Predictive Factors and Strategies to Prevent the Development of Type 2 Endoleaks following Endovascular Aneurysm Repair

Nicholas Voutsinas, MD¹ Edward Kim, MD, FSIR¹ Robert A. Lookstein, MD, FSIR¹

¹ Department of Diagnostic, Molecular, and Interventional Radiology, Icahn School of Medicine at Mount Sinai Hospital, New York, New York

Semin Intervent Radiol 2020;37:389–394

Address for correspondence Nicholas Voutsinas, MD, Department of Diagnostic, Molecular, and Interventional Radiology, Icahn School of Medicine at Mount Sinai Hospital, 1 Gustave Levy Place, Box 1234, New York, NY, 10029
(e-mail: Nicholas.voutsinas@mountsinai.org).

Abstract

Keywords

- ▶ abdominal aortic aneurysm
- ▶ endovascular repair
- ▶ endoleak
- ▶ preoperative embolization
- ▶ interventional radiology

Type 2 endoleaks are a potential complication of endovascular aortic repair for abdominal aortic aneurysms. They are caused by vessels that have been excluded from the aorta lumen, but may still fill the aneurysm sac due to collateral filling. Type 2 endoleaks may lead to increased morbidity and need for additional procedures. Being able to identify patients at risk for Type 2 endoleaks and prevent them is important for any physician who is performing endovascular aortic repair.

An abdominal aortic aneurysm (AAA) is a dilatation of the aortic diameter to greater than 3 cm due to weakening of the endoluminal wall.¹ Pressure within the AAA sac will cause progressive widening and, if left untreated, eventual rupture.¹ AAA rupture has a high mortality rate, up to 80% in some studies, and results in 175,000 deaths around the world, including 1% of deaths for men older than 65 years.^{1,2} Elective repair of the AAA, whether by an open or endovascular approach, has been shown to reduce mortality from this entity exponentially.³ Long-term survival is comparable between patients who undergo endovascular versus open repair with better perioperative mortality in patients undergoing endovascular repair, although some studies have suggested trends toward slightly better long-term survival after endovascular aortic repair (EVAR).^{3–6} A point of contention when comparing EVAR to open repair is the need for secondary procedures postrepair, with some studies finding more secondary procedures post-EVAR and others finding no significant difference.^{3,5} These secondary procedures can include procedures to correct an endoleak. The purpose of this article is to briefly review the different types of endoleaks post-EVAR, with a specific focus on

Type 2 endoleaks, factors related to the development of Type 2 endoleak, and potential endovascular techniques that can be employed to prevent Type 2 endoleaks post-EVAR.

Presentation of Endoleak after Endovascular Aneurysm Repair

An endoleak is a potential complication after aortic aneurysm repair related due to incomplete treatment characterized by leakage into the aneurysm sac postprocedure.^{7–9} The classification system for endoleaks identifies five different types of endoleaks.^{7–9} A Type 1 endoleak is due to poor apposition of the stent graft with one of the sites of the native artery, either proximally (Type 1A) or distally (Type 1B), which allows for leakage around the stent graft and into the aneurysm sac.^{8,9} A Type 2 endoleak is due to retrograde blood flow through an arterial branch that is excluded by the graft but opens into the AAA sac.^{8,9} Type 2 endoleaks are the most common form of endoleak after EVAR.^{8,9} Type 3 endoleaks are related to graft failure, leading to direct spillage into the aneurysm sac of blood product.^{8,9} A Type 4 endoleak is typically related to graft

porosity, but are normally seen transiently during the intraoperative setting and then resolve.^{8,9} Type 5 endoleaks are those that result in sac enlargement without an obvious source of the endoleak and are likely secondary to endotension.^{8,9}

Predictive Factors Related to Incidence of Type 2 Endoleak

Any extra procedures post-EVAR increase patient cost and potential morbidity from complications.⁵ As a result, it is important to identify which patients are most at risk to develop a Type 2 endoleak so that it can be treated either prior to or during the EVAR procedure. Type 2 endoleaks can be seen in up to 25% of patients depending on the study and are caused by retrograde blood flow into branch vessels that arise from the excluded portions of the aneurysm sac.^{10,11} The most common arteries involved in Type 2 endoleaks are the inferior mesenteric artery (IMA) and lumbar artery branches, although there are also reports in the literature of accessory renal arteries causing them as well.^{10–12} Type 2A

endoleaks are secondary to one vessel, while Type 2B endoleaks are secondary to two or more vessels.¹¹ The major preoperative risk factors for the development of Type 2 endoleaks are related to patient anatomy; so, factors like number of patent lumbar arteries, a patent IMA, or patent accessory renal arteries, in addition to aneurysm sac size, have been correlated with increased incidence of Type 2 endoleaks.^{11,13} During the EVAR procedure, operators need to be aware that if a Type 2 endoleak can be seen for greater than 6 seconds on angiography, the patient will likely present with a Type 2 endoleak on postprocedural imaging.^{11,14} Hypogastric artery embolization prior to or during EVAR procedure and distal graft extension were also associated with increased rates of Type 2 endoleak.¹⁵ Patient factors such as cigarette smoking, advanced age, and the presence of cancer can be associated with decreased rates of postprocedure Type 2 endoleaks.^{11,15} Conversely, the presence of certain anticoagulation medication is shown to have an increased rates Type 2 endoleaks, which may indicate that the patient's ability to form clot is related to the presentation of Type 2 endoleaks.^{11,16}

Fig. 1 Selected CT angiographic images of a 58-year old man obtained to assess the patient's AAA and plan for patient's EVAR procedure. Images are ordered from superior to inferior. Accessory renal arteries (arrows) are identified bilaterally (a, b). The IMAs (arrows) are identified traversing originating inferiorly and traversing superiorly through the thrombosed aneurysm sac (c, d). The patient would subsequently go on to preoperative embolization of both accessory renal arteries and the IMA (► Figs. 2–4). AAA, abdominal aortic aneurysm; IMA, inferior mesenteric artery; EVAR, endovascular aortic repair.

Fig. 2 The IMA has been cannulated with a 5-Fr Sos catheter (AngioDynamics, Latham, NY) with subsequent angiography performed (a). A microcatheter was advanced through the IMA and 0.018 interlock coils (Boston Scientific, Marlborough, MA) were deployed prior to the IMA branching point. Postdeployment angiography demonstrates significantly reduced flow to the distal branches of the IMA with most of the contrast being retained proximal to the deployed coils (b). IMA, inferior mesenteric artery.

Fig. 3 The main left renal artery (a) and accessory left renal artery (b) were cannulated with a 5-Fr Sos catheter (AngioDynamics, Latham, NY). Differentiation was made based on how much parenchyma was supplied by each artery; limited parenchymal enhancement of the lower pole was identified from the left accessory renal artery (b). 0.018 interlock coils (Boston Scientific, Marlborough, MA) were subsequently deployed into the left accessory renal artery, with significantly reduced flow seen on postdeployment angiography (c).

Fig. 4 The main right renal artery (a) and accessory right renal artery (b) were cannulated with a 5-Fr JR4 guide catheter (Merit Medical, South Jordan, UT). Most of the renal parenchyma enhances from the main renal artery (a), with some lower pole enhancement noted from the accessory right renal artery (b). After deployment of 0.018 interlock coils (Boston Scientific, Marlborough, MA), angiography demonstrates reduced flow through the artery, with most of the contrast being seen proximal to the coils (c).

Strategies and Techniques to Prevent Development of Type 2 Endoleak

It is a well-established technique that embolizing vessels that may potentially cause a Type 2 endoleak, such as the IMA, lumbar arteries, or accessory renal arteries, can reduce the incidence of Type 2 endoleak in the postoperative course.^{12,17-19} Preoperative embolization has shown reduced need for follow-up procedures, improved morbidity, and decreased chance of aneurysm sac size enlargement.¹⁷⁻¹⁹

In performing EVAR, computed tomography angiography (CTA) is a useful preprocedure tool for assessing aneurysm sac size and identifying arteries for potential side branch embolization (►Fig. 1).¹⁷ CTA is often employed for evaluating endoleaks postprocedurally, and comparison to preoperative imaging will allow for comparisons in aneurysm sac size between pre- and postprocedure values, confirming the presence of an endoleak as well as the success or failure of preoperative embolization.^{8,9,17}

On CTA assessment of the IMA, certain factors can be assessed to determine if the patient is more likely to have a Type 2 endoleak from this artery including diameter greater than 2.5 mm and lack of calcification, stenosis, or mural thrombus at the IMA origin.²⁰ IMA embolization has been demonstrated to be cost neutral due to prevention of repeat procedures, and can lead to a reduction in overall aneurysm sac diameter compared with those patients who do not receive IMA embolization.²¹ Coils are a commonly used embolic agent for this procedure.^{17,22} IMA embolization is generally considered to be a safe procedure, with most patients having no evidence of complications.¹⁷ The most common complication is nonlocalized abdominal pain, which resolves with supportive management.¹⁷ While a

Fig. 5 Aortography performed during patient's EVAR procedure, 2 weeks after preoperative embolization. Planning aortogram (a) shows coil embolization material in the bilateral renal arteries with no evidence of filling of the bilateral accessory renal arteries and IMA. Post-EVAR deployment aortogram (b) does not show evidence of Type 2 endoleak. IMA, inferior mesenteric artery; EVAR, endovascular aortic repair.

Fig. 6 Delayed axial CT angiographic images of the patient 1 month post-EVAR. Coil embolization material is noted in the bilateral accessory renal arteries (a) and IMA (c). Small renal infarcts are noted in the lower poles of the bilateral kidneys (b), with normal parenchymal enhancement otherwise and no change in patient's baseline renal function. There is no evidence of contrast within the thrombosed aneurysm sac to suggest any endoleak (b-d). Distal branches of the IMA that supply the left hemicolon are seen to be opacified, due to filling of collateral branches from superior mesenteric artery (SMA) supply. Patient has had follow-up for over 2 years without evidence of endoleak, has seen slight reduction in aneurysm sac size, and no need for secondary procedures. IMA, inferior mesenteric artery; EVAR, endovascular aortic repair

potential for mesenteric ischemia does exist, most patients are well collateralized from the superior mesenteric artery via the arc of Riolo and the arc of Drummond.¹⁷ **Fig. 2** demonstrates the utility of IMA embolization.

Accessory renal arteries are an anatomic variation that leads to multiple vessels supplying the kidneys.^{12,18} Exclusion of the accessory renal arteries has not been shown to cause significant worsening of renal function postprocedurally due to preservation of the main renal artery, although small renal infarcts may be identified (**Fig. 3b**).^{12,18} Accessory renal arteries with diameters larger than 3 mm are more prone to result in Type 2 endoleaks.¹² When deciding to embolize these patients, it is important to identify main renal artery supply angiographically to ensure the appropriate vessel is being selected. **Figs. 3 to 5** demonstrate renal artery embolization pre-endograft placement.

Lumbar arterial branches may be too small to identify on CTA to warrant significant consideration with regard to preoperative embolization.¹⁷ However, if large enough, lumbar arteries are a common artery that can lead to Type 2 endoleak.¹⁹ Lumbar arteries with diameters larger than 2 mm are

more likely to lead to Type 2 endoleaks.²² Preoperative coil embolization of lumbar artery branches can reduce incidence of Type 2 endoleak in these patients.²²

Other techniques to prevent Type 2 endoleaks that can be performed intraoperatively are described in the literature. Direct injection of the aneurysm sac with thrombin appears to be an additional safe procedure that reduces incidence of Type 2 endoleaks.²³ Another potential maneuver is the use of an endovascular sealant device at the time of EVAR placement, which has had positive results in reducing rates of Type 1 and Type 2 endoleaks.²⁴

Conclusion

Type 2 endoleaks have historically been a common complication of EVAR for AAA. Their presence can potentially increase the morbidity of the patient and cost of patient care due to the requirement of follow-up procedures to treat them. Preoperative embolization of arterial branches that could cause Type 2 endoleaks is safe and can reduce the incidence of Type 2 endoleaks in these patients.

Conflicts of Interest

N.V. has no relevant financial disclosures. E.K. is a paid consultant for Accurate Medical, Boston Scientific, and Bristol Meyers Squibb; on the advisory board for Boston Scientific, Bristol Meyers Squibb, and Roche; and receives research support from Boston Scientific and Philips Healthcare. R.A.L. is a paid consultant for Medtronic and Boston Scientific; on the advisory board for Medtronic, Summa Medical, and Boston Scientific; and a speaker for Abbott Vascular.

References

- Kuivaniemi H, Ryer EJ, Elmore JR, Tromp G. Understanding the pathogenesis of abdominal aortic aneurysms. *Expert Rev Cardiovasc Ther* 2015;13(09):975–987
- Howard DP, Banerjee A, Fairhead JF, Handa A, Silver LE, Rothwell PM; Oxford Vascular Study. Population-based study of incidence of acute abdominal aortic aneurysms with projected impact of screening strategy. *J Am Heart Assoc* 2015;4(08):e001926
- Lederle FA, Kyriakides TC, Stroupe KT, et al; OVER Veterans Affairs Cooperative Study Group. Open versus endovascular repair of abdominal aortic aneurysm. *N Engl J Med* 2019;380(22):2126–2135
- Behrendt CA, Sedrakyan A, Rieß HC, et al. Short-term and long-term results of endovascular and open repair of abdominal aortic aneurysms in Germany. *J Vasc Surg* 2017;66(06):1704–1711.e3
- Greenhalgh RM, Brown LC, Powell JT, Thompson SG, Epstein D, Sculpher MJ; United Kingdom EVAR Trial Investigators. Endovascular versus open repair of abdominal aortic aneurysm. *N Engl J Med* 2010;362(20):1863–1871
- Lederle FA, Freischlag JA, Kyriakides TC, et al; Open Versus Endovascular Repair (OVER) Veterans Affairs Cooperative Study Group. Outcomes following endovascular vs open repair of abdominal aortic aneurysm: a randomized trial. *JAMA* 2009;302(14):1535–1542
- Cao P, De Rango P, Verzini F, Parlani G. Endoleak after endovascular aortic repair: classification, diagnosis and management following endovascular thoracic and abdominal aortic repair. *J Cardiovasc Surg (Torino)* 2010;51(01):53–69
- Bashir MR, Ferral H, Jacobs C, McCarthy W, Goldin M. Endoleaks after endovascular abdominal aortic aneurysm repair: management strategies according to CT findings. *AJR Am J Roentgenol* 2009;192(04):W178–W186
- Stavropoulos SW, Charagundla SR. Imaging techniques for detection and management of endoleaks after endovascular aortic aneurysm repair. *Radiology* 2007;243(03):641–655
- White SB, Stavropoulos SW. Management of Endoleaks following Endovascular Aneurysm Repair. *Semin Intervent Radiol* 2009;26(01):33–38
- Kuziez MS, Sanchez LA, Zayed MA. Abdominal aortic aneurysm Type II endoleaks. *J Cardiovasc Dis Diagn* 2016;4(05):255
- Nishie R, Toya N, Fukushima S, et al. Prophylactic accessory renal artery coil embolization for prevention of type II endoleak following endovascular aneurysm repair: a case report. *Surg Case Rep* 2017;3(01):58
- Arko FR, Rubin GD, Johnson BL, Hill BB, Fogarty TJ, Zarins CK. Type-II endoleaks following endovascular AAA repair: preoperative predictors and long-term effects. *J Endovasc Ther* 2001;8(05):503–510
- Mursalin R, Sakamoto I, Nagayama H, et al. Imaging-based predictors of persistent Type II endoleak after endovascular abdominal aortic aneurysm repair. *AJR Am J Roentgenol* 2016;206(06):1335–1340
- Lo RC, Buck DB, Herrmann J, et al; Vascular Study Group of New England. Risk factors and consequences of persistent type II endoleaks. *J Vasc Surg* 2016;63(04):895–901
- Lazarides MK, Georgiadis GS, Charalampidis DG, Antoniou GA, Georgakarakos EI, Trellopoulos G. Impact of long-term warfarin treatment on EVAR durability: a meta-analysis. *J Endovasc Ther* 2014;21(01):148–153
- Ward TJ, Cohen S, Fischman AM, et al. Preoperative inferior mesenteric artery embolization before endovascular aneurysm repair: decreased incidence of type II endoleak and aneurysm sac enlargement with 24-month follow-up. *J Vasc Interv Radiol* 2013;24(01):49–55
- Malgor RD, Oderich GS, Vrtiska TJ, et al. A case-control study of intentional occlusion of accessory renal arteries during endovascular aortic aneurysm repair. *J Vasc Surg* 2013;58(06):1467–1475
- Bonvini R, Alerci M, Antonucci F, et al. Preoperative embolization of collateral side branches: a valid means to reduce type II endoleaks after endovascular AAA repair. *J Endovasc Ther* 2003;10(02):227–232
- Fukuda T, Matsuda H, Sanda Y, et al. CT findings of risk factors for persistent Type II endoleak from inferior mesenteric artery to determine indicators of preoperative IMA embolization. *Ann Vasc Dis* 2014;7(03):274–279
- Vaillant M, Barral PA, Mancini J, et al. Preoperative inferior mesenteric artery embolization is a cost-effective technique that may reduce the rate of aneurysm sac diameter enlargement and reintervention after EVAR. *Ann Vasc Surg* 2019;60:85–94
- Aoki A, Maruta K, Hosaka N, Omoto T, Masuda T, Gokan T. Evaluation and coil embolization of the aortic side branches for prevention of Type II endoleak after endovascular repair of abdominal aortic aneurysm. *Ann Vasc Dis* 2017;10(04):351–358
- Zanchetta M, Faresin F, Pedon L, Ronsivalle S. Intraoperative intrasac thrombin injection to prevent type II endoleak after endovascular abdominal aortic aneurysm repair. *J Endovasc Ther* 2007;14(02):176–183
- Carpenter JP, Cuff R, Buckley C, et al; Nellix Investigators. Results of the Nellix system investigational device exemption pivotal trial for endovascular aneurysm sealing. *J Vasc Surg* 2016;63(01):23–31.e1