



Optimal EVAR Fixation:

Infrarenal Fixation Is the Safest Option

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Surgical repair of abdominal aortic aneurysms (AAAs) was first reported in 1952¹ and remained the only effective and classical treatment for AAAs until the advent of endovascular aneurysm repair (EVAR).²

During the past 15 years, EVAR has gained wide acceptance in the treatment of suitable patients with infrarenal AAAs.^{3,4} But some new problems such as stent graft migration, endoleak, and modular component disconnections were observed, which are quite different from those of conventional open repair.^{5,6} One of the most important modifications in aortic stent grafts was the development of suprarenal fixation, which was first proposed by Lawrence et al.⁷ Suprarenal fixation of stent grafts is designed to obtain secure fixation of the proximal end of the stent graft to avoid graft migration and to prevent type 1 endoleaks. Theoretically, the suprarenal stent graft technique can extend the applicability of EVAR to more complex AAAs, such as those with short, angulated necks, etc. These issues are regarded as the advantages of suprarenal fixation.

Currently, there are several endografts that provide suprarenal fixation: Fortron (Cordis Corporation, a Johnson & Johnson Company, Miami, FL), Talent (Medtronic Vascular, Santa Rosa, CA), Trivascular (Boston Scientific Corporation, Natick, MA), and Zenith (Cook Incorporated, Bloomington, IN) grafts. The Powerlink (Endologix, Inc., Irvine, CA) and Vanguard (Boston Scientific Corporation) grafts provide the possibility of both suprarenal and infrarenal fixation. It is a fact that with suprarenal fixation, the anchoring zone is extended upward, and more resistant forces against displacement are acquired. Satisfactory results in the short- to midterm have been published in the literature.⁸⁻¹¹

POTENTIAL DISADVANTAGES

The controversy about suprarenal and infrarenal fixation of stent grafts in EVAR usually focuses on renal blood flow and function and migration with proximal endoleak.

However, we believe that there are at least six possible disadvantages of suprarenal fixation.

Renal Blood Flow/Renal Function

The primary difference between suprarenal and infrarenal stent graft fixation is the deployment of uncovered stent struts above the renal arteries. Thus, single or multiple stent wires may cross the renal artery ostia in various configurations, which may interfere with blood flow to the renal arteries. The interference outcome lies in the diameter of the renal artery, the diameter of the stent struts, and the number and location of struts in front of the renal ostium. Liffman et al found that smaller-diameter (3 mm) renal arteries had a larger percentage decrease in flow rate caused by stent wires than larger (7 mm) vessels.¹² They also confirmed that a single off-center wire produced a smaller percentage decrease in flow rate versus a central wire, but two stent wires always had the largest impact on flow. Thus, a potential complication of reduction of cross-sectional area of the renal ostium is easy to imagine. It is also easy to understand that the flow rate declines to a greater degree for a small-diameter renal artery.

Covering these small renal arteries with multiple stent wires may significantly reduce flow and induce renal damage. Sun reported that virtual intravascular endoscopy of spiral CT might play a role in correlating stent wire/ostium configurations to renal blood flow measured on Doppler ultrasound.¹³ However, these interference outcomes are usually neglected. We consider that long-term follow-up results and even experimental studies are required.

Kidney infarction by atherosclerotic emboli is widely recognized and accepted^{10,11,14} and is caused by aortic adherent plaques and/or thrombus dispersion and embolization, possibly resulting from endovascular manipulation and altered hemodynamics. Of course, the suprarenal anchoring might bring higher risk of renal embolization. Occasionally, occlusion of the renal artery origin due to moving diseased intima

TABLE 1. COMPLICATIONS RELATED TO THE PROXIMAL FIXATION OF THE ENDOGRAFT

Complications	Total Cohort (%)	IRF Group (%)	SRF Group (%)
Proximal type 1 endoleak	76 (7.3)	51 (7.4)	25 (7.1)
Primary	36 (3.5)	19 (2.8)	17 (4.8)
Secondary	40 (3.9)	32 (4.7)	8 (2.3)
Conversion to open	55 (5.3)	36 (5.3)	19 (5.4)
Early conversion (30 days)	9 (0.9)	6 (0.9)	3 (0.8)
Post-EVAR rupture	6 (0.6)	4 (0.6)	2 (0.6)
Renal infarction	97 (9.4)	36 (5.3)	61 (17.4)

Abbreviations: IRF, infrarenal fixation; SRF, suprarenal fixation.

(plaque/thrombus) into or across the vessel during deployment may occur, especially when ballooning is required.

Meanwhile, it is not difficult to imagine the phenomenon of distortion of the renal ostium by stent struts because the aortic wall is relatively soft and susceptible to deformation by the metal wires. Sun observed distortion of renal ostium with the virtual intravascular endoscopy technique of spiral CT.¹⁵

The surface of a stent itself constitutes a thrombogenic foreign body, and the wall injury by the hooks or barbs at the anchoring site provides a powerful stimulus to platelet activation and thrombus formation. Animal research confirmed neointimal hyperplasia formation in the stented segment within 12 weeks of implantation.¹⁶ In addition, the stent above the renal ostia might reduce the cross-sectional renal artery area and compromise renal blood flow because neointimal proliferation tends to fill the spaces between the struts.

Interference With the SMA

Similar interference of the superior mesenteric artery (SMA) and celiac axis may occur if the suprarenal stent is above the SMA and/or the celiac artery. The bare stent above or in the SMA and/or the celiac artery will also interfere with the blood flow at the orifices of SMA and/or the celiac, and may bring about possible atherosclerotic emboli and neointimal hyperplasia.

Increased Atheroembolic Events

There is the potential for an increase of atheroembolic events of the lower extremity, colon, small bowels, buttock, spinal cord, etc., which are recognized as “not uncommon” after EVAR.¹⁷⁻¹⁹ It is easy to understand that the bare wire stent (with its spring or flare morphology) and hooks above the renal arteries will definitely induce the atherosclerotic

plaques and/or thrombus around the visceral arteries’ orifices and will affect the regional hemodynamics, which might lead to the dispersion of multiple emboli.

Dilatation of the Visceral Abdominal Aortic Segment

Aortic neck dilation after EVAR is significant in a subset of patients and may be related to neck degeneration.²⁰ The oversized stent has a radial force in the anchoring region to resist migration, which may also result in neck dilation.²⁰

Renal Artery Complications

There may be difficulty in dealing with the renal artery if further intervention is required. Most AAA patients also have renal artery stenosis to varying degrees; therefore, intervention with the renal artery will become more difficult if PTA and/or stenting, or if bypass is required after EVAR.

Anchor Stent System Complications

The possibility exists for difficulty in dealing with the anchor stent system if graft explantation is required. The post-EVAR rupture rate is reported to be 1.6% to 10%.^{21,22} Conversion surgery will definitely become more difficult in suprarenal fixation cases.

OUR OPINIONS

The goal of EVAR is to provide secure device placement. EVAR shares a similar principle with conventional surgery of AAA—the stent in EVAR has the same function as the suture in open surgery. EVAR is designed for infrarenal AAAs, so the graft should be sutured in the infrarenal region of the aorta. From this point of view, we preferred the endovascular stent grafts with proximal hooks or fixation crimps, such as the Ancure (Guidant Corporation, Indianapolis, IN) and Lifepath (Edwards Lifesciences LLC,

Irvine, CA) systems.²³ These two grafts remain in place without migration using these fixation systems.

Pullout experiments have been performed using harvested pig aortas to examine the stability and durability of stents after deployment.²⁴ The force required to pull out and displace a nonhooked stent was 5 N to 6 N compared to 40 N to 50 N for the hooked stents, which means that up to 10 times the force is required to dislodge a graft by straightening the hooks. An experimental study mimicking an infrarenal AAA neck in human cadavers (deceased patients aged more than 60 to 70 years) has also demonstrated that hooks and barbs improve the fixation of self-expandable stents.²⁵

Balloon dilatation of the proximal stent after deployment might increase fixation. A recent retrospective study compared EVAR results using the Ancure endograft in patients with and without hostile neck anatomy.²⁶ The outcome showed that unsupported endografts with active fixation can yield excellent results in treating many medically compromised patients with hostile neck anatomy. Thereby, we believe that suitable patients with indicated EVAR anatomy can be treated successfully with proper endovascular devices.

Migration is always considered a very severe complication and is associated with proximal type 1 endoleak even with post-EVAR rupture. There are many reasons for migration. Intraoperative migration may be associated with improper sizing or technical factors at the time of implantation. Postoperative migration may be correlated to fixation-system design, fixation-site dilatation, or material fatigue. Also, the presence of a suprarenal stent within the visceral aortic segment does not necessarily confer ultimate stability because migrations have been reported with these devices as well.²⁷ Finally, documented movement of a device does not necessarily indicate failure of treatment or risk of rupture. Aortas enlarge and elongate over time, and changes in position of a device may occur. Zarins reported that 68% of the AneuRx cases with migration in the clinical trial have not required treatment and appear to be stable over follow-up extending more than 7 years.²⁸

OUR EXPERIENCES

We have experience with EVAR for 1,064 consecutive infrarenal AAAs between August 1994 and May 2005. A review of the data for 983 men and 81 women who ranged in age from 42 to 98 years showed that the average diameter of the AAAs was 4.9 cm (range, 2.8-10 cm). In total, 11 different endovascular devices were used. Six hundred eighty-four cases were treated with infrarenal fixation (IRF group), and 351 cases were treated with suprarenal fixation (SRF group). Follow-up visits were scheduled at 1, 6, and 12 months, and annually thereafter. The mean dura-

tion of follow-up was 33 months (range, 0.2-88 months). We compared the complications related to proximal fixation (Table 1).

There are no significant differences between the IRF group and the SRF group for the complications of main body migration, proximal type 1 endoleak, conversion and post-EVAR rupture rates. The renal infarction rate (evaluated by preoperative and postoperative CT) after EVAR using infrarenal fixation was more than three times lower than with suprarenal fixation. Furthermore, the renal infarction rate with the Zenith graft (SRF) was very high at 21.1%. The renal infarction rate with the Ancure device (IRF) was 6.4%; 5.7% with the Lifepath device (IRF); and 3.8% with the Powerlink system (IRF). These data document that the potential risk of impairing renal function increases with the suprarenal attachment and complex reconstructions.

CONCLUSIONS

Although suprarenal fixation has expanded the proximal anchoring zone and strengthened proximal fixation forces, no significant differences of the proximal fixation-related complications were found between infrarenal fixation and suprarenal fixation in our consecutive 1,064 EVAR patients. However, the post-EVAR renal infarction rate with suprarenal fixation was more than three times higher than with infrarenal fixation. We preferred infrarenal fixation with proximal hooks (Ancure) or fixation crimps (Lifepath). But we believe that today's endografts that provide strong radial force and columnar support, such as the Powerlink device, can also achieve optimal long-term results (eg, low proximal type 1 endoleak rate). Approximately 60% to 70% of infrarenal AAA patients in our department can be successfully treated with infrarenal fixation devices.

Suprarenal fixation has many potential defects. Most of the clinical studies were limited due to short-to-medium follow-up periods. Longer follow-up with a larger number of patients is needed to confirm the safety of this technique. ■

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