

Duplex ultrasound as the sole long-term surveillance method post-endovascular aneurysm repair: A safe alternative for stable aneurysms

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Objective: Long-term surveillance with computed tomography (CT) after endovascular aneurysm repair (EVAR) increases both cost and risk. The purpose of this study was to evaluate the safety of an alternative follow-up modality with color flow duplex ultrasound scanning (CDU) as the sole method of imaging.

Methods: In 2003, we initiated a new follow-up (FU) schedule with yearly CDU as the sole imaging method for selected patients. Indications included a residual sac of less than 4 cm, expanded later to stable sac size for more than 2 years. A stable type II endoleak was not a contraindication. CT scans were obtained selectively-based on suspicious findings of a new endoleak or enlarging sac on CDU. The records of all patients with at least 1 year FU under this schedule were reviewed.

Results: One hundred eighty-four patients were followed with CDU only for 1 to 4 years for a mean of 24 ± 13 months. The new schedule was initiated at a mean of 34 ± 24 months after EVAR (range 1-112 months). Twenty-three patients had previous endoleaks that had resolved spontaneously or had been treated. During CDU FU, three new endoleaks were detected, one with sac enlargement. All prompted CT evaluation: one type II endoleak with stable sac size could not be identified on CT 3 months later, and two distal type I endoleaks that required limb extension. All three had a prior Ancure endograft. No ruptures or graft occlusions were noted. One abdominal aortic aneurysm (AAA) related death followed graft explantation for infection. There were two additional deaths from malignancy and two from cardiac causes. After the FU switch, freedom from endoleaks was 96%, and from secondary interventions 95% at 48 months by life table method. Mean AAA diameter at baseline was 54 ± 8 mm and decreased to 40 ± 11 mm before the switch to CDU only FU. At last FU mean aneurysm diameter was 39 ± 11 mm. When the current switch criteria were applied to a consecutive series of 200 EVAR patients, 97% would have been eligible for CDU only surveillance by 3 years postoperatively.

Conclusions: CDU only surveillance post-EVAR is safe and can be initiated early after treatment in patients with shrinking or stable aneurysms. This policy should result in cost savings advantage and avoid the complications associated with CT. (*J Vasc Surg* 2009;49:845-50.)

Endovascular aneurysm repair (EVAR) has seen rapid diffusion as a minimally invasive alternative to open repair and is currently widely accepted for the treatment of abdominal aortic aneurysms (AAAs). Although EVAR offers immediate advantages over open aneurysm repair with lower perioperative mortality and morbidity,¹⁻³ it carries the need for lifelong surveillance for potential complications, including endoleak, change in aneurysm size, graft migration, structural graft failure, and limb outflow impairment caused by limb stenosis or occlusion. The ideal surveillance modality should be noninvasive, cheap, and reproducible, with high sensitivity and specificity for the detection of endograft related adverse events. Computed tomography with intravenous contrast injection (CT) is

currently the standard for long-term EVAR surveillance, but is associated with increased cost⁴ and radiation exposure.⁵ It could also contribute to the decline in renal function seen after EVAR as a result of contrast nephropathy.⁶ Color-flow duplex ultrasound scanning (CDU) can also detect endoleaks as well as size changes over time but is more operator dependent.⁷ It, however, has the distinct advantage of being noninvasive, safer, and cheaper than CT scans. Although several studies have evaluated the ability of CDU to detect endoleaks and have established good correlation with CT for the measurement of AAA sac diameter,⁷ there currently is no published series of patients followed with CDU only post-EVAR to document the safety of this follow-up protocol. The purpose of this study was therefore to evaluate the safety of a selective policy of EVAR follow-up with CDU as the only imaging study.

METHODS

Surveillance policy. Starting in 2003, a new follow-up schedule for EVAR surveillance was initiated for selected patients. Annual CDU as the sole imaging modality was offered as early as 1 year post-EVAR for those patients with a collapsed AAA sac ≤ 4 cm in diameter. This policy was

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Competition of interest: none.

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expanded 1 year later to include patients with significant shrinkage of the aneurysm sac to any size, or a stable aneurysm without enlargement for 2 years whether a type II endoleak was present or not. Patients with contrast allergy or significant renal insufficiency (serum creatinine >2) were switched at earlier intervals depending on AAA size and presence or absence of endoleaks. Diameter measurements were defined as the minor axis of the largest axial slice on CT. A significant shrinkage was considered to be a minimum of 5 mm from the baseline 1-month CT. A stable aneurysm was defined as an aneurysm with <3 mm increase in diameter from baseline. Patients with enlargement of the sac by ≥ 3 mm from the baseline CT were not considered for switching. Most patients underwent a CDU to complement the CT scan when the decision to switch the patient was made. All patients with suboptimal studies secondary to anatomy or body habitus were not switched to CDU surveillance. All medical records and imaging studies of patients switched to CDU surveillance between 2003 and 2006 were retrospectively reviewed. Only patients with at least 1 year follow-up on this surveillance schedule were included and form the study population. The study protocol was reviewed and approved by the Institutional Review Board of the University of Pittsburgh.

Duplex ultrasound. All duplex scans were performed by an experienced registered vascular technologist in a fully accredited office-based vascular laboratory. A LOGIQ 9 GE (General Electric Medical Systems, Milwaukee, Wis) ultrasound machine and 3.5 MHz curvilinear transducer were used. Patients were asked to fast overnight or at least 6 hours prior to their study. The CDU protocol included longitudinal and transverse interrogation of the entire aortic sac and iliac arteries. Peak systolic velocities were obtained in the iliac vessels to assess for the presence of limb flow anomalies. Endoleak detection as well as characterization of the source was based on direct visualization and spectral confirmation. Patients included in this study all had adequate examinations with clear visualization of the endograft, excluded sac, and iliac limbs.

CT scan. CT scans were routinely obtained at 1 month and 1 year after EVAR, and only selectively thereafter in patients on CDU surveillance. Helical CT was performed with a Lightspeed QXi multi-detector-row CT scanner (General Electric Medical Systems) from the diaphragm to the femoral heads. Contrast CT scans were performed after a Smart Prep series and reconstructed with a 1.3 or 2.5-mm slice thickness. Noncontrast studies were obtained routinely and late imaging selectively to detect slow endoleaks. Size measurements were all performed by using an electronic caliper tool.

Applicability of the policy. Since criteria were gradually expanded during the report period and many patients were on a regulatory study protocol dictating CT scans for up to 5 years, the applicability of the final policy to the general EVAR population was not apparent from the study group. To assess how many patients are suited for the switch and how late after EVAR it could be implemented, the clinical and follow-up imaging records of 200 consec-

Table I. Demographics and patient comorbidities

| Characteristic | Percent or mean \pm SD (range) (n = 184) |
|------------------------------|---|
| Age (y) | 73.9 \pm 7.1 (52.6–93.4) |
| Male | 86.4% |
| Smoking status | |
| Never | 42.1% |
| Former | 42.6% |
| Current | 15.3% |
| History of diabetes mellitus | 12.5% |
| Hypertension | 90.8% |
| Dyslipidemia | 69.6% |
| ESRD | 3.3% |
| Coronary artery disease | 63.0% |
| COPD | 23.9% |

ESRD, End stage renal disease; COPD, chronic obstructive pulmonary disease.

utive patients with available imaging, treated in 2004 and 2005 were reviewed for findings allowing a switch to CDU. They form the applicability cohort.

Statistics. Baseline demographic, clinical, and procedural characteristics were summarized as mean \pm standard deviation (SD) and ranges for continuous variables and as frequencies for categorical data. Kaplan-Meier methodology was used to estimate survival, freedom from endoleaks, and freedom from reintervention event rates.

RESULTS

One hundred eighty-four patients (159 males) were switched to CDU surveillance between 2003 and 2006 and were reviewed. The mean age was 73.9 ± 7.1 years (range 52.6–93.4 years). Demographics and comorbidities are detailed in Table I. All CDU examinations were technically satisfactory for determination of aneurysm size and presence of endoleak. Mean follow-up on CDU only was 24 ± 13 months (range 1–4 years).

All patients had undergone an EVAR at the University of Pittsburgh Medical Center. Endografts used were: Ancure in 76 patients (Guidant, Menlo Park, Calif), Zenith in 58 (Cook Medical, Bloomington, Ind), Excluder in 39 (Gore Medical, Flagstaff, Ariz), AneurX in 7 (Medtronic, Santa Rosa, Calif), and Lifepath in 4 (Edwards Lifesciences, Irvine, Calif) (Table II). Initial follow-up of these patients included x-rays and CT 1 month after EVAR, 6 months (for patients on protocols), 12 months, and yearly thereafter. Following commercial release of each graft the 6 months follow-up was discontinued because of the low incidence of adverse events detected.⁸ The CDU follow-up schedule was initiated 34 ± 24 months after EVAR (range 1–112 months). The mean AAA diameter at baseline was 54 ± 8 mm and had decreased to 40 ± 11 mm before the decision to implement CDU only surveillance. Forty nine percent of patients had a collapsed aneurysm (≤ 4 cm) at the time of initiation of the new surveillance protocol. At last follow-up, the mean aneurysm diameter

Table II. Graft specific aneurysm characteristics and follow-up pre- and post-switch to CDU only follow-up

| | Graft type N (%) | Baseline AAA size (minor axis, mm) | AAA size at switch to CDU surveillance (minor axis, mm) | Time to CDU switch post-EVAR (mo ± SD) (range) | Mean follow-up post-switch (mo ± SD) (range) |
|----------|---------------------|---------------------------------------|--|--|--|
| Ancure | 76 (41) | 53.7 ± 7.6 | 36.5 ± 8.4 | 52.1 ± 23.3 (5-112) | 33.8 ± 11.1 (12-54) |
| AneuRx | 7 (4) | 53.5 ± 4.2 | 36.9 ± 6.5 | 48.8 ± 27.4 (19-87) | 21.1 ± 15.7 (11-41) |
| Excluder | 39 (21) | 55.3 ± 10.8 | 46.1 ± 11.4 | 21.1 ± 24.6 (1-98) | 13.8 ± 6.9 (12-31) |
| Lifepath | 4 (2) | 56.0 ± 3.6 | 43.5 ± 13.2 | 44.7 ± 4.1 (41-48) | 16.1 ± 1.1 (15-17.0) |
| Zenith | 58 (32) | 52.4 ± 6.9 | 41.1 ± 11.5 | 17.3 ± 12.9 (1-75) | 20.0 ± 11.8 (13-44) |

CDU, Color-flow duplex ultrasound; AAA, abdominal aortic aneurysms; EVAR, endovascular aneurysm repair.

was 39 ± 11 mm. The graft specific changes in sac diameter are detailed in Table II.

Endoleaks. Among the patients on CDU only surveillance, a history of endoleak was present in 36 (19.5%). At the time of the switch, 23 had spontaneously resolved or were treated, and 13 were active persistent type II endoleaks with a stable or shrinking AAA sac.

Three new endoleaks were diagnosed during the CDU only surveillance, only one presenting with sac enlargement. All prompted CT evaluation: one type II endoleak with stable sac size could not be identified on the CT obtained 3 months later, and two distal type I endoleaks that required limb extension. All three patients had a prior Ancure endograft. Two of these patients (1 Ancure, 1 AneuRx) had increased sac size with no endoleak visualized on CDU or CT scan. The patient treated with a prior Ancure was found to have a distal type I endoleak on angiogram and required coil embolization and limb extension into the external iliac artery. This endoleak had not been identified either on CDU nor CT imaging. No endoleak was identified on an angiography in the other patient without any further changes noted in sac diameter on later follow-up.

Clinical outcomes. No patient had any clinical adverse event during the period of observation. No ruptures or graft occlusions were noted. There was one AAA related death 3 days following graft explantation of an Ancure for infection that was diagnosed 4 years after EVAR. There were two additional deaths from lung cancer and two from an acute coronary event with postinfarction heart failure and a prolonged stay in the coronary care unit. After the switch to CDU surveillance, the freedom from clinically significant endoleaks was 96%, and from secondary interventions 95% at 48 months by life table method.

Clinical applicability. Among the 200 patients in the applicability cohort, 86 patients (44%) were actually switched to CDU surveillance. However, by applying the current criteria to this group, 97% of patients would have been eligible for CDU only surveillance by 3 years after EVAR. The corresponding applicability at each yearly follow-up anniversary is presented in the Fig. Many patients were not actually switched in this cohort despite eligibility, frequently because of participation in regulatory trials with mandated CT follow-up protocols, or surgeon preference.

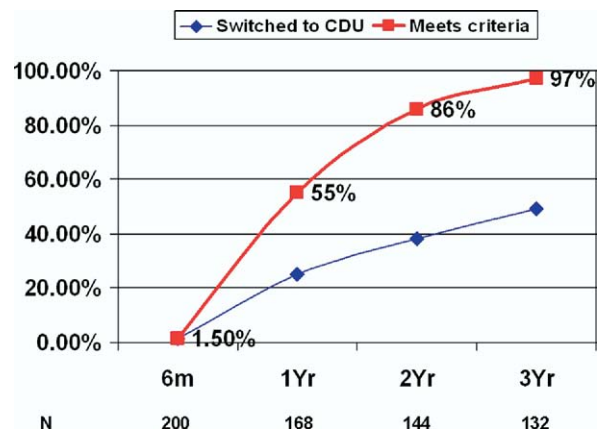


Fig. Eligibility of a consecutive EVAR cohort for CDU surveillance using the current switch criteria up to 3 years post repair.

DISCUSSION

After EVAR, the need for lifelong surveillance drives the search for an optimal means of monitoring endoleaks, aneurysm size changes, migrations, structural failures, and limb abnormalities. Ideally, one diagnostic modality would identify any and all of these possible failure modes reliably. Since the advent of EVAR, CT scanning has been the mainstay of follow-up providing the most information needed for this long-term surveillance. CT, however, suffers from significant drawbacks including side effects related to contrast allergy and a significant radiation exposure resulting in an increased risk of cancer.⁵ Moreover, the nephrotoxic effect of iodinated contrast media used in CT may contribute to a progressive deterioration in renal function over time reported in many patients after EVAR.⁶ Repeated frequent contrast exposure has been implicated in chronic oxidative renal injury, contributing to a steady decline in renal function. Finally, the high costs of CT follow-up contribute a substantially to the financial disadvantage of EVAR compared with open repair.⁴

CDU is an attractive alternative imaging technique. It is less invasive, rapidly available, less expensive, and does not require repeated exposure to radiation or to contrast agents. It has also been validated in the evaluation of endoleaks as well as size changes after EVAR.⁹⁻¹⁴ Endoleaks may be the most frequent complication and consti-

tute by definition a failure of complete exclusion of the aneurysm sac. Although CDU has been shown to have an excellent sensitivity and negative predictive value compared with CT for the diagnosis of endoleak,⁷ these results have not been uniformly reproduced.^{10,11} Our initial experience with CDU in a hospital lab setting with old ultrasound equipment was disappointing as we failed to establish good correlation with CT for the detections of endoleaks.¹⁴ A subsequent move to an office-based lab with modern equipment and a stable experienced technologist pool improved our results significantly. The current study was performed entirely after the move to the office-based lab. On the other hand, the correlation of CDU with CT in the measurement of AAA sac diameter has been well established and is a good surrogate for clinically significant endoleaks.¹⁴ As more experience and late follow-up continue to be acquired, it is well established that late problems following EVAR seem to present as endoleaks with sac enlargement, or limb occlusion with claudication or critical limb ischemia, both of which can be readily diagnosed by CDU. Catastrophic events such as rupture frequently follow poor compliance with follow-up schedules no matter what the imaging technique is. Access to proper imaging equipment and experienced technologists, quality control, as well as the implementation of a standard imaging protocol for EVAR remain essential, however, for the safe adoption of CDU follow-up.^{7,14}

We followed a prudent and stepwise course in establishing duplex scan as a satisfactory EVAR follow-up modality. Although we started testing the hypothesis in a highly selected group, this was not the case in patients switched later, because our current criteria would apply to the majority of patients by 3 years after EVAR. The latter group may not have the same degree of evidence as the initial one. However, we do not believe this affects the conclusion that selected patients can be followed with CDU as every patient had at least 1 year of follow-up safely by CDU.

The time cutoff chosen for switch to CDU surveillance is fairly arbitrary and is based on the institutional experience with EVAR over a period of 7 years prior to the implementation of this follow-up regimen in addition to some regulatory requirements that prevented more patients from being switched earlier. Our observation that patients with a collapsed sac after EVAR are very stable, has been reproduced by others,⁷ and form a good subset for changing imaging modalities. However, the applicability of such a policy shift is more widespread as noted in the safety of the switch in patients with no sac shrinking and even active type II endoleaks. Although a persistent type II endoleak has been postulated to eventually lead to pressurization of the aneurysm sac in some patients,¹⁵ this is always associated with increasing AAA diameter and can be readily diagnosed by CDU. The 2-year cutoff for CDU surveillance in patients with a nonshrinking sac or an active but stable type II endoleak is arbitrary but quite conservative, and could probably be shortened as individual vascular laboratories

become more comfortable with this technique and validate their result with internal quality control.

As the new generation endografts in use continue to generate longer term follow-up data attesting to the durability of the technique and the current devices, early switch to CDU surveillance may gain wider acceptance. In fact, most patients would be eligible for this regimen in most practices since up to 97% of our patient population examined meets our switch criteria by 3 years after EVAR. A change in clinical practice will therefore not only have a significant impact on the cost of EVAR follow-up, but could potentially obviate the steady deterioration in renal function seen in this patient population, as well as the possible risks of gastrointestinal and hematologic malignancies due to radiation exposure.

It is important to note, that although we applied our CDU surveillance policy to several devices, the device specific clinical results may dictate follow-up methods over time. Most new generation devices seem to be associated with less long-term failures and may be better suited for this imaging regimen than older devices.¹⁶ Similarly, patients with initial suboptimal anatomy for EVAR may be at a higher risk for future complications and be better followed by CT at least intermittently alternating CDU with CT to detect early changes in aortic neck anatomy and morphology. Other patients who may not benefit from this follow-up regimen include those being concomitantly followed for a thoracic aortic aneurysm, and patients with excessive bowel gas, ascites or a challenging body habitus.¹⁷

There were no adverse events related to the CDU surveillance regimen, with no ruptures, device failures or limb occlusions in the selected series. These findings parallel those from other reports looking at the fate of endoleak missed on ultrasound.¹⁰ All patients who developed a late type I or type II endoleak either presented with sac enlargement or were diagnosed by direct visualization of the endoleak channel. Only three patients developed a late endoleak, and the high freedom from secondary interventions attests to the safety of the utilized switch criteria. It is important to note, however, that this study was not intended to compare CDU and CT follow-up modalities, and the high freedom from endoleak reported points out that this is a well selected group of patients to caution against indiscriminate application of CDU only surveillance. Although several other follow-up modalities have been proposed for EVAR follow-up, CDU remains the simplest, the least expensive, and the most expeditious, especially in an office-based setting. Magnetic resonance angiography and contrast enhanced CDU may be more sensitive for the detection of endoleaks but suffer again from increased costs and are less readily available.¹⁸ It is estimated that approximately 65% of the total cost of EVAR follow-up is attributable to CT imaging.⁴ With longer follow-up and accrual of more experience with this regimen, earlier switch to CDU surveillance should have an even more significant socioeconomic impact. The risks and cost of CT surveillance have been used as a justification for limiting the use of EVAR. A significant change is this follow-up policy, appli-

cable to most patients, could significantly expand the justified use of EVAR for aneurysm treatment. Follow-up regimens post-EVAR continue to be refined, with a clear trend toward readily available office-based testing. The wider application of aneurysm sac pressure sensors is expected to enhance the safety of follow-up without CT but awaits further confirmation.¹⁹ However, even if the setting of collapsed nonpressurized sacs, it may be prudent to continue obtaining a CT scan every 5 years to detect new remote aneurysms.²⁰

AUTHOR CONTRIBUTIONS

Conception and design: RC, RR, LM, SL, JC, MM
Analysis and interpretation: RC, RR, LM, SL, JC, MM
Data collection: RC, AG, RR, LM, SL, JC, MM
Writing the article: RC, AG, MM
Critical revision of the article: RC, AG, RR, LM, SL, JC, MM
Final approval of the article: RC, MM
Statistical analysis: RC, MM
Obtained funding: RR, MM
Overall responsibility: RC, MM

REFERENCES

1. Prinssen M, Verhoeven EL, Buth J, Cuypers PW, van Sambeek MR, Balm R, et al; Dutch Randomized Endovascular Aneurysm Management (DREAM) Trial Group. A randomized trial comparing conventional and endovascular repair of abdominal aortic aneurysms. *N Engl J Med* 2004;351:1607-18.
2. Blankensteijn JD, de Jong SE, Prinssen M, van der Ham AC, Buth J, van Sterkenburg SM, et al; Dutch Randomized Endovascular Aneurysm Management (DREAM) Trial Group. Two-year outcomes after conventional or endovascular repair of abdominal aortic aneurysms. *N Engl J Med* 2005;352:2398-405.
3. EVAR trial participants. Endovascular aneurysm repair versus open repair in patients with abdominal aortic aneurysm (EVAR trial 1): randomized controlled trial. *Lancet* 2005;365:2179-86.
4. Prinssen M, Wixon CL, Buskens E, Blankensteijn JD. Surveillance after endovascular aneurysm repair: diagnostics, complications, and associated costs. *Ann Vasc Surg* 2004;18:421-7.
5. Brenner DJ, Hall EJ. Computed tomography--an increasing source of radiation exposure. *N Engl J Med* 2007;357:2277-84.
6. Walsh SR, Tang TY, Boyle JR. Renal consequences of endovascular abdominal aortic aneurysm repair. *J Endovasc Ther* 2008;15:73-82.
7. Sato DT, Goff CD, Gregory RT, Robinson KD, Carter KA, Herts BR, et al. Endoleak after aortic stent graft repair: diagnosis by color duplex ultrasound scan versus computed tomography scan. *J Vasc Surg* 1998;28:657-63.
8. Go MR, Barbato JE, Rhee RY, Makaroun MS. What is the clinical utility of a 6-month computed tomography in the follow-up of endovascular aneurysm repair patients? *J Vasc Surg* 2008;47:1181-6.
9. Tomlinson J, McNamara J, Matloubieh J, Hart J, Singh MJ, Davies MG, et al. Intermediate follow-up after endovascular aneurysm repair: can we forgo CT scanning in certain patients? *Ann Vasc Surg* 2007;21:663-70.
10. AbuRahma AF. Fate of endoleaks detected by CT angiography and missed by color duplex ultrasound in endovascular grafts for abdominal aortic aneurysms. *J Endovasc Ther* 2006;13:490-5.
11. AbuRahma AF, Welch CA, Mullins BB, Dyer BJ. Computed tomography versus color duplex ultrasound for surveillance of abdominal aortic stent-grafts. *Endovasc Ther* 2005;12:568-73.
12. Sandford RM, Bown MJ, Fishwick G, Murphy F, Naylor M, Sensier Y, et al. Duplex ultrasound scanning is reliable in the detection of endoleak following endovascular aneurysm repair. *Eur J Vasc Endovasc Surg* 2006;32:537-41.
13. Elkouri S, Panneton JM, Andrews JC, Lewis BD, McKusick MA, Noel AA, et al. Computed tomography and ultrasound in follow-up of patients after endovascular repair of abdominal aortic aneurysm. *Ann Vasc Surg* 2004;18:271-9.
14. Raman KG, Missig-Carroll N, Richardson T, Muluk SC, Makaroun MS. Color-flow duplex ultrasound scan versus computed tomographic scan in the surveillance of endovascular aneurysm repair. *J Vasc Surg* 2003;38:645-51.
15. Veith FJ, Baum RA, Ohki T, Amor M, Adiseshiah M, Blankensteijn JD, et al. Nature and significance of endoleaks and endotension: summary of opinions expressed at an international conference. *J Vasc Surg* 2002;35:1029-35.
16. Leurs LJ, Buth J, Laheij RJ. Long-term results of endovascular abdominal aortic aneurysm treatment with the first generation of commercially available stent grafts. *Arch Surg* 2007;142:33-41.
17. Collins JT, Boros MJ, Combs K. Ultrasound surveillance of endovascular aneurysm repair: a safe modality versus computed tomography. *Ann Vasc Surg* 2007;21:671-5.
18. van der Laan MJ, Bartels LW, Viergever MA, Blankensteijn JD. Computed tomography versus magnetic resonance imaging of endoleaks after EVAR. *Eur J Vasc Endovasc Surg* 2006;32:361-5.
19. Ohki T, Ouriel K, Silveira PG, Katzen B, White R, Criado F, et al. Initial results of wireless pressure sensing for endovascular aneurysm repair: the APEX Trial—Acute Pressure Measurement to Confirm Aneurysm Sac EXclusion. *J Vasc Surg* 2007;45:236-42.
20. Kalman PG, Rappaport DC, Merchant N, et al. The value of late computed tomographic scanning in identification of vascular abnormalities after abdominal aortic aneurysm repair. *J Vasc Surg* 1999;29:442-50.

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INVITED COMMENTARY

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One important disadvantage of endovascular aneurysm repair (EVAR) is the requirement for intense and lifelong surveillance. Dr Chaer et al have put this assumption to the test in a retrospective analysis of outcomes after EVAR in a selection of patients with a shrinking or stable aneurysm sac in whom follow-up was switched to color duplex ultrasound (CDU) imaging as the sole surveillance method. They conclude that CDU-only surveillance is safe in these patients and that it can be applied in almost all patients by 3 years postoperatively. There are several reasons why these conclusions must be interpreted with caution.

First, the reported safety is established in a highly selected group of patients who had been doing fine for 2 to 5 years under

the previous (elaborate) follow-up protocol and after having been scrutinized and treated for endoleak: in short, successful EVAR patients.

Furthermore, the selection criteria for CDU-only surveillance were expanded after 1 year, skewing the study population. The early switchers were predominantly long-term successful Ancure (Guidant, Minneapolis, Minn) patients. Although this device is no longer commercially available, it was shown to lead to early and considerable sac shrinkage and to be durable. Conversely, the late switchers were the patients with the newer endografts—mainly Excluder (W. L. Gore and Assoc, Flagstaff, Ariz) and Zenith (Cook Inc, Bloomington, Ind)—and therefore had shorter follow-up