Endoluminal Abdominal Aortic Aneurysm Repair
The Latest Advances in Prevention of Distal Endograft Migration and Type 1 Endoleak

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Endovascular abdominal aortic aneurysm repair (EVAR) is an attractive alternative to open surgical repair. Distal endograft migration and type 1 endoleak are recognized to be the 2 main complications of EVAR. First-generation endografts had a stronger propensity for distal migration, modular component separation, thrombosis, and loss of structural integrity. Substantial progress has been made in recent years with 2nd- and 3rd-generation devices to prevent these complications. Some of the most common predictors of endograft failure are angulated and short infrarenal necks, large-diameter necks, and thrombus in the aneurysmal sac. The purpose of this study is to describe and review our experience in using innovative techniques and a newer generation of endografts to prevent distal migration and type 1 endoleak in patients with challenging infrarenal neck anatomy. The use of these innovative EVAR techniques and the new generation of endografts in patients with challenging infrarenal neck anatomy has yielded encouraging procedural and intermediate-term results. (Tex Heart Inst J 2010;37(1):19-24)

Since Parodi and coworkers performed the 1st endovascular abdominal aortic aneurysm repair (EVAR) in 1990,1 substantial progress has been made in treating patients with abdominal aortic aneurysms (AAA). Although feasible in the great majority of patients, EVAR can have a high incidence of postprocedural complications in patients who have challenging infrarenal aortic neck anatomy. Some of the more common sequelae include endoleaks, separation of modular components, aneurysm enlargement, stent or hook fractures, and distal migration of the endograft.2 One major concern is the potential for migration: the incidence has ranged from 9% to 45%.3,4 Type 1 endoleak is also one of the dreaded sequelae of EVAR, because there is a potential for aneurysm rupture.

Factors that Influence Endograft Migration and Type 1 Endoleak
Distal migration of the endograft is one of the main recognized complications of EVAR. Migration of the stent-graft is defined as device movement of greater than 10 mm or movement of less than or equal to 10 mm when this last results in secondary interventions, as set forth by the Society for Vascular Surgery and the American Association for Vascular Surgery in their reporting standards for endovascular aortic aneurysm repair.5 Migration is generally believed to be a late-occurring event. Type 1 (a or b) endoleak is a persistent perigraft channel of blood flow that is caused by an inadequate seal at either the proximal (a) or the distal (b) end of the stent-graft. Type 1a endoleak is a persistent perigraft channel of blood flow that is caused by an inadequate seal at either the proximal (a) or the distal (b) end of the stent-graft. Type 1b endoleak is closely associated with stent-graft migration, and these conditions are commonly seen in the same patient. Endograft migration and type 1 endoleak are major problems after EVAR that significantly increase the incidence of rupture of abdominal aneurysm and the need for conventional surgical repair.

The many factors that affect the success and failure of EVAR are strongly influenced by preprocedural planning, the experience of the operator, the technique employed, and the type and the generation of the endograft. The EUROSTAR Registry collaborators have reported that some of the most common predictors of endograft failure—

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resulting in type 1 endoleak and stent migration—are angulated and short infrarenal necks, large neck diameter, large maximal AAA diameter, neck thrombus, and complex iliac artery anatomy. The presence of extensive thrombus or excessive calcium deposition at the arterial implantation sites, specifically at the proximal aortic neck or the common iliac artery interface, can prevent satisfactory anchoring of the stent-graft and thereby increase the chance of migration and type 1 endoleak. Calcium or thrombus, or both, can compromise the fixation and sealing of the endograft at the implantation sites.

Postprocedural causes for the migration of stent-grafts and for type 1 endoleak include aortic neck dilation, morphologic changes of the aneurysmal sac enclosing the endograft (most notably longitudinal shrinkage), endograft shortening, and stent-graft displacement secondary to proximal external compression. In addition to these postprocedural factors, the dimensions of the aneurysmal sac at the time of the procedure play an important role in endograft migration. The accepted criterion for secure endograft fixation is an infrarenal neck length of greater than 15 mm; but this has been challenged recently, and a minimum neck length of 10 mm has been stipulated as sufficient to produce good sealing of the stent-graft.

Similarly, an increased incidence of stent-graft migration has been associated with severe infrarenal neck angulation (>60° angle between the infrarenal aortic neck and the longitudinal axis of the aneurysm). Such severe neck angulation increases the incidence of type 1 endoleak by facilitating small leaks through the gaps between the stent and the neck. According to a bench-test study, stiffness of the stent also contributes substantially to stent migration in such patients.

**Innovative Techniques to Prevent Distal Migration of the Endograft**

Currently, 5 endovascular stent-grafts are approved for clinical use in the United States. They include Zenith (Cook Medical Inc.; Bloomington, Ind), AneuRx (Medtronic, Inc.; Minneapolis, Minn), Gore Excluder AAA Endoprosthesis (W.L. Gore & Associates, Inc.; Flagstaff, Ariz), Powerlink (Endologix, Inc.; Irvine, Calif) and Talent (Medtronic). In order to treat patients who have tortuous infrarenal neck anatomy, several manufacturers have modified their original designs to make the endograft more flexible. Some of the newer-generation endografts—the Zenith (Fig. 1), the Excluder (Fig. 2), and the Aorfix (Lombard Medical Technologies; Newton, Mass)—also offer active fixation to the aortic wall with the use of barbs, clips, or hooks that are an integral part of the device.

Because the anatomic causes of stent migration cannot be changed, success in preventing such migration lies in modifying the deployment technique and the design of the stent-graft itself. Modifications in technique should begin with how the delivery system is introduced. When the angulation, for example, is on one side of the coronal plane, introducing the delivery system from the side opposite the angle will facilitate passage at the top of the bend.

**Superstiff-Guidewire Technique**

It is usually helpful to bench-test the endograft to match the neck anatomy. Maneuvers like bending the guidewire before introduction, in order to align it with the
axes of the aneurysm and the neck, could be helpful (Fig. 3). Also of benefit is the use of a superstiff guidewire, such as the 0.035-inch Lunderquist (Nycomed US Inc.; Melville, NY) or the 0.035-inch Amplatz® (Boston Scientific, Inc.; Natick, Mass), in combination with slow and controlled deployment of the endograft (Figs. 4A and 4B). It is not advisable to attempt to reposition the endoprosthesis after deployment has been initiated, because this increases the risk of migration. Several techniques have specifically applied the EXCLUDER endograft to the prevention of distal migration and type 1 endoleak in patients who have severe infrarenal neck angulation, short infrarenal necks, or both.³

**Combination Technique Using the Palmaz XL Stent with the EXCLUDER Stent-Graft**

One of the described techniques, for use in patients who have complicated infrarenal neck anatomy, is the permanent deployment of the Palmaz® XL stent (Cordis Corporation, a Johnson & Johnson company; Miami Lakes, Fla) in the infrarenal neck before permanent deployment of the EXCLUDER endograft. This technique has been shown to offer a reliable mode of EXCLUDER fixation and prevention of distal migration. The combination of the use of the Palmaz XL stent after the deployment of the EXCLUDER has also been successful in preventing type 1 endoleak and distal migration (Figs. 5A and 5B).

**Endowedge Technique with the EXCLUDER Stent-Graft**

In patients who have short infrarenal neck anatomy, the “endowedge technique” described by Minion and coworkers also offers satisfactory juxtarenal sealing during EXCLUDER endograft placement (Fig. 6). This
technique enables the scalloped proximal 4 mm of the EXCLUDER endoprosthesis to be wedged against the renal angioplasty balloons, which are placed via the brachial approach. The first 2 to 3 rings of the endograft are slowly deployed (flowering technique), and then the device is advanced upwards against the inflated renal balloons for the completion of deployment.

Kilt Technique with the EXCLUDER Stent-Graft
In patients who have funnel-shaped or reverse-tapered aortic necks, an adjuvant procedure called the “kilt technique” is another possibility. In this technique, an aortic cuff is deployed in the distal infrarenal seal zone before the main body is deployed. The proximal end of the EXCLUDER contains barbs, which enable the device to remain above the aortic extension and thereby prevent distal migration. Careful inflation of an angioplasty balloon of the appropriate size then achieves the proximal seal of the prosthesis.

Anatomic Fixation with the Powerlink Stent-Graft
Powerlink is a bifurcated unibody stent-graft system that provides an “anatomic fixation” by straddling the aortoiliac junction (Fig. 7). The endograft is deployed so that its bifurcated component rests on the aortoiliac bifurcation. An additional aortic extension can, if necessary, lengthen the endograft to the infrarenal neck. This device helps to create an endoluminal channel system from the bottom up and prevents distal migration.

Newer-Generation Endografts to Prevent Distal Migration and Type 1 Endoleak
The Aorfix™ Endovascular AAA Repair System (Lombard) is a newer-generation endograft that is designed to overcome problems with infrarenal neck anatomy. This device—currently undergoing clinical trial in the United States—is made of polyester material and is partially supported by nitinol frames (Fig. 8). The proximal part of the Aorfix has incorporated nitinol clips for active fixation of the device to the aortic wall. The Aorfix has excellent procedural outcomes in terms of technical success, mortality rate, and avoidance of endoleak, migration, and stent-graft fracture. This stent-graft is very flexible and can conform to severely tortuous infrarenal necks (Fig. 8). Due to its unique ring design, the Aorfix resists kinking, tolerates oversizing, and does not transfer strain to seal zones. In the study reported by Albertini and colleagues, there were no instances of stent-graft migration with Aorfix after a mean follow-up time of 12 months (range, 1–43 mo). Those investigators also
showed that the incidence of type 1 endoleak was very low with the use of this stent-graft in patients who had severely angulated aortic necks. Lombard Medical (the maker of Aorfix) also offers EndoRefix™ nitinol clips that can be advanced through a delivery catheter and a 16F sheath to staple the stent-graft to the aortic wall in patients who experience distal migration of the previously placed endograft. The EndoRefix clips are currently undergoing clinical trial in the United States for use in patients who have previously placed stent-grafts with distal migration or who have challenging infrarenal neck anatomy that places them at risk of distal migration and type 1 endoleak. Only patients with polyester stent-grafts are candidates for the use of EndoRefix clips. The polytetrafluoroethylene graft material apparently is at risk of damage from the use EndoRefix clips.

Another innovation in the field of AAA repair is the Aptus stent-graft (Aptus Endosystems, Inc.; Sunnyvale, Calif), which incorporates an endostapling system with the endograft to prevent migration (Fig. 9).

The Anaconda™ (Vascutek, part of Terumo Cardiovascular Systems Corp.; Ann Arbor, Mich) is another device, undergoing clinical trials in the United States, that represents the next generation of stent-graft systems for AAA repair. This is the only graft system that enables repositioning of the graft after deployment. The Anaconda’s highly unusual flexibility and excellent

Fig. 7 Artistic rendering of a Powerlink® stent-graft demonstrates the principle of anatomic fixation of the endograft at the aortoiliac junction to prevent migration.

Fig. 8 Three-dimensional computed tomographic image of the Aorfix® device reveals severe angulation of the infrarenal aortic neck.

Fig. 9 Nitinol stent frame of the Aptus device in the infrarenal aorta. Endostaples can be seen affixing the graft to the vessel wall.
torque control enable accurate deployment and optimal placement even in patients with challenging anatomy.14

We have previously shown15 that when EVAR fails to resolve type 1 endoleak, the aortic wrap technique can be an important surgical alternative. In using this technique, the infrarenal retroperitoneum is opened through a 5-cm left-flank incision, and the aneurysmal aorta is exposed. After both renal arteries have been exposed, the aorta is dissected circumferentially from the surrounding tissues below the renal arteries. A graft “passer” is then placed around the aorta, which enables a 12-mm Hemashield® graft (Boston Scientific Corporation; Natick, Mass) to be pulled around the aortic neck, encircling it just below both renal arteries. The graft is measured and tightened, and is then secured with 2-0 ICRON sutures (Covidien Syneture; Mansfield, Mass) (Fig. 10). An abdominal aortic angiogram is then performed to check for type 1 endoleak. If the results are satisfactory, the omentum is placed between the duodenum and aortic grafts to prevent any erosion of the graft into the intestine, and the abdominal incision is closed in standard fashion.15

Conclusion

The key factors influencing the success of the EVAR technique are preprocedural planning, the experience of the operator, the technique used, and the generation of the endograft. Several adjunctive techniques during stent-graft deployment can also achieve successful endovascular repair in patients who have challenging infrarenal neck anatomy. Regular follow-up of patients with complex infrarenal neck anatomy after EVAR is mandatory. When EVAR fails, the aortic wrap is a reasonable surgical alternative. Future improvements in device attachment will simplify and improve the results of EVAR.

References