Predictive Factors for the Development of Type 2 Endoleak Following Endovascular Aneurysm Repair

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Abstract

Type 2 endoleak (T2EL) is the most common complication following endovascular aneurysm repair (EVAR) for abdominal aortic aneurysms. The management of T2ELs is controversial due to the relatively low incidence of negative outcomes when secondary intervention is avoided. Some studies challenge this practice as demonstrated by adverse events following conservative treatment of T2ELs. Evidence has shown that the preoperative computed tomographic angiogram can predict the development of T2EL based on a patient's arterial anatomy, specifically vessels associated with increased rates of post-EVAR endoleak development. Preoperative embolization of those aortic branch vessels associated with T2ELs has shown decreased rates of postoperative complications and may result in a decreased need for surveillance and reintervention.

Keywords
- abdominal aortic aneurysm
- endovascular aneurysm repair
- type 2 endoleak
- inferior mesenteric artery embolization
- interventional radiology

Objectives: Upon completion of this article, the reader will be able to describe the predictive factors for the development of type 2 endoleak following EVAR, and role of preoperative inferior mesenteric artery embolization.

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Ruptured abdominal aortic aneurysms (AAAs) result in approximately 15,000 deaths annually.[1] Patients with AAAs measuring 5.5 cm or larger are recommended to undergo aneurysm repair to reduce the high risk of mortality from rupture. Endovascular aneurysm repair (EVAR) is now a widely accepted treatment for AAA.[2] EVAR has been associated with a significant improvement in 30-day postoperative mortality compared with the original repair technique performed via an open transabdominal or retroperitoneal approach.[3–5] The postoperative course following EVAR is associated with increased complication rates compared with the open approach. Following EVAR, endoleaks complicate 10 to 50% of cases that result in an increased need of repeat intervention.[6] Due to high complication rates, lifelong radiographic surveillance is currently recommended following EVAR. Identification of an endoleak and/or increased aneurysm growth may prompt repeat intervention to prevent aneurysm rupture.[7] Preoperative computed tomographic (CT) angiogram evaluation can identify anatomical risk factors predisposing to complications, including patent aortic branch vessels associated with type 2 endoleaks (T2ELs) formation.[8] Preoperative embolization of these vessels has shown decrease rates of T2EL and aneurysm sac growth.

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Endoleak Following Endovascular Aneurysm Repair

Endoleaks are defined as the persistence or reconstitution of perigraft blood flow within the aortic aneurysm sac. Morbidity and mortality rates vary widely based on the mechanism of endoleak. Timely detection and accurate subclassification are important to determine management strategies and prognosis.

The main indication for repeat intervention following EVAR is identification of aneurysm sac enlargement, as this finding is most associated with the risk of sac rupture. The presence of an endoleak has been shown to be the primary predictive factor in aneurysm sac enlargement.[6] Four subtypes (1–4) of endoleaks have been described.[9] The subtypes can be categorized into high-pressure or low-pressure endoleak. A type 1 endoleak results from a failure to seal at the proximal or distal graft limb attachment site. This subtype occurs in up to 10% of all endoleaks. T2ELs form from retrograde filling of the aneurysm sac through patent aortic branches within the extent of the graft. Type 3 endoleaks develop from leakage through a junctional site of modular endograft components or directly from a disruption of the endograft fabric itself. Type 4 endoleaks, also referred to as endotension, occur in the setting of aneurysm sac enlargement without angiographic demonstration of arterial blood extravasation. Type 4 endoleaks are rarely encountered with modern endografts. High-pressure (type 1 and 3) endoleaks expose the aneurysm sac to systolic arterial pressure, and by consensus intervention is required due to the high risk of aneurysm sac rupture. Type 2 and type 4 endoleaks expose the aneurysm sac to relatively low diastolic arterial pressure associated with less risk of aneurysm rupture. Identification of a low-pressure endoleak may or may not prompt repeat intervention.

Current postoperative management involves close aneurysm surveillance in response to the high incidence of complications following EVAR. The medical community lacks a universally accepted consensus for long-term endoleak surveillance (i.e., intervals of imaging and patient selection) and appropriate use of repeat intervention that satisfies concerns for patient safety and resource utilization.

Type 2 Endoleak

T2EL is the most frequent complication encountered following EVAR, estimated to occur in 8 to 45% of cases. Diagnosis is typically made on completion angiogram or initial follow-up imaging. Several studies have demonstrated a high rate of spontaneous resolution of T2EL, ranging from 40 to 67% of patients managed conservatively.[10–17] Other retrospective study outcomes challenge the practice of conservative management with findings of increased morbidity, including aneurysm rupture, when intervention is not performed. In a review of AAA ruptures following EVAR, 160 of the 235 patients with ruptured aneurysms were attributed to endoleak; of these cases, 14% were attributed to a T2EL alone.[18]

A large systematic review[19] demonstrated that aneurysm rupture following an isolated T2EL was noted in less than 1% of all T2EL. Aneurysm sac expansion greater than 5 mm, a common threshold for initiating intervention, was absent in greater than one-third of these ruptures. This review also noted that T2ELs that fail to resolve spontaneously after 6 months are associated with increased long-term complications including sac enlargement, repeat intervention with a high rate of conversion to open surgical approach, and rupture. Another large study demonstrated no correlation of T2EL with an increased risk of aneurysm rupture.[13]

The opposing findings of many well-designed studies have created controversy regarding the management of T2ELs. The majority of studies have found that conservative management of T2EL is likely a safe approach due to low rates of major adverse events. Other studies have reported that T2ELs pose a significant risk for aneurysm rupture, and therefore promote closer surveillance and a lower threshold for initiating aggressive interventional management.

Several recent studies have added helpful information to guide postoperative management decisions. A retrospective review of 103 patients without endoleak on an immediate postoperative CT angiogram did not develop significant complications or require reintervention in the first 3 years. These finding suggest that those patients with normal early postoperative angiography may benefit from a less strict surveillance schedule that may lead to decreased medical costs, radiation, intravenous contrast exposure, and patient anxiety.[20] Early postoperative CT angiography demonstrating sac enlargement has also shown value for predicting the future need for repeat intervention. Additionally, detailed aneurysm sac features, including endoleak volume, nidus maximal diameter, and quantity of patent aortic side branches, help to identify patients who will benefit from early T2EL intervention.[21] Another patient series reported that patients with delayed endoleaks noted after 1 year following EVAR represented the majority of all endoleaks. Of these patients with delayed endoleak development, there was a significant association with increased aneurysm sac diameter. These finding suggest that a relaxed long-term screening strategy may overlook delayed endoleaks, which will delay detection of significant complication rates.[22] Larger studies are needed to identify specific patient factors predisposing to early versus late T2EL, and those who benefit from early aggressive management.

Predictive Factors of Type 2 Endoleaks

A review of preoperative CT angiography has defined anatomical risk factors associated with the development of postoperative T2EL. Risk of T2EL was found to significantly increase based on the number of patent aortic side branch vessels found within the proposed AAA graft site. The presence of two patent L4 lumbar arteries, two patent L3 lumbar arteries, and a patent inferior mesenteric artery (IMA) was associated with a significantly increased incidence of post-EVAR T2EL (►**Fig. 1**); a patent IMA was associated with the highest risk of a T2EL.[23]

The preoperative finding of occluded L3 or L4 lumbar arteries was associated with a decreased incidence of T2EL, suggesting a protective effect. Mural thrombosis greater than 50% of the

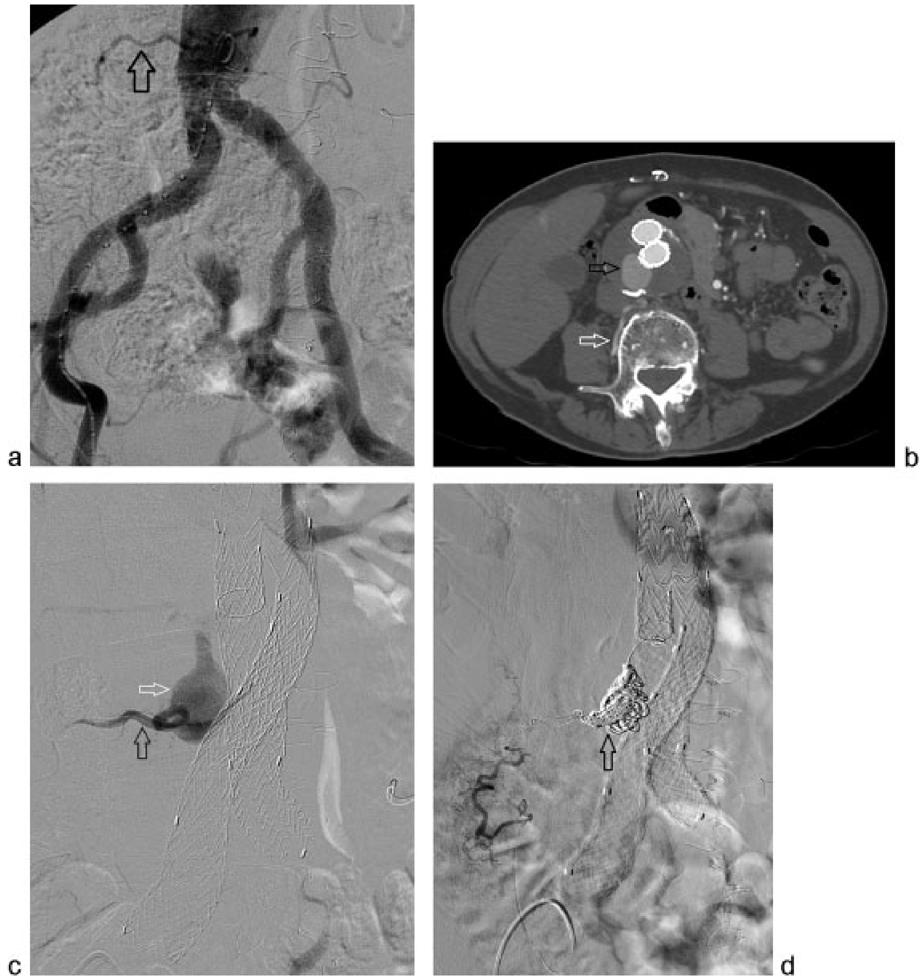

Fig. 1 Pre-EVAR planning angiogram (**a**) demonstrates a patent right lumbar artery (arrow). Postoperative year-4 surveillance CT angiogram (**b**) shows a patent right lumbar artery (white arrow) and type 2 endoleak (black arrow) with significant growth of the aneurysm sac. Selective right lumbar angiogram (black arrow) (**c**) shows filling of the aneurysm sac (white arrow). Completion angiogram (**d**) following successful coil embolization (arrow) of the aneurysm sac and right lumbar artery.

diameter of the sac was not associated with an increased or decreased risk. Prior studies have reported a protective effect of an aortic thrombus–covered perimeter of 67% or greater. Identification of aortic side branch vessel patency, regardless of size, was satisfactory to determine T2EL risk in one study.[24] In a separate study of 120 patients who underwent EVAR, orifice size of the IMA was measured retrospectively from preoperative CT angiography. Fifty percent of the patients with transient T2EL and 100% of patients with persistent endoleak had an IMA orifice greater than 2.5 mm. In patients without endoleak, only 24% were found to have an IMA orifice of greater than 2.5 mm.[25] These findings suggest that a size greater than 2.5 mm or vessel patency, regardless of orifice size, may predict preoperative risk for a T2EL. Anatomical predictors allow a clinician to identify patients who may benefit from more frequent postoperative surveillance or preoperative intervention to decrease the risk of endoleak.

Preoperative Embolization

Currently, there is no consensus for ideal surveillance duration or timing of intervention, as there is uncertain clinical significance of T2EL. A valid solution to this dilemma is to decrease the likelihood of T2EL development prior to EVAR. Preoperative EVAR aortic branch vessel embolization has shown to be a reliable, feasible, and safe modality for decreasing the incidence of T2EL. Preoperative embolization of a patent IMA has been shown to significantly decrease this incidence by 15%, and to decrease aneurysm sac volume by 21%.[26] Additionally, the technical success rate of IMA embolization approaches 100%.[26–28] Lumbar artery embolization has significantly lower reported success rates due to increased procedural time and technical challenges. Studies suggest that the IMA is an ideal pre-EVAR embolization target due to the higher risk of T2EL associated with a patent IMA compared with a patent lumbar artery. Prospective randomized studies comparing preoperative EVAR IMA and lumbar embolization have not yet been performed.

Pre-EVAR embolization performed to prevent development of a T2EL may be preferable to managing a postoperative endoleak with transarterial feeding vessel embolization techniques, which have shown unsatisfactory success rates approaching only 60%.[29,30] Although preoperative embolization exposes the patient to additional operative risks, the benefit of reduced postoperative complications may outweigh any downside. Decreasing the incidence of significant outcomes, including T2EL formation and aneurysm size increase, may lessen the need to perform invasive and technically challenging repeat interventions later in a patient's course. Larger long-term studies are needed to investigate whether preoperative embolization of patent perigraft vessels predisposing to T2EL safely allows less frequent imaging and decrease risk of repeat intervention, aneurysm rupture, and mortality.

Inferior Mesenteric Artery Embolization Operative Technique

Candidates for IMA embolization prior to EVAR are identified by a patent IMA on routine preoperative CT angiography. Per the authors' institutional standard preoperative EVAR workup, patients undergo conventional angiography of the infrarenal aorta to establish longitudinal measurements and again demonstrate a patent IMA during calibrated flush aortography. A 5F calibrated pigtail catheter with 1-cm radiopaque markers is used for flush aortography via a transfemoral approach. Aortography protocol includes anteroposterior and lateral projections at the level of the renal arteries, as well as right and left anterior oblique projections of the pelvis. The IMA is then selectively catheterized using a 5F reverse-curve selective catheter, followed by a selective angiogram to confirm patency and identify the origin of the left colic artery. Using a coaxial technique, a 3F microcatheter is advanced into the IMA proximal to the origin of the left colic artery. Interlocking 0.018-inch platinum microcoils are sequentially deployed in the proximal IMA, proximal to the origin of the left colic artery. Interlocking coils are preferred over pushable coils in this procedure because precise IMA delivery is necessary to avoid bowel ischemia. Intermittent

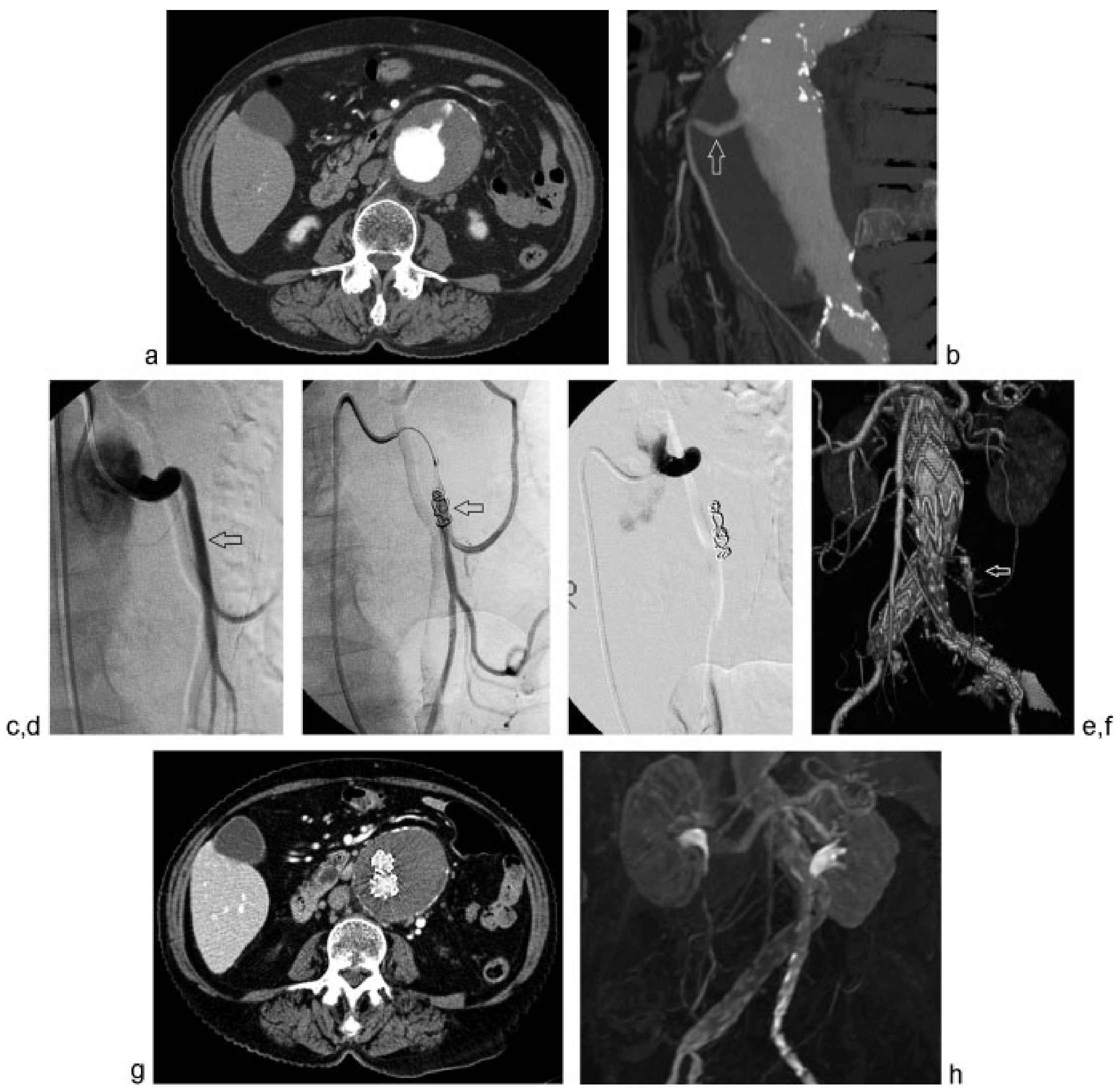

Fig. 2 Axial CT angiogram (**a**) demonstrates a large infrarenal AAA with a widely patent IMA. 3D CT angiogram reconstruction (**b**) re-demonstrates a patent IMA (arrow). Pre-EVAR angiogram (**c**) demonstrates a patent IMA (arrow). Platinum coils were deployed with intermittent angiography (arrow) (**d**) until complete IMA stasis was achieved (**e**). CT angiogram 3D reconstruction (**f**) obtained 1 month post-EVAR demonstrates occlusion of the IMA (arrow) and absence of endoleak. Surveillance CT (**g**) and MR (**h**) angiogram, obtained at 2 and 3 years postoperatively, respectively, again demonstrate freedom from type 2 endoleak or sac enlargement.

angiography is performed until complete vascular stasis is achieved (►**Fig. 2**). IMA embolization is routinely performed on an ambulatory basis 1 day prior to EVAR.[31]

Major complications following IMA embolization are infrequent. Most minor complications are due to nonlocalized abdominal pain that resolves with intravenous hydration and observation. Postembolization abdominal pain is hypothesized to be related to a transient steal syndrome from newly dilated collateral vessels preferentially supplying the descending and sigmoid colon; the risk of mesenteric ischemia is limited by the proximal location of IMA embolization. Proximal embolization allows collateral pathways, including the arc of Riolan and the marginal artery of Drummond, to remain functional. Complications resulting in mesenteric ischemia are associated with high mortality rates; therefore, evaluation for nonstandard anatomy including evidence of prior colon resection or other procedures resulting in disruption of collateral flow must be thoroughly evaluated during initial patient consultation and prior imaging. If the past history is unclear, a superior mesenteric artery angiogram can be performed for evaluation of middle colic artery patency. Disrupted collateral pathways are considered to be a contraindication to IMA embolization.[26]

Conclusion

The management of T2EL following EVAR continues to present a dilemma due to uncertain significance and appropriate use of interventional techniques. Conservative management of T2EL has been reported by many authors to be a safe and cost-effective approach; however, several studies oppose this finding, including cases of aneurysm rupture occurring without warning. Multiple opposing studies leading to unclear understanding of T2EL significance demonstrate the need for further research. Anatomic factors predisposing to T2EL, including patent IMA and lumbar arteries, have been identified and shown to decrease complication incidence when preoperatively embolized. In the absence of a consensus for postoperative management, a reasonable approach to improving patient's safety and resource utilization may include decreasing known risk factors of postoperative complications. Preoperative IMA embolization has demonstrated feasibility and shown a decreased incidence T2EL formation. Larger long-term studies are necessary to determine if preoperative embolization results in a reduced need for repeat intervention and postoperative morbidity.

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