

What are your primary solutions for stent graft migration? Have you seen upward migration in the iliacs? How do you manage this?



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The goal of endovascular aortic aneurysm repair (EVAR) is to achieve both immediate aneurysm exclusion, as well as long-term durability. Migration can lead to EVAR failure at any point. The best solution to prevent migration is to have favorable anatomy. Proximally, this entails a healthy, neck-long, parallel, nonangulated, nondiseased anatomy. This allows for maximal endograft apposition to the aortic wall, minimizing the risk of migration. That being said, we often treat aneurysms without ideal anatomy. Understanding this, it is important to select an endograft that allows for adequate fixation. Fixation can be achieved with barbs (active), via stabilization with a suprarenal stent, or by securement on the aortic bifurcation.

Differing anatomy can require different approaches. For example, single angulation at the aneurysm neck may benefit from a suprarenal stent, whereas dual angulation involving the pararenal aorta and aneurysm neck may have worse results with a suprarenal stent. Thus, tailoring the particular mode of fixation to the aortic anatomy is best. With the advent of endoanchors, direct anchoring can be used to help prevent migration as well, especially for the more difficult aortic necks. In addition, fenestrated/branched technology may be ideal to extend the endograft to a healthier proximal aortic segment. Ultimately, anatomic factors will dictate the best approach for achieving appropriate fixation to minimize the chance of migration.

In regard to upward migration of the iliac limbs, this phenomenon does occur. Again, anatomy can play a large role.

Anatomy consisting of short, tortuous iliac arteries with a large sac tends to have the highest predisposition for this. As there are no specific stent graft designs for alleviating this situation, gaining adequate purchase into the iliac arteries is the best solution, recognizing that tortuosity mandates more purchase. Endoanchors, again, may be useful in this setting. In addition, new technology will play a role. For instance, the Nellix endovascular sealing system (Endologix, Inc., Irvine, CA) may obviate this, as obliteration of the sac may prevent any upward (as well as downward) migration.

Although our understanding of EVAR and the technology for this procedure evolve, migration continues to be a mode of failure for this treatment. Recognizing this potential problem and taking the appropriate steps to prevent it is the best solution.



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In my practice, the need to treat migration is much more common as an issue related to proximal fixation compared to iliac fixation. I think that the majority of migration cases can be treated with endovascular intervention. I always approach this problem with open conversion as the last option.

The loss of proximal fixation is most commonly seen with older devices, but all devices can have treatment failures with migration. This is especially true when the devices are placed in marginal anatomy that does not comply with the instructions for use. The extent of migration determines how I treat this problem. My usual treatment paradigm is to convert the original device to an

aorto-uni-iliac device. I think this approach is more durable than placing aortic cuffs to “build up” from a failed device, as this is an unstable temporary solution. The uni-iliac system allows for gaining fixation in both a healthy aortic neck with an appropriately sized device that also gains excellent fixation distally. I occlude the other limb with an Amplatzer vascular plug (St. Jude Medical, Inc., St. Paul, MN). The most challenging part of the procedures is usually the redo groin exposures to complete the femoral-femoral artery bypass.

In rare circumstances, the device has migrated so far distally that a bifurcated device can be placed to correct the migration. In fact, the most recent migration case that I treated presented with this type of anatomy. The complex portion of the repair was navigating the tortuous limb anatomy created by the distal migration. I did not need an upper extremity approach to navigate the anatomy, but I was prepared for this circumstance. I would never “pull down” a device to create this anatomy and the ability to place a bifurcated device, but it is better to avoid the prosthetic bypass in the femoral region when possible.

I think iliac migration is usually easier to treat. Even if the device has completely retracted into the aneurysm sac, a combination of an upper extremity and lower extremity approach will allow for wire catheterization of the migrated limb and placement of a new extension limb.



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With the latest generation of endovascular aortic prostheses, migration is extremely rare. This has been demonstrated in large, real-world registries and is reflected in my own clinical experience. However, the same cannot be said of endovascular devices of the past. As Australia was an early adopter of EVAR technology in the early to mid-1990s, it is not infrequent to see these early and mid-generation devices return with late migration of the proximal component or retrograde migration of the iliac limbs.

A type IA endoleak resulting from distal migration of the main body usually requires active treatment. If it is a case of mechanical migration without proximal aneurysm neck expansion, it may be possible to simply extend the in

situ device with an appropriately sized, off-the-shelf cuff to provide a seal at the level of the lowest renal artery. More commonly, however, we observe an aneurysm neck that has dilated to become a juxtarenal abdominal aortic aneurysm (AAA), where a cuff is unlikely to provide an adequate seal. If the anatomy is suitable and there is sufficient time to custom manufacture a fenestrated aortic cuff, then this is the treatment of choice. However, if it is detected in the context of an emergent presentation, other options must be considered.

Chimney grafts or snorkels can be utilized in a variety of configurations to perfuse the visceral arteries retrograde or antegrade in conjunction with one or more stacked aortic cuffs or tube grafts to approximate the aortic seal zone. I have frequently used this technique in conjunction with Onyx (Covidien, Mansfield, MA) sac and gutter leak embolization, which is achieved by leaving a microcatheter in the sac from an upper limb access, then filling it and the leak by slowly injecting while withdrawing the catheter. In a rupture scenario, even slow gutter leaks are unacceptable, and this technique has derived considerable success.

Another option, albeit more invasive, is the periaortic ligature technique, which can be performed through a limited, upper-midline laparotomy incision. I use two to three 5-mm nylon tapes looped behind the aorta immediately beneath the lowest renal and spaced every 5 mm. These are tied down by hand until resistance is felt from the endograft exoskeleton. This is an effective method of sealing a proximal endoleak, with or without the need for an aortic extension piece.

Proximal migration of an iliac limb component resulting in type IB endoleak is also rare. It may occur in a large aneurysm as it remodels or through ongoing expansion of the native common iliac arteries. It is exacerbated by short, tortuous iliac arteries with insufficient initial graft length and/or oversizing. Frequently, this condition poses a challenge to establishing wire access if the limb is sitting freely in the aneurysm sac and to safe tracking of a new device once wire access is obtained. My preference is to capture an antegrade wire from the upper limb and externalize it “through and through” the femoral sheath. This not only facilitates a prompt cannulation with the aid of a large trilobed snare in the sac, but it also permits a taught delivery wire with straight-line passage for the new device, or for a long sheath through which that device may be delivered. Clearly, it is then important to appropriately oversize the new iliac limb and extend it as far toward the common iliac bifurcation as possible. I have a low threshold for extending to the external iliac artery in the context of an expanding common iliac artery and usually try to maintain internal iliac patency with the use of an iliac branch device or the sandwich technique whenever possible.



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Graft migration has certainly been a relevant cause of late failure after EVAR and can result in secondary interventions; therefore, it has been called the Achilles' heel of EVAR. However, in my personal experience, the risk of graft migration is minimized, and this has to do with new-generation devices with secure fixation systems, as well as greater experience among clinicians and centralization of expertise in many nations. For example, recently reported results from the ENGAGE registry show 0% migration, a type I endoleak rate of 1.2%, and a 0.2% AAA rupture risk.

To avoid migration, we are rigorous in our patient selection based on aortic neck morphology. Patients who are unsuitable for open surgery with proximal neck lengths < 10 mm are selected for fenestrated stent grafting. Chimney grafts are technically feasible, but in my opinion, they are bailout solutions for urgent cases. Active fixation of stent grafts, either suprarenal bare stents or infrarenal with hooks, and appropriate oversizing of 15% to 20% are the keys to successful EVAR from my perspective.

If it happens over time, our primary solution for distal main body migration, which is mostly combined with repressurizing endoleaks, is proximal cuff extension with or without the use of endostaples. Chimneys belong in the armamentarium, as well as elective surgical conversion if discussed at an early stage of decision making and if the patient is suitable, which has been performed with good results.

I have occasionally observed upside migration in the iliacs, mostly in patients with larger, diseased iliac diameters at the distal landing zone at the time of primary implantation and then developing progressive dilatation. With regard to treatment, we prefer distal extension, whenever possible, with preservation of the hypogastrics as the first-line option. We either use extensions (including the "bell-bottom" technique) from the initial manufacturer or balloon-expandable stent grafts (Advanta V12, Maquet Vascular Systems, Hudson, NH) with postdilatation and flaring. If there is no landing zone, we either use iliac side branch devices or redo percutaneous transluminal angioplasty and endostaples, depending on diameter mismatch and wall morphology (thrombus and calcium load).

Hypogastric occlusion techniques, preferably with a

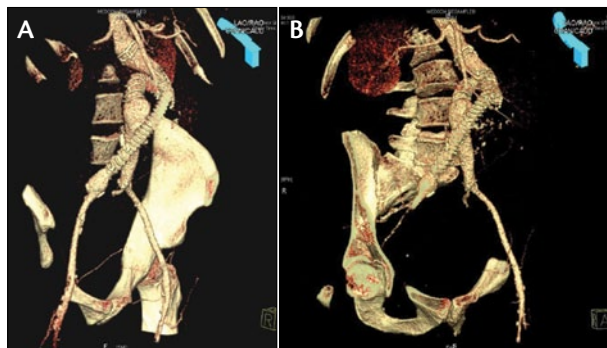


Figure 1. An example of both distal migration of the main body of an endograft (A), as well as upward migration and separation of the contralateral limb, leading to type IB endoleak (B). The patient was converted to surgery.

vascular plug (Amplatzer), is our last option, which we try to avoid whenever possible. I do not have experience with sandwich techniques and see more burdens (eg, gutter, transbrachial access, and cost) than benefits. However, Dr. Armando Lobato from São Paulo, Brazil, has reported favorable personal experience with the sandwich technique. Surgical conversion for distal iliac migration is seldom necessary and was performed only twice in the last 3 years in patients being treated in a referring hospital, as shown in Figure 1.

In summary, many technical solutions are offered and applied in our institution in order to preserve the hypogastrics. Buttock claudication (16%–55%), sexual dysfunction (up to 17%), and colon ischemia (1%–35%) are serious potential complications. In the future, new solutions such as endovascular sealing with polymer technology may further reduce or even extinguish stent graft migration from the list of causes of treatment failure after EVAR.

My conclusions for migration are that it is not a leading problem anymore, and prevention is always better than troubleshooting. There is no silver bullet for managing proximal or distal migration, but endovascular therapy is the definitive first-line treatment. Appropriate patient selection, surveillance, and timely endovascular reinterventions are perhaps the most important factors to ensure robust long-term outcomes of endovascular repair, even when native vessel morphology changes. Primary open surgery (still 30%–40% at our institution) is not "dead," achieving excellent results in high-volume aortic centers.

Industry registry evidence and large, single-unit case series are now generating a healthy evidence base for EVAR durability in contemporary endovascular practice, which affirms its role as a first-line therapy in the majority of morphologically suitable patients.



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Migration is a failure of fixation sites of an endograft after EVAR, as evidenced by downward or upward slippage of the device. This may be due to inherent problems with endograft fixation properties or EVAR technique, although aortic neck dilation and iliac dilatation, calcification and tortuosity, and AAA remodeling may also play a role.

A plethora of solutions exist for treating distal endograft migration including cuffs, endoanchors, and secondary tube graft extension with chimneys or fenestrated/branched grafts. Proximal displacement may result in loss of one or both renal arteries, which can be treated by downward displacement of the bifurcated graft by a femorofemoral floss and downward traction with or without renal artery stenting.

Despite all of these available solutions, prevention is nevertheless the best option to prevent endograft migration by understanding the following dictums.

One of my primary steps during EVAR to prevent migration includes improved endograft fixation by extending the landing zone to the common iliac bifurcation. One study¹ showed that increasing iliac fixation length significantly increases the force needed to displace stent grafts. This was especially true for patients with short aortic necks.²

Another technique is molding the sealing zones even if the completion angiogram shows no endoleak prior to molding. Cadaver studies have substantiated the view³ that molding with appropriate compliant balloons can result in better fixation. Furthermore, I choose devices with active proximal fixation (ie, hooks and barbs) as an additional mechanism of fixation and resistance to migration. I do not recommend excessive oversizing of iliac limbs (> 10%), as greater oversizing may contribute to dilation of the landing zones and therefore migration.

I would also suggest maintaining an optimal contralateral iliac limb sealing overlap, perhaps even generously up to the bifurcation in patients with tortuous iliac artery origins to prevent type III endoleak. The use of iliac limb endografts with higher radial force is also recommended (eg, the nitinol-based Spiral Z graft limbs, Cook Medical, Bloomington, IN). Finally, to achieve a good seal in the

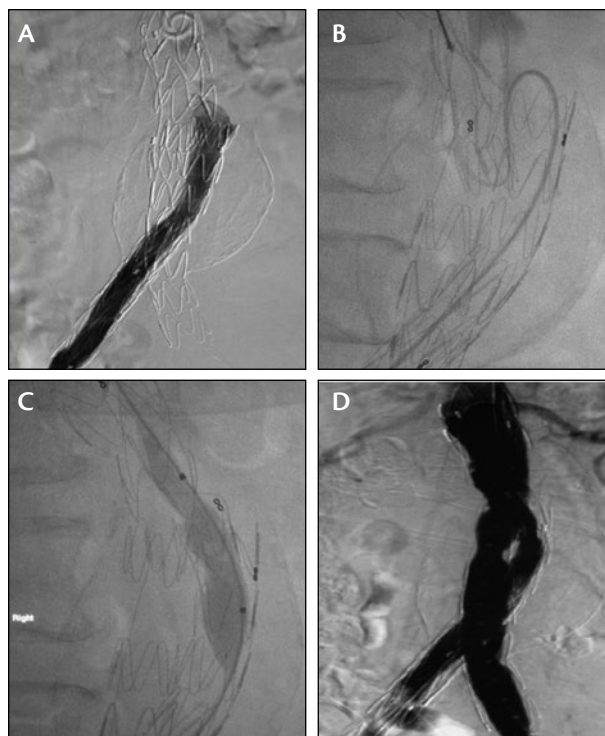


Figure 2. Upward migration of an Iliac limb with dislocation of the limb from the contralateral gate (A). Blow-back angiography of the iliac limb shows filling of the sac but not the aortic bifurcated graft main body. Capture of the transfemoral wire through the dislocated limb from a brachial approach (B). Alignment of the contralateral gate with the contralateral displaced and migrated limb (C). Completion angiography after a bridge covered stent was placed across the contralateral gate and limb (D). Successful management of iliac limb migration and dislocation.

presence of a common iliac artery that is > 20 mm in diameter, it may be best to extend the limb to the external iliac artery after embolization of the internal iliac artery or to use an iliac branch device if the internal iliac artery needs to be preserved.

On two occasions, I have seen upward migration in the iliacs. One resulted in contralateral limb dislocation, and the other ended in kinking and graft thrombosis. In the first case, the contralateral limb overlap was only one stent length, and this caused the limb to dislocate during upward displacement of the stent during sac shrinkage and remodeling (ie, technique related). The second case involved an acute bend in the contralateral limb due to increasing tortuosity of common iliac artery (ie, stent graft usage outside the instructions for use).

For the first case (Figure 2A), I used a brachiofemoral approach and floss technique. A Glidewire (Terumo Interventional Systems, Somerset, NJ) was placed in the

AAA sac from a brachial approach via the contralateral gate and was captured by an Amplatz GooseNeck snare (Covidien) introduced via the femoral route through the distal part of contralateral stent graft (Figure 2B). An 8-mm PTA balloon was used to align the limb ends by inflation, and the Glidewire was exchanged for a Lunderquist Super-Stiff wire (Cook Medical) placed across the dislocated but aligned limbs. Larger-diameter balloons were used to further dilate the engagement ends of the dislocated limbs (Figure 2C). A suitable endograft limb was then deployed across the gap. Good limb continuity was seen on completion angiography (Figure 2D), with no endoleak, and has been sustained as such in the follow-up period of 2 years.

For the second case, thrombolysis was initiated with alteplase followed by successful passage of a guidewire and a bridge covered stent (Advanta V12). Percutaneous transluminal angioplasty resulted in relief of limb ischemia.

1. Heikkinen MA, Alsac JM, Arko FR, et al. The importance of iliac fixation in prevention of stent graft migration. *J Vasc Surg*. 2006;43:1130-1137.
2. Waasdorp EJ, de Vries JP, Sterkenburg A, et al. The association between iliac fixation and proximal stent-graft migration during EVAR follow-up: mid-term results of 154 Talent devices. *Eur J Vasc Endovasc Surg*. 2009;37:681-687.
3. Melas N, Saratzis A, Saratzis N, et al. Aortic and iliac fixation of seven endografts for abdominal-aortic aneurysm repair in an experimental model using human cadaveric aortas. *Eur J Vasc Endovasc Surg*. 2010;40:429-435.



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Aortic aneurysm is a degenerative disease that primarily affects the infrarenal aorta. Fundamentally, this process is an example of the degradation of the aortic wall that often precludes the mortality of the host and should be considered predictive of the impending cellular failure of the patient. As aortic surgeons, we are most gratified when we can interrupt selective failure of the aorta and provide more years of reasonably good health for our patient. As our medical treatment improves with time (such as the application of EVAR), we find that our patients live longer after we have repaired their aneurysm. In fact, if our patients live long enough, I suspect that more of them will develop further aortic degeneration that is often exhibited as graft migration. Thus, while migration may be considered a problem of older grafts that do not have active or suprarenal fixation,

I suspect we will see more migration problems in the new generation of grafts. This phenomenon might be considered a degeneration of the proximal aorta that is actually dilatation that we simply classify as migration.

I might consider migration to be synonymous with proximal aortic dilatation causing endograft failure. If patients are followed for an extended period, often longer than 5 years, the paravisceral aortic segment may degenerate. Therefore, when treating an aortic aneurysm, I prefer to seek the most secure portion of the aorta for fixation—whether that be the supra- or infrarenal segment—with the expectation that the patient still needs to be followed for an extended period. If the patient has a large aortic neck at time of treatment, perhaps HeliFX anchors (Aptus Endosystems, Sunnyvale, CA) may be used to prophylactically provide more secure fixation to prevent long-term failure. I will also use anchors for a suprarenal graft that may need a secure fixation point in the infrarenal segment. Again, the larger-diameter (> 26 mm) infrarenal aorta is probably more indicative of this “at-risk” aorta and has a greater potential for long-term failure, such as migration.

When migration does occur, I will treat based on the same principles as previously stated. First, I consider a supra- or infrarenal cuff depending on the healthiest remaining segment of the aorta. After a cuff is used, I will often reinforce it with anchors that can penetrate through both the new endograft segment and the preexisting graft into the aortic wall. While this represents the simplest option, I will also consider placing another bifurcation graft inside the migrated graft if the anatomy allows (usually 4 cm of migration and 7 cm to flow divider of the migrated endograft). Last, the graft can be converted to an aorto-uni-iliac system with a cross-femoral bypass after the excluded proximal iliac is secured with ligation or plugging. This last option represents an involved repair that includes surgical bypass, which is still well tolerated by most patients.

At times, there is no healthy aorta, and open surgical repair should be considered in the patient who has a reasonable life expectancy. If the general medical condition of the patient suggests a shorter life expectancy, and the pararenal aorta offers no area of solid fixation, branched or parallel grafts can be used. When a migrated graft is present, one can also consider a periscope configuration (downward directed parallel graft) at the same time chimney grafts (upward directed parallel graft) are placed from an upper extremity access location. The orientation (periscope vs chimney) is chosen based on the angle of the branch vessels and its position relative to the failed endograft. While gutter leaks are sometimes evident at the conclusion of the procedure, these often thrombose over time and may be of little consequence for these usually infirm patients. ■