. I obtain the first CTA at 3 months postprocedure as long as there is no change in the patient's clinical status. I think this allows sufficient time to allow for possible false lumen thrombosis and/or aortic remodeling. I then follow these patients yearly with noncontrast CT, as the long-term endpoint is aneurysmal degeneration of the aorta. If noncontrast CT demonstrates aneurysmal degeneration, then patients undergo CTA to evaluate for treatment options.

Another modality worth mentioning is MRI/MRA. Although I do not utilize these imaging modalities in my

practice for TEVAR surveillance, with advancement of techniques, they may be a good alternative to avoid the radiation and possible contrast dose and obtain the necessary information, and possibly more detailed information about specific endoleaks.

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TEVAR has become the standard of care in treatment of descending aortic pathology over the last 2 decades and is a viable option for more proximal segments of the aorta in patients at risk for open surgery. Results of fenestrated and branched endografts in the aortic arch show comparable short- and midterm outcomes compared with open surgery and offer significantly reduced perioperative morbidity. There is not much doubt that TEVAR will become first-line therapy in the foreseeable future for the majority of cases in the whole thoracic aorta. To maintain good results, a clear and comprehensive follow-up protocol is key, as most complications of TEVAR can be addressed with reinterventions without significant harm to the patient. However, in order to establish a standardized post-TEVAR surveillance program, gaps in the evidence and the potential harm from radiation and repeated administration of iodine-based contrast agent need to be addressed.

In our clinical practice, follow-up intervals generally include postoperative CTA on postoperative days 3 to 6. If the scan does not detect any abnormalities, the next CTA is performed at 1, 3, and 6 years, and every 5 years thereafter. The time between CTAs increases as long as the most recent scan shows no abnormalities and a regressing thoracic aortic aneurysm is excluded without endoleak. Many patients also have pathologic findings in untreated segments of the aorta, such as aortic dissection, so surveillance intervals need to be modified based on these findings. If complex repair included fenestrations, branches, or chimneys, follow-up intervals would be modified depending on the vessels involved.

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Serial follow-up after TEVAR can be very different as compared with how we follow endovascular aneurysm repair (EVAR) for infrarenal abdominal aortic aneurysms. First, EVAR is performed almost exclusively for aneurysmal disease, while TEVAR is performed for dissection, traumatic aortic disruption, the occasional saggy aorta, and aneurysms. The majority of EVAR is for infrarenal disease. TEVAR frequently requires seal in zone 2 or just distal to the left common carotid artery, and thus we don't have a set follow-up protocol for TEVAR. We could obtain a CTA at 6 months and then yearly, but for many patients, this is unnecessary and creates increased cost and risk to the patient.

With this in mind, I tend to divide TEVAR into aneurysmal and nonaneurysmal disease. For aneurysmal disease that does not involve the great vessels, I perform a chest CTA at 6 months, then noncontrast CT annually out to 3 years. If there is any sac growth, we obtain a CTA at that visit. At this point, a new algorithm of workup is created. However, if there is no graft migration or aneurysmal sac growth, we perform a repeat noncontrast CT scan at 5 years. At the 5-year visit, we typically perform a noncontrast CT scan that includes the abdomen and pelvis as well. Further scheduled follow-up scans are based on patient's age, general health, and level of suspicion for disease progression.

It is ironic that we think of the thoracic aorta as having a significant number of lumbar arteries, but we don't see nearly the same number of type II endoleaks in TEVAR patients as compared with EVAR patients. Some may argue it's because we're not doing CTAs. This may be true, but in our practice, significant sac shrinkage has been seen in a much higher proportion of patients who underwent TEVAR as compared with EVAR. We rarely see sac growth in TEVAR patients. For TEVAR that extends into the arch, we add carotid duplex and graft surveillance studies to the follow-up protocol.

TEVAR in patients with nonaneurysmal disease typically is due to type B dissections or traumatic disruption. For traumatic disruption, we usually obtain a chest CTA at 1 month. If all looks well, we obtain posteroanterior

and lateral chest radiographs at 1 year to rule out migration. After that, we perform a chest CT every 5 years to rule out migration and verify good wall apposition. Further scheduled scans are based on patient's age, general health, and level of suspicion for disease progression. Of note, a large number of these patients who receive stents for trauma are young, and it is not determined how the aorta and stent will age together.

The patient population with type B dissections can be very challenging. If the dissection is isolated to the chest, follow-up is fairly straightforward. If there is an acute dissection, it can act very much like traumatic disruption with the aorta remodeling back to a relatively normal state. Our follow-up protocol in acute type B dissection is a chest CTA at 1 month, then CT without contrast at 6 months, then annually out to 3 years. If everything is stable, we evaluate every 5 years after that. For chronic type B dissections with aneurysmal changes, we typically obtain a chest CTA at 1 and 6 months and then CT without contrast annually out to 3 years. It is important to remember that chronic type B dissections with aneurysmal changes rarely resolve and frequently involve the abdominal aorta. We follow patients with chronic type B dissections the same as patients with acute type B dissections, except we usually also obtain yearly noncontrast CT abdomen scans. Even if the dissection involves the visceral segment, we tend to limit our contrast scans as long as the patient is asymptomatic and the aneurysm sac is either stable or regressing. We verify visceral vessel patency on duplex imaging, and then we obtain a CTA of the chest, abdomen, and pelvis at 5 years. Further scheduled scans are based on patient's age, general health, and level of suspicion for disease progression.

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Thoracic aortic endografts were originally indicated for patients with thoracic aneurysms that were felt to be too high risk for open thoracic repair. The only option for repair was TEVAR. The potential complications of postimplantation surveillance modalities, frequency of surveillance, and duration of surveillance were not a significant concern in this high-risk population. With the proven decrease in acute morbidity and mortality of TEVAR, there has been liberalization in patient selection to include the non–high-risk patients and an expansion of indications from only aneurysmal disease to penetrating aortic ulcerations (PAUs), dissections, and traumatic disruptions. With expanded indications and inclusion of lower-risk patients, more patients are living longer after TEVAR. This is especially true in patients treated with TEVAR for aortic disruption secondary to trauma, which can occur at a much younger age than aneurysmal disease. This makes the follow-up and its potential risk and cost more of a concern.

Depending on the indication for TEVAR, the follow-up requirements may be varied. Patients who were treated for complex thoracic aneurysmal disease or aortic dissections may require more intensive follow-up than patients treated with an appropriately sized thoracic endograft for traumatic disruption or PAU. Complications after TEVAR for aneurysmal disease and dissections can include endoleak, graft migration or collapse, wireform fracture, false lumen perfusion in the case of dissection, and progression of aneurysmal disease in adjacent aortic segments. Late type I or type III endoleaks after TEVAR for aneurysmal disease can occur in 2% to 11% of cases, with an overall late endoleak rate approaching 30%. Of those patients with late endoleaks after TEVAR, 50% will require reintervention. Proximal aortic "bird beaking" and subsequent proximal aortic collapse have been reported as late as 3 years after endograft implantation with TEVAR.

To minimize the risk of paraplegia, we tend to treat only the aneurysmal portion of thoracic aorta, and further aortic degeneration can occur, resulting in subsequent aneurysmal disease proximal or distal to the TEVAR. Large thoracic aneurysms treated with TEVAR

can have late graft migration or separation with remodeling of the thoracic aorta. Patients with PAU and traumatic aortic disruptions generally have more normal aortic tissue proximal and distal to the diseased aorta and do not need TEVAR graft oversizing for TEVAR graft fixation, and the risk of migration or endoleak is decreased. In these patients, once the TEVAR and aorta are confirmed as stable, more intensive follow-up may not be required.

Unlike the abdominal aorta, the thoracic aorta cannot be imaged using ultrasonic duplex evaluation due to the lack of fluid density within the thoracic cavity to transmit the ultrasonic waves. Postoperative surveillance must be performed using chest x-ray, CT, CTA, and MRI/MRA when the TEVAR graft does not contain ferrous metals. Chest x-ray can evaluate for wireform fracture or graft separation, and CT without contrast can also evaluate aneurysm sac size as well as graft separation or migration but cannot detect endoleaks or persistent perfusion of the false lumen of a dissection. CTA, MRA, and invasive digital subtraction angiography are the only modalities currently available to assess for these aberrant blood flow patterns. Two major concerns for the use of CT include the use of ionizing radiation, which has been shown to increase the incidence of leukemia as well as solid tumors (2.7%–12% risk increase), and renal insufficiency in the deleterious effect of multiple contrast dye administrations on renal function with repetitive exposures.

In our practice, we tend to individualize follow-up based on the patient's age, aortic pathology, and results of previous evaluations. After initial evaluation, we tend to follow abdominal aortic pathology with ultrasound and only obtain CT if there is a question found on ultrasound. In patients treated with TEVAR for thoracic aortic aneurysms and dissections, we obtain a CT scan of the chest at 1-month postimplantation and then generally 6 months, 12 months, and yearly thereafter. If they have a concurrent aortic aneurysm or dissection, we follow that with ultrasound and only extend the CT scan to evaluate the abdomen and pelvis if the ultrasound is suspicious, thereby decreasing the overall radiation exposure. For patients who have been treated with TEVAR for traumatic aortic disruption or PAU and are stable for 2 years, we usually extend the follow-up CT scans to every 2 years. Obviously, more frequent evaluations or angiography may be required if there is any concern on the CT scan for any TEVAR patient.

In patients with renal dysfunction, surveillance is more complicated. A noncontrast CT scan will certainly allow evaluation of the graft integrity and aneurysm sac size but will not evaluate for endoleak or persistent false lumen flow. In patients with moderate renal dysfunction, intravenous hydration prior to contrast-infused CT scan has shown to be an advantage in the acute phase, but the long-term impact is still uncertain. In patients with thoracic endografts with nitinol wireforms, MRI is a possibility. Gadolinium is contraindicated in patients with renal insufficiency due to the potential for nephrogenic systemic fibrosis, but newer MRI technology does allow for nongadolinium imaging with reasonable blood flow evaluation.

Finally, post-TEVAR surveillance needs to be individualized based on the aortic disease pathology treated and the results of previous evaluations to detect acute and late TEVAR complications, optimize patient safety, and decrease cost. The judicial use of CT scan of the thoracic aorta in conjunction with duplex ultrasonography of the abdominal aorta can minimize overall total body radiation exposure. As technology advances and more TEVAR grafts are constructed using nitinol or other nonferrous metals, MRI technology may significantly decrease the overall risk of follow-up imaging. ■