A photograph of a sunrise over a mountain range. The sun is a bright yellow-orange circle on the horizon, partially obscured by a thin layer of clouds. The sky is a gradient of orange and yellow. The mountains in the foreground are dark silhouettes against the bright sky.

Recommendations for Postoperative Surveillance after EVAR *2019 Update*

David L Dawson, MD, FACS, RPVI

Sunrise from Haleakala summit

Disclosures

- No relationships or conflicts of interest to disclose
- Discussion of “off label” use of ultrasound contrast agents

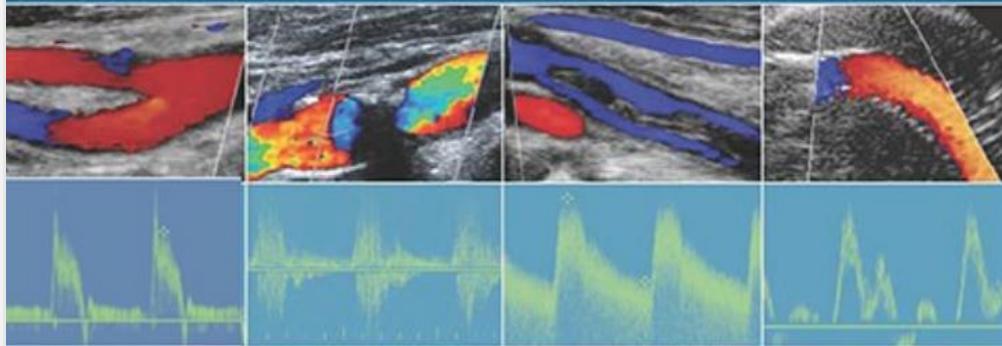
Endovascular Aortic Aneurysm Repair

- Most common complication is endoleak
 - 15% to 45% reported incidence
 - secondary interventions in 9% of cases (23 ± 12 months)
- 30% to 40% overall complication rate
 - Persistent aneurysm growth
 - New aneurysm formation
 - Device migration
 - Kinking
 - Stent graft thrombosis
 - Infection
 - Access site complications

A comprehensive analysis of contemporary Medicare patients revealed that the incidence of late rupture 8 years after EVAR is >5%

Strandness's DUPLEX SCANNING IN VASCULAR DISORDERS

Fifth Edition



 Wolters Kluwer

R. Eugene Zierler
David L. Dawson

CHAPTER 16

DUPLEX ASSESSMENT OF AORTIC ENDOGRAFTS

NASIM HEDAYATI, DAVID DEL PIZZO AND DAVID L. DAWSON

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THE ROLE OF SURVEILLANCE AFTER EVAR

Classification of Endoleaks

Imaging Techniques

OVERVIEW OF POST-EVAR DUPLEX SCANNING

SCANNING TECHNIQUE

Instrumentation

Patient Preparation and Positioning

Examination Protocol

Contrast-Enhanced Ultrasound

TECHNICAL PITFALLS AND LIMITATIONS

CLINICAL STUDIES AND GUIDELINES

CONCLUSION

Parodi and coworkers^{1,2} first reported successful exclusion of an abdominal aortic aneurysm (AAA) by an intraluminal graft in 1991. Since that time, the increased use of endovascular aneurysm repair (EVAR) has led to a decrease in traditional open surgical repair, and currently, nearly 75% of all AAAs are being treated via an endovascular approach.^{3,4,5,6} Advantages of EVAR include shorter operative time and hospital length of stay, as well as lower perioperative morbidity and mortality compared with those of traditional open AAA repair.^{6,7,8,9} However, late complications such as aneurysm sac enlargement, endoleaks, stent fracture, endograft migration, and stenosis or occlusion of the iliac graft limbs make lifelong endograft surveillance a necessity.¹⁰

Surveillance can identify conditions that might represent a risk for aneurysm growth and rupture, such as an endoleak with continued pressurization of the aneurysm sac. Post-EVAR follow-up has traditionally been performed with computed tomography (CT), which has been the “gold standard” for surveillance designed to evaluate aneurysm sac size and detect endoleaks. Follow-up schedules have generally reflected the protocols developed in the clinical trials of EVAR, with postprocedure surveillance CT scans being performed at approximately 1 month, 6 months, 12 months, and annually thereafter.

CT imaging and duplex ultrasonography are the two primary post-EVAR surveillance methods currently being used. Other imaging modalities, such as magnetic resonance angiography (MRA), are rarely used for EVAR surveillance, but the use of duplex ultrasound for the evaluation of abdominal aortic endografts has been gaining wider acceptance. At many institutions, including our own, a duplex ultrasound is performed after the initial post-EVAR CT scan. Subsequent CT imaging is reserved for confirming aneurysm sac enlargement or delineation of an endoleak. An *endoleak* is defined as blood flow outside the lumen of the endograft or in the aneurysm sac, and it is identified in 15% to 32% of all patients who undergo an EVAR.^{11,12,13,14,15} An increasing number of studies have compared duplex ultrasound to CT angiography for detecting endoleaks and measuring aneurysm sac diameter. As discussed in this chapter, the efficacy, feasibility, and financial advantages of duplex ultrasonography in comparison with CT angiography for post-EVAR surveillance are well documented.^{16,17,18,19,20,21,22,23,24,25,26,27,28,29}

Updates and new consensus guidelines

- Duplex ultrasound scanning for surveillance after endovascular aortic aneurysm repair (EVAR) has been addressed in prior Strandness Symposia
- Growing body of data now guides recommendations
 - Meta-analyses of trial comparing ultrasound to CT imaging for follow up
 - Role of contrast-enhanced ultrasound (CEUS)



REVIEW ARTICLES

Michael C. Dalsing, MD, **SECTION EDITOR**

A systematic review of surveillance after endovascular aortic repair



Feras Zaiem, MD,^a Jehad Almasri, MD,^a Mouaffaa Tello, MD,^a Larry J. Prokop, MLS,^b Elliot L. Chaikof, MD, PhD,^c and Mohammad Hassan Murad, MD, MPH,^a *Rochester, Minn; and Boston, Mass*

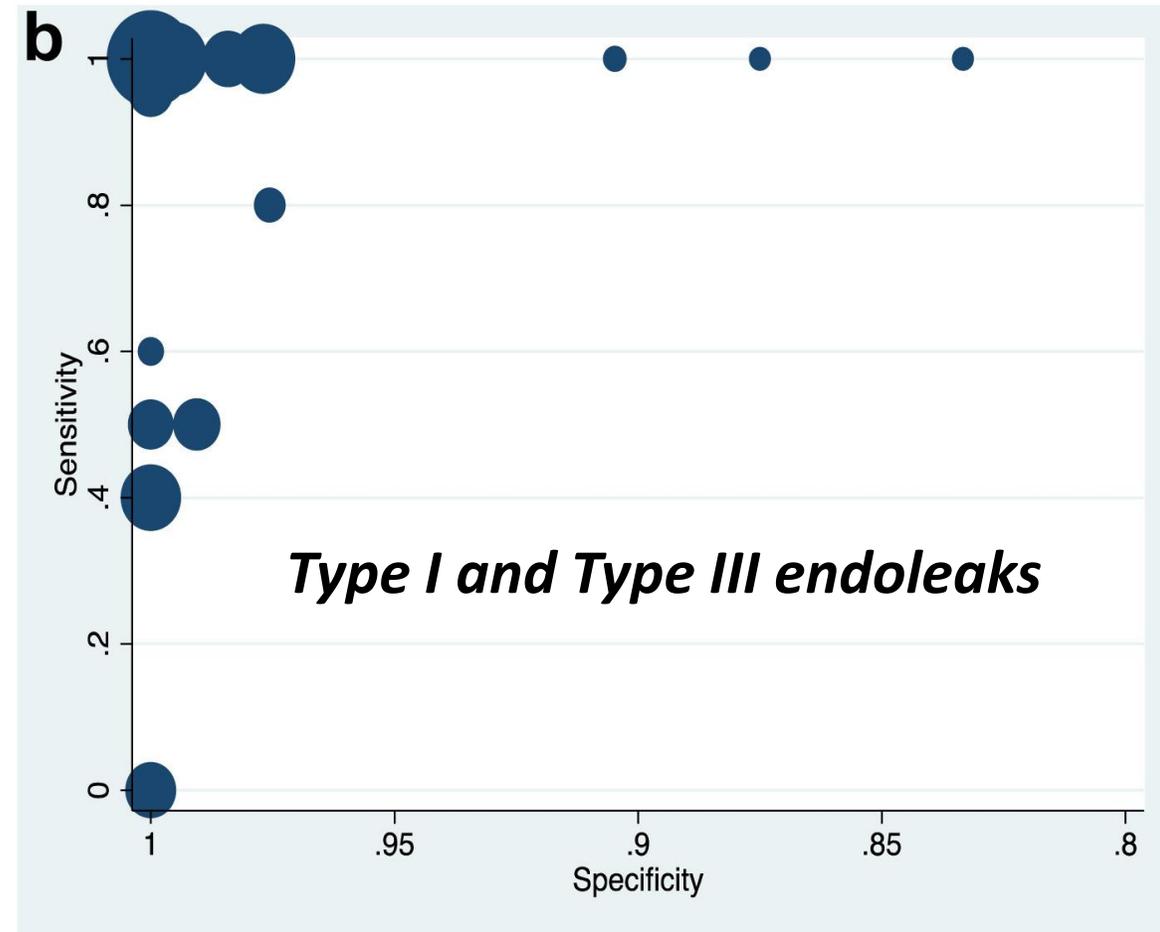
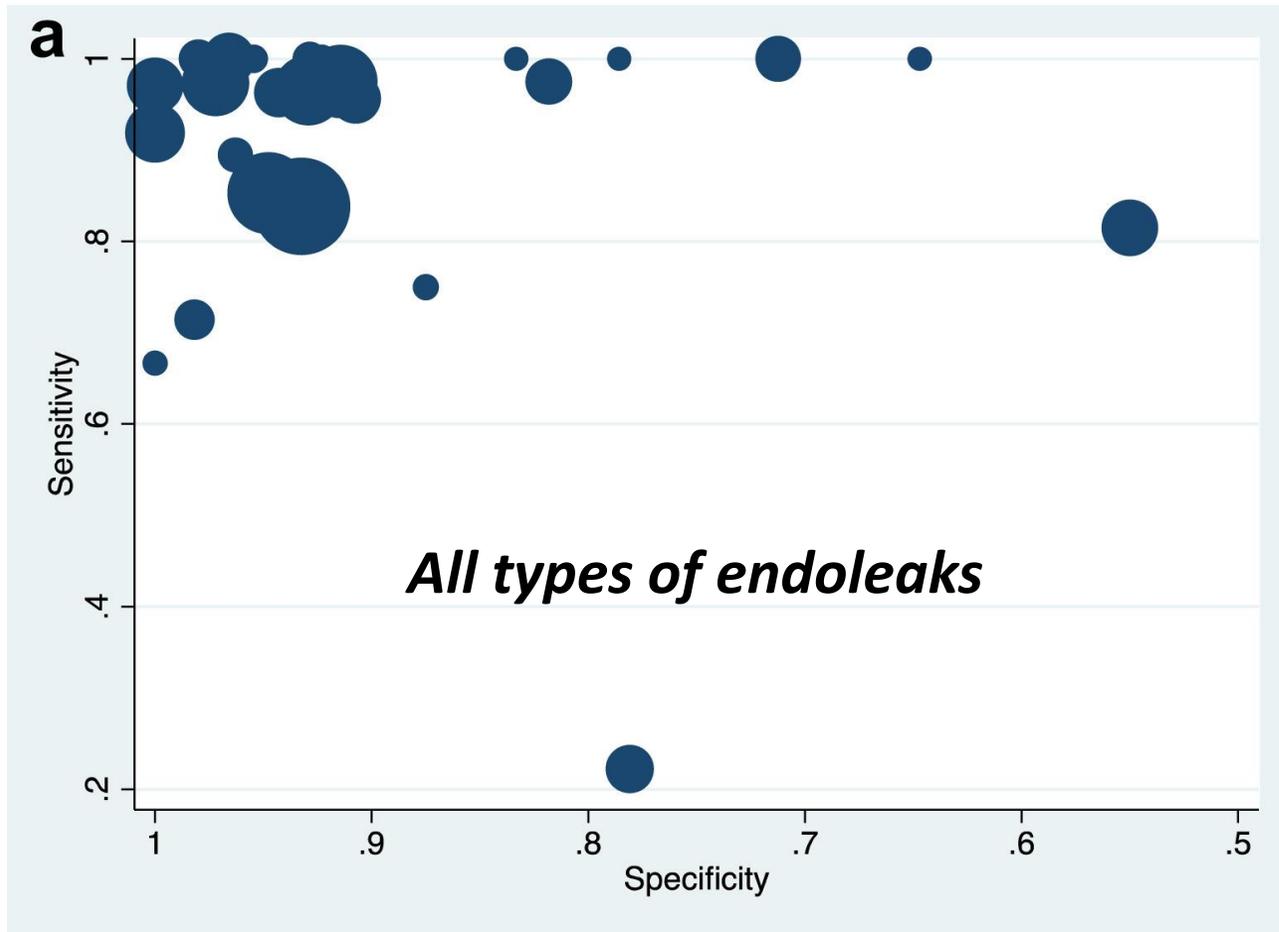
- Society for Vascular Surgery committee
 - Systematic review and meta-analysis
 - Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (PRISM)

Review Findings

- 58 studies included
 - 10 were comparative studies
 - 42 noncomparative studies
 - 6 systematic reviews and meta-analyses
- Endoleak detection at 1 month was as high as 24% with combined imaging approach
- Risk of endoleak, mortality, limb ischemia, rupture, and renal complications was high and persisted for several years after EVAR
 - Basis of subsequent SVS recommendations

Review Results

- Doppler US had lower sensitivity than contrast-enhanced CT but a higher specificity for the detection of endoleaks
- Doppler US had poor sensitivity for endoleak detection, whereas contrast-enhanced US had high sensitivity
- Contrast-enhanced US was likely to be as sensitive as CTA in detecting endoleaks and had higher sensitivity for delayed type II endoleaks
- Both Doppler US and contrast-enhanced US were highly specific for type I and type III endoleaks
- The quality of this diagnostic evidence was low to moderate because it was derived from observational studies



Simple scatter plot: the size of the nodes is proportional to the sample size of each study

The Society for Vascular Surgery practice guidelines on the care of patients with an abdominal aortic aneurysm

Elliot L. Chaikof, MD, PhD,^a Ronald L. Dalman, MD,^b Mark K. Eskandari, MD,^c Benjamin M. Jackson, MD,^d W. Anthony Lee, MD,^e M. Ashraf Mansour, MD,^f Tara M. Mastracci, MD,^g Matthew Mell, MD,^b M. Hassan Murad, MD, MPH,^h Louis L. Nguyen, MD, MBA, MPH,ⁱ Gustavo S. Oderich, MD,^j Madhukar S. Patel, MD, MBA, ScM,^{a,k} Marc L. Schermerhorn, MD, MPH,^a and Benjamin W. Starnes, MD,^l
Boston, Mass; Palo Alto, Calif; Chicago, Ill; Philadelphia, Pa; Boca Raton, Fla; Grand Rapids, Mich; London, United Kingdom; Rochester, Minn; and Seattle, Wash

- Updated recommendations, new strategies to enhance perioperative outcomes after elective and emergency AAA repair
- Areas of uncertainty highlighted, including limitations in diagnostic tests

Modalities for Aneurysm Imaging

- For asymptomatic patients, ultrasound detects AAA accurately, reproducibly, and efficiently
 - Sensitivity and specificity approach 100%
 - Aorta cannot be visualized because of bowel gas or obesity in 1-3%
 - Insufficiently precise for procedural planning or complex morphologic analyses
- CT imaging more reproducible than ultrasound
 - >90% of measurements within 2 mm of initial reading
 - Techniques not standardized
- Axial CT measurements may be larger in diameter than ultrasound measurements
 - CT cross-sectional measurements not obtained perpendicular to aortic centerline

Grading of Recommendations Assessment, Development, and Evaluation (GRADE)

Strength of recommendation	
1 (Strong)	
	Benefits > Risks
	Risks > Benefits
2 (Weak)	
	Benefits ≈ risks
	Quality of evidence precludes accurate assessment of risks and benefits.
Quality of evidence	
A (High)	
	Additional research is considered very unlikely to change confidence in the estimate of the effect.
B (Moderate)	
	Further research is likely to have an important impact on the estimate of the effect.
C (Low)	
	Further research is very likely to change the estimate of the effect.

Adapted from Guyatt G, Gutterman D, Baumann MH, Addrizzo-Harris D, Hylek EM, Phillips B, et al. Grading strength of recommendations and quality of evidence in clinical guidelines. Chest 2006;129:174-81.

- GRADE categories use standardized terminology
- Strength of recommendation
 - *Should it be done?*
- Quality of evidence
 - *How good are the objective data supporting the recommendation?*

Post-EVAR Follow-up

Recommendation	Level of recommendation	Quality of evidence
<ul style="list-style-type: none">• Baseline imaging in first month after EVAR with contrast-enhanced CT and color duplex ultrasound imaging• In the absence of an endoleak or sac enlargement, imaging should be repeated in 12 months using contrast-enhanced CT or color duplex ultrasound imaging	1 (Strong)	B (Moderate)
<ul style="list-style-type: none">• If a type II endoleak is observed 1 month after EVAR, postoperative surveillance with contrast-enhanced CT and color duplex ultrasound imaging at 6 months	2 (Weak)	B (Moderate)

Post-EVAR Follow-up

Recommendation	Level of recommendation	Quality of evidence
<ul style="list-style-type: none">• Annual surveillance in no endoleak or AAA enlargement observed at 1 year• Color duplex ultrasound when feasible, or CT imaging if ultrasound not possible	2 (Weak)	C (Low)
<ul style="list-style-type: none">• For type II endoleak associated with aneurysm sac that is shrinking or stable, use color duplex ultrasound for continued surveillance at 6-month intervals for 24 months and then annually thereafter	2 (Weak)	C (Low)

Post-EVAR Follow-up

Recommendation	Level of recommendation	Quality of evidence
<ul style="list-style-type: none">• If a new endoleak is detected, evaluate for a type I or type III endoleak	2 (Weak)	C (Low)
<ul style="list-style-type: none">• Non-contrast CT imaging of entire aorta at 5-year intervals after open repair or EVAR	2 (Weak)	C (Low)

SOCIETY FOR VASCULAR SURGERY[®] DOCUMENT

Editors' Choice

The Society for Vascular Surgery practice guidelines on follow-up after vascular surgery arterial procedures

R. Eugene Zierler, MD,^a William D. Jordan, MD,^b Brajesh K. Lal, MD,^c Firas Mussa, MD,^d Steven Leers, MD,^e Joseph Fulton, MD,^f William Pevec, MD,^g Andrew Hill, MD,^h and M. Hassan Murad, MD, MPH,ⁱ *Seattle, Wash; Atlanta, Ga; Baltimore, Md; Columbia, SC; Pittsburgh, Pa; Poughkeepsie, NY; Sacramento, Calif; Ottawa, Ontario, Canada; and Rochester, Minn*

- Comprehensive review of follow-up practices and their supporting data
- Addressed extracranial carotid artery, thoracic and abdominal aorta, mesenteric and renal arteries, and lower extremity arterial revascularization

Grading of Recommendations Assessment, Development, and Evaluation (GRADE)

Strength of recommendation	
1 (Strong)	
	Benefits > Risks
	Risks > Benefits
2 (Weak)	
	Benefits ≈ risks
	Quality of evidence precludes accurate assessment of risks and benefits.
Quality of evidence	
A (High)	
	Additional research is considered very unlikely to change confidence in the estimate of the effect.
B (Moderate)	
	Further research is likely to have an important impact on the estimate of the effect.
C (Low)	
	Further research is very likely to change the estimate of the effect.

Adapted from Guyatt G, Gutterman D, Baumann MH, Addrizzo-Harris D, Hylek EM, Phillips B, et al. Grading strength of recommendations and quality of evidence in clinical guidelines. Chest 2006;129:174-81.

- Some strong recommendations for surveillance were made despite low-quality evidence
 - Costs and risks of surveillance considered relatively low
 - Early detection of complications deemed critical from patient's perspective

“Strong” Recommendations for EVAR Follow-up

- Contrast-enhanced CT scan at 1 month and 12 months after EVAR, consider more frequent imaging if endoleak or other concerning abnormality detected at 1 month
 - Quality of Evidence: B (Moderate)
- Duplex ultrasound scan (DUS) at 12-month intervals as alternative imaging surveillance if no endoleak or sac enlargement detected during first year after EVAR
 - Quality of Evidence: B (Moderate)
- DUS and non-contrast-enhanced CT scanning as alternative imaging surveillance in patients with contraindications to iodinated contrast agents
 - Quality of Evidence: B (Moderate)
- Total aortic imaging with non-contrast-enhanced CT scanning at 5-year intervals after open surgical repair or EVAR to detect aneurysmal degeneration of other aortic segments
 - Quality of Evidence: C (Low)

Meta-analysis of the accuracy of contrast-enhanced ultrasound for the detection of endoleak after endovascular aneurysm repair

Dimitrios Kapetanios, MD,^a Nikolaos Kontopodis, MD, PhD,^b Dimitrios Mavridis, PhD,^{c,d} Richard G. McWilliams, FRCR,^e Athanasios D. Giannoukas, MD, MSc, PhD, FEBVS,^f and George A. Antoniou, MD, PhD, MSc, FEBVS,^{g,h} *Munich, Germany; Heraklion, Ioannina, and Larissa, Greece; Paris, France; and Liverpool and Manchester, United Kingdom*

- 26 studies with a total of 2638 paired scans in 2217 patients
- CEUS has a high sensitivity and specificity in the detection of endoleaks after EVAR
- Concluded that CEUS is useful for post-EVAR surveillance

Meta-analysis of Contrast Enhanced US

- Pooled sensitivity and specificity of CEUS for all endoleaks were 0.94 and 0.93 (95% CI, 0.89-0.96), respectively
- Summary estimate of sensitivity and specificity for type I and type III endoleaks was 0.97 (95% CI, 0.8-1.00) and 1.00 (95% CI, 0.99-1.00), respectively
- Identified risk of bias of the selected studies related to blinding for the index test and the reference standard

Need for Contrast Enhanced Ultrasound?

- Selectively used
- Contraindications and precautions
- Need RN or MD for injection
- Added time and supplies for continuous infusion
- Still operator dependent
- Added costs that may not be reimbursed



Contrast in patent limbs and in sac from endoleak

Imaging quality and color Doppler sensitivity of modern scanners identifies most endoleaks without use of contrast agents

Summary: Post-EVAR Surveillance

- Using ultrasound eliminates radiation exposure, reduces cost, and avoids use of nephrotoxic contrast agents
- Color duplex ultrasound and contrast-enhanced color duplex ultrasound are accurate for detecting type I and type III endoleaks, as well as sac enlargement
- Surveillance with ultrasound is safe if there is no endoleak and sac size is stable, or for patients with a type II endoleak and stable aneurysm size
- A new endoleak, graft migration, or aneurysm sac growth >5 to 10 mm should prompt further evaluation with a CT scan

Caveats

- Surveillance noncompliance rates approach 60%, with gaps observed 3 to 4 years after EVAR
- Particularly among patients of advanced age, with Medicaid eligibility, or after treatment at a low-volume center
- Although the risks of late device-related complications and aneurysm rupture are well documented, population studies have not demonstrated that annual EVAR surveillance confers a survival benefit or decreases aneurysm-related mortality
- Not all late ruptures preceded by identified endoleak or sac enlargement
 - *Not all late ruptures can be prevented by vigilant surveillance*

