

# Achieving Limb Patency

How specific devices and techniques can help maximize outcomes.

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**E**ndovascular aneurysm repair (EVAR) has proven to be a safe and effective alternative to open aneurysm repair. Clearly, that is true in terms of early mortality and morbidity. However, long-term durability is marred by late complications, especially those requiring reintervention. Despite the fact that the majority of these reinterventions can be performed at low risk via an endovascular approach, the overall cost and need for surveillance limits the perceived advantage of the EVAR technique. After endoleak and device migration, limb thrombosis is the most common postoperative complication.<sup>1,2</sup> Reported limb thrombosis prevalence ranges between 0.7% and 6.4%<sup>1-4</sup> and can occur immediately postoperative (up to 50% of limb thrombosis cases occur during the first postoperative month<sup>5</sup>) or months to years after surgery. The overall annual incidence rate is as high as 3.2%.<sup>6</sup> These reported prevalence rates indicate a relationship between the technical selection of the endograft and the EVAR procedure itself.

Symptoms of lower extremity ischemia develop with graft limb occlusion. Actually, the first cause of leg ischemia after EVAR is limb thrombosis, not atheroembolization or thrombosis of runoff vessels.<sup>7</sup> Clinical severity depends not only on graft occlusion but also the severity of other collateral flow loss, which is mainly due to external iliac graft extension and subsequent occlusion of the hypogastric artery. Presenting symptoms can range from mild to moderate claudication (31%), severe claudication (61%), or paresthesia and rest pain (8%).<sup>6</sup> These symptoms may require additional interventions (including endovascular [thrombolysis and stenting] or direct surgical revascularization [thrombectomy, femorofemoral, or axillary-femoral bypass]),<sup>2</sup> which increase mortality, morbidity, rehospitalization, and overall cost.

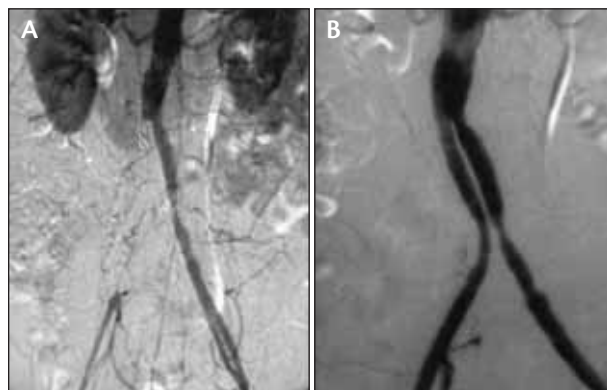
## CAUSES OF LIMB OCCLUSION

Identifying factors that have been attributed to increasing limb occlusion could assist in selecting the best graft and endovascular technique for each patient and their respective anatomy. This ideal selection also decreases complications and reinterventions, thus improving short- and long-term outcomes of EVAR. Factors that potentially predispose a patient to limb thrombosis are listed in the succeeding paragraphs.

Limb kinking has been identified as a major prothrombotic factor and is more frequent in areas of stenosis or narrow anatomies. The distal aortic neck or the aortic bifurcation should accommodate both limbs of a bifurcated endograft. If this area is not large enough, the limbs will be competing and ultimately constrained, likely causing limb thrombosis (Figure 1). Tortuous and angulated iliac arteries increase the risk of graft kinking and twisting,<sup>5,8-11</sup> and subsequent limb thrombosis could occur. Some arterial kinking at the distal edge of the stent graft could promote late limb occlusion. Less often, extensive thrombus within the aneurysm sac can also prevent complete deployment of the endograft, promoting kinking, extrinsic graft compression, hemodynamic modification, and limb occlusion.<sup>6</sup>

Unsupported endograft devices have been associated with lower primary and assisted primary patency rates,<sup>5,8</sup> which may be due to a higher risk of kinking and twisting in tortuous iliac anatomy.<sup>9</sup> To avoid graft folding in unsupported grafts, adjunctive intraoperative insertion of additional bare-metal stents in narrowed or angulated limbs have been used, significantly increasing limb patency rates.<sup>10</sup> A comparison of different types of graft supports is lacking.

Decreased arterial outflow is another main factor in limb occlusion. The use of small graft limb diameters (10 mm or less) and extension to the external iliac artery can be attrib-



**Figure 1.** Right limb thrombosis due to a narrow distal neck 30 days after the procedure, which was treated with local thrombolysis, use of the AngioJet thrombectomy system (Medrad Interventional/Possis, Minneapolis, MN), and insertion of a bare-metal stent.

uted to decreased outflow. Also, underlying arterial occlusive disease and iliac angulation are both associated with a higher thrombosis rate.<sup>5,9</sup> Smaller arterial diameters, arterial dissection,<sup>5,8,11</sup> and irregularity of the endograft lumen from device overlap<sup>12</sup> are also correlated with lower patency rates. Aortomonoiliac grafts with femorofemoral bypass have been identified as having better patency rates than bifurcated grafts.<sup>8,13</sup> This outcome is mostly likely related to hemodynamic factors, such as lack of flow divider issues, no limb competition in aortic bifurcation, and better outflow.

Migration and dislodgement of the endograft limb have also been proposed as a cause of limb thrombosis.<sup>9</sup> Although they were stent supported, first-generation devices (ie, Stentor [formerly MinTec, the Bahamas] and Vanguard [Boston Scientific Corporation, Natick, MA]) were clearly associated with an elevated risk of limb thrombosis, mainly based on their high rate of migration, limb kinking, and disconnection.<sup>6</sup>

Stent graft material is also of significance. Expanded polytetrafluoroethylene grafts (ie, EXCLUDER Device [W. L. Gore & Associates, Flagstaff, AZ]) have been correlated to lower inflammatory response<sup>14</sup> and better limb patency rates,<sup>6</sup> but data are lacking in this area, and the role of other factors, such as particular graft support, are not well defined. The EXCLUDER Device has also been associated with lower kinking rates,<sup>6</sup> probably due to its specific design, which is more flexible and fully supported by a nitinol stent.

Intragraft mural thrombus appears frequently in wide and long main bodies with small limbs and more often in polyester than expanded polytetrafluoroethylene grafts. A relationship between distal embolization and limb occlusion has been suggested. Polyester grafts and small limbs are associated with a higher limb occlusion risk. However, the clinical relevance of intragraft thrombus formation is not well defined, and the literature is not conclusive.<sup>15,16</sup>

A lack of heparin administration is an unusual cause of early limb occlusion. Nevertheless, it should be pointed out as a clearly avoidable risk factor. Mechanical

obstruction of the outflow by large introducer sheaths is another easily avoidable cause of early limb occlusion and ischemia.

Other rare causes of limb occlusion have been reported, such as using microwave therapy or other physical warming waves for lumbar pain treatment. It has been well described that the metallic stent acts as an antenna, attracting heat energy and thereby causing blood coagulation inside the stent graft.<sup>17</sup> There have been no clinical warnings associated with the use of magnetic resonance imaging techniques.

## HOW TO AVOID LIMB THROMBOSIS

It seems easy to avoid limb occlusions once the causes are identified. Some recommendations will be dependent on device choice, and others will be particular to the technical aspects of the EVAR procedure itself.

First, regarding the device choice issue, we must take the morphological anatomy into account. For very narrow and calcified distal necks, it would be preferable to choose an endograft with an aortouni-iliac configuration. When the iliac anatomy is tortuous, a more flexible stent graft will fit better (Figure 2). For narrow iliac arteries or when the distal landing zone is targeted in external iliac arteries, a flexible and thinner material with high conformability and without infolding behavior would work best.

There are factors to be considered during the procedure, such as the use of heparin. Long periods of iliac occlusion by large sheaths should also be avoided. Be careful to avoid arterial dissections when introducing wires and introducing systems, and use extra overlapping lengths of the endograft in tortuous anatomies. Avoid placing the distal edge of the stent graft in an acute angle, as well as inducing any twisting during the limb deployment. For narrow distal necks or in acute aortoiliac angles, the intentional "cross leg" or "ballerina" position conforms better (Figure 3). Kissing-balloon techniques can be used in the case of limb competition in the distal aortic neck. Bare-metal stents are also useful if

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**Figure 2.** X-ray image of 8-year follow-up control after implantation of an EXCLUDER Device. Intense left tortuosity; the distal end is in both external iliac arteries with excellent conformability of the stent graft.



**Figure 3.** Angiogram showing the "ballerina" position for narrow distal aortic necks.

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any kinking is suspected. It is best to obtain the completion angiogram at the end of the procedure without stiff wires in the patient and to explore femoral and distal pulses before leaving the operating room. Finally, advise patients about the use of warming waves.

## CONCLUSION

Endograft limb occlusion is a serious complication of EVAR that leads to reintervention. The device and technical causes have been described throughout this article. Various tips and tricks should be considered to minimize adverse events and increase confidence in the EVAR technique. ■

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