Self expandable stent application to prevent limb occlusion in external iliac artery during endovascular aneurysm repair

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INTRODUCTION

Abdominal aortic aneurysm (AAA) was accompanied by common iliac artery aneurysm (CIAA) in approximately 20% to 30% of patients [1,2]. CIAA could require extension of the stent-graft limb to the external iliac artery (EIA) in the case of standard bifurcated stent-graft. The risk of iliac limb occlusion (LO) increases in stent-graft limb deployment in EIA [3,4]. LO of a stent-graft is a serious complication that can lead to amputation; and the prevalence of LO has been reported ranging from 0.7% to 6.4% after endovascular aneurysm repair (EVAR) [3,5-8]. The LO rate of stent-graft limb landed in the EIA was significantly higher in comparison with the common iliac artery (CIA) (15% vs. 3%) [3]. The causes for higher LO are the EIA’s smaller caliber, tortuous course and reduction of outflow by covering the internal iliac artery (IIA) [9].

Some papers had reported that the use of adjunctive iliac stent (AIS) with EVAR significantly reduced the risk of LO without any complications. AIS should be considered as a preventive procedure of LO if stent-graft needs to be extended to EIA during EVAR.

KEY WORDS: Abdominal aortic aneurysm, Endovascular procedures, Stents, Iliac artery

Purposes: Iliac extension of stent-graft during endovascular aneurysm repair (EVAR) increases the incidence of limb occlusion (LO). Hypothetically, adjunctive iliac stent (AIS) could offer some additional protection to overcome this anatomic hostility. But still there is no consensus in terms of effective stent characteristics or configuration. We retrospectively reviewed our center’s experience to offer a possible answer to this question.

Methods: Our study included 30 patients (38 limbs) with AIS placed in the external iliac artery (EIA) from January 2010 to December 2013. We classified iliac tortuosity based on anatomic characteristics. AIS’s were deployed in EIA with a minimum 5-mm stick-out configuration from the distal edge of the stent-graft.

Results: According to the iliac artery tortuosity index, grade 0, grade 1, and grade 2 were 5 (13.2%), 30 (78.9%), and 3 (7.9%), respectively. The diameter of all AIS was 12 mm, which was as large as or larger than the diameter of the stent-graft distal limb. SMART stents were preferred in 34 limbs (89.5%) and stents with 60-mm length were usually used (89.5%). During a mean follow-up of 9.13 ± 10.78 months, ischemic limb pain, which could be the sign of LO, was not noticed in any patients. There was no fracture, kinking, migration, in-stent restenosis, or occlusion of AIS.

Conclusion: The installation of AIS after extension of stent-graft to EIA reduced the risk of LO without any complications. AIS should be considered as a preventive procedure of LO if stent-graft needs to be extended to EIA during EVAR.

[Ann Surg Treat Res 2016;91(3):139-144]
retrospectively reviewed our center’s experience about stent characteristics and configuration.

METHODS

Study population
From January 2010 to December 2013, 98 patients with AAA underwent EVAR in our institution. Among them, CIAA was accompanied with AAA in 35 patients and 55 limbs. This study included 30 patients and 38 limbs requiring extension of the stent-graft limb to the EIA and deployment of AIS.

Surgical procedure
When a stent-graft iliac limb was needed to extend to the EIA, we always deployed AIS for prevention of LO. All patients were related to the CIAA which required stent-graft placement across the origin of the IIA. When the CIAA was close to or involved the iliac bifurcation or when the CIA was too large to fit the available stent-grafts, we determined to cover IIA. If IIA was not occluded in the preprocedural imaging study, IIA was embolized to prevent type II endoleak. After IIA embolization, stent-grafts were deployed for aneurysm exclusion in the usual manner.

After standard deployment of the endovascular stent-graft, AIS was implanted in EIA. Self-expandable, bare metal stents, such as SMART stent (Cordis Co., Miami, FL, USA), Zilver stent (Cook Inc., Bloominton, IN, USA) and Wall stent (Boston Scientific, Natick, Ma, USA) were used as AIS in our institution. The diameter of all AIS was 12 mm regardless of the diameter of stent-graft distal limb. The AIS was deployed a minimum of 5 mm beyond the distal stent-graft limb into the EIA, rendering a smooth transition from the stent-graft limb into the native iliac arterial curvature. All of the AIS were placed from the limb to native artery (Fig. 1).

Patient assessment
Three-dimensional computed tomographic angiography (3D CTA) using Aquarius, iNtuition Ed ver. 4.4.6 (TeraRecon Inc., Foster City, CA, USA) was examined to plan EVAR and to determine the necessity for iliac limb extension and coverage of the IIA. 3D CTA was performed for review of the aortoiliac anatomy, tortuosity of vessels, and IIA diameter. Iliac artery tortuosity was classified from 0 to 3 by tortuosity index using a 3D workstation (Fig. 2). This data was used to determine the optimal approach for successful catheterization, the size of stent-graft, and the ideal AIS. Follow-up 3D CTA was performed within the 1st postoperative week and then at 6 months and every following year to determine fracture, kinking, migration, in-stent restenosis, and occlusion of AIS as well as the patency of the stent-graft. Physical examination with pulse status and ankle-brachial index were routinely checked with doppler for the assessment of LO.

RESULTS

Between January 2010 and December 2013, 30 patients and 38 limbs requiring extension of the stent-graft limb to the EIA and deployment of AIS at the time of EVAR were reviewed retrospectively. All patients were related to the combined aneurysm of aorta and CIA. Seventeen patients with bilateral CIAAs and 13 patients with unilateral CIAA were included in this study.

Patient demographics and past medical history were listed in Table 1. Mean age of all patients with AIS was 72.13 ± 6.83 years and there were 27 men (90.0%). Thirteen patients (43.3%) had hypertension as comorbidity and 12 patients (40%) had a history of smoking. Procedural characteristics were presented in Table 2. Eight patients (26.7%) were implanted with both AIS’s and all underwent additional procedures to prevent pelvic ischemia. Bypass operation from EIA to IIA was performed in 7
patients and an iliac-branched device was used in 1 patient for prevention of pelvic ischemic complications. IIA embolization ipsilateral to AIS was performed in 20 patients to prevent type II endoleak from IIA.

Twenty-seven Zenith (Cook Inc., Bloomington, IN, USA) and 3 Excluder (W.L. Gore & Associates, Sunnyvale, CA, USA) stent-grafts were used. The diameter of all AIS was 12 mm, which was as large as or larger than the diameter of stent-graft distal limb. The diameters of stent-graft distal limbs were 12 mm (28 limbs, 73.8%), 10 mm (9 limbs, 23.7%) and 8 mm (1 limb, 2.6%). SMART stents were preferred in 34 limbs (89.5%) and stents with 60-mm length were used mainly (89.5%) (Table 3). Mean CIA maximum diameter including CIAA was 30.64 mm and mean EIA minimum diameter was 10.97 mm (Table 4). By iliac tortuosity index, grade 1 was found in 30 (78.9%). There was no iliac anatomy as tortuous as grade 3 (Table 5).

During a mean follow-up of 9.13 ± 10.78 months, there was
the SMART stent (89.5%). This stent is an open-cell designed
used as AIS in our study. Our most commonly used AIS was
SES works better for this intention. Different SES’s also were
demonstrated in atherosclerotic stenotic artery. We believe
the flexible native artery using radial force, which had been
implantation, as do we.

Sivamurthy et al. [10] now routinely insert AIS in cases of EIA
based on preoperative imaging or completion angiography [4].

Trend toward primary rather than secondary utilization of AIS
implantation. As EVAR experience increases, there has been a
EIA. There remains uncertainty regarding the timing of AIS
implantation, as do we.

Although we did not compare self-expandable stents (SES)
with balloon expandable stents, SES has been compared in
another report [11]. The main purpose of the stent was to offer
a smooth transition zone between the stiff stent-graft and
the flexible native artery using radial force, which had been
demonstrated in atherosclerotic stenotic artery. We believe
SES works better for this intention. Different SES’s also were
used as AIS in our study. Our most commonly used AIS was
the SMART stent (89.5%). This stent is an open-cell designed
SES that is flexible and resistant to deformation, unlike
balloon-expandable stents [12,13]. There were no LOs and no
complications in the Wall stent group [10]. On the other hand,
the use of Zilver stent as AIS for limbs deployed into the EIA
did not reduce the rate of limb thrombosis. Three limbs occluded
despite the use of AIS in 8 limbs [3]. Insufficient numbers in
the studies did not explain clearly that the different results
happened although they were also SES’s. Because SMART stent,
used mainly in our institute, had greater radial resistive force
and longitudinal stability, it was believed that SMART stent
played an appropriate role as AIS. AIS of 12 mm in diameter, as
large as or larger than the diameter of stent-graft distal limb,
was safe regardless of different EIA diameter size (8.45–13.10
mm). The configuration of AIS is important for the successful
function of AIS. We always place the AIS sticking out at least 5
mm beyond the stent-graft. Since other studies did not make
clear statements about the stent configuration, we could not
compare whether this policy works in a positive way or not. Iliac
tortuosity grade 1 or less occupied most of our study (92.1%) and
there was no iliac anatomy as tortuous as grade 3. AIS caused
relatively less tortuous iliac artery and never created any kink
points in EIA. Because tortuous iliac artery can increase the
risk of kinking, fracture, migration in-stent restenosis and occlusion of
AIS.

DISCUSSION

In our study, LO and other complications of AIS procedure
didn’t happen after AIS deployment with EVAR. This is
compatible with previous studies. Oshin et al. [4] compared the
group with more aggressive AIS stenting strategy (n = 293) and
the group with an ad hoc AIS stenting basis (n = 288). More
frequent use of AIS was associated with a concurrent reduction
in the rate of LO. Sivamurthy et al. [10] evaluated limb patency
with and without AIS. No LO occurred in the group with AIS
while there were 13 instances (5.2%) of LO in the group without
AIS. Like our results, the studies reported that AIS significantly
reduced the risk of LO without complications. AIS protruding
from stiff stent-graft to native artery seemed to create a
protective radial force to prevent LO. We unexceptionally
deployed primary AIS, when stent-graft was extended to
EIA. There remains uncertainty regarding the timing of AIS
implantation. As EVAR experience increases, there has been a
trend toward primary rather than secondary utilization of AIS
based on preoperative imaging or completion angiography [4].
Sivamurthy et al. [10] now routinely insert AIS in cases of EIA
implantation, as do we.

Although we did not compare self-expandable stents (SES)
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another report [11]. The main purpose of the stent was to offer
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SES works better for this intention. Different SES’s also were
used as AIS in our study. Our most commonly used AIS was
the SMART stent (89.5%). This stent is an open-cell designed

### Table 4. Diameter of iliac artery

| Diameter                     | Limbs with iliac limb stent (n = 38) |
|------------------------------|-------------------------------------|
| CIA maximum diameter (mm)*   | 30.64 (21.50–49.72)                |
| EIA minimum diameter (mm)**  | 10.97 (8.45–13.10)                 |

Values are presented as mean (range)
CIA, common iliac artery; EIA, external iliac artery.
*Outer diameter. **Inner diameter.

### Table 5. Iliac tortuosity

| Grade | Tortuosity index | Limbs with iliac limb stent (n = 38) |
|-------|-----------------|-------------------------------------|
| 0     | ≤1.25           | 5 (13.2)                            |
| 1     | >1.25, ≤1.5     | 30 (78.9)                           |
| 2     | >1.5, ≤1.6      | 3 (7.9)                             |
| 3     | >1.6            | 0 (0)                               |

Values are presented as number (%).
factors to prevent LO. Despite the short follow-up duration (9.13 ± 10.78 months), LO will be less likely to occur because the majority of LO occurred within 6 months [3,4]. Routine insertion of AIS with limb extension into EIA has limited our ability to interpret the findings of this study without a control group. It may be argued that routine use of AIS is adequate in cases where the limb extends into the EIA. The additional expense and potential risk associated with stent insertion should be considered. By Oshin et al. [4], AIS with limb extension into EIA was selectively performed in cases with a perceived risk of iliac LO based upon either preoperative computed tomography assessment or completion angiography. Routine intravascular ultrasound following stent-graft placement to identify graft limb stenosis [18] and intraoperative 3D rotational angiography [19] can be used to avoid unnecessary AIS. 

Our study had some limitations. First, this is a retrospective study with small sample size. Second, this is not a comparative study between ‘with AIS’ and ‘without AIS’ because AIS was always deployed when stent-graft was extended to EIA. A larger size and a randomized controlled trial would be needed to evaluate the suitability of AIS. 

In conclusion, the installation of AIS after extension of stent-graft to EIA seemed to prevent LO without any procedure-related complications. Primary AIS deployment using 12-mm SES in less tortuous iliac artery should be a good technique to prevent the risk of LO in the Korean population with a small EIA diameter. AIS may be considered as a preventive procedure of LO if stent-graft needs to be extended to EIA during EVAR.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Hobo R, Sybrandy JE, Harris PL, Buth J: EUROSTAR Collaborators. Endovascular repair of abdominal aortic aneurysms with concomitant common iliac artery aneurysm: outcome analysis of the EUROSTAR Experience. J Endovasc Ther 2008; 15:12-22.
2. Armon MP, Wenham PW, Whitaker SC, Gregson RH, Hopkinson BR. Common iliac artery aneurysms in patients with abdominal aortic aneurysms. Eur J Vasc Endovasc Surg 1998;15:255-7.
3. Conway AM, Modarai B, Taylor PR, Carrell TW, Waltham M, Salter R. et al. Stent-graft limb deployment in the external iliac artery increases the risk of limb occlusion following endovascular AAA repair. J Endovasc Ther 2012;19:79-85.
4. Oshin OA, Fisher RK, Williams LA, Brennan JA, Gilling-Smith GL, Vallahbaneni SR. et al. Adjunctive iliac stents reduce the risk of stent-graft limb occlusion following endovascular aneurysm repair with the Zenith stent-graft. J Endovasc Ther 2010;17:108-14.
5. Hobo R, Buth J: EUROSTAR collaborators. Secondary interventions following endovascular abdominal aortic aneurysm repair using current endografts. A EUROSTAR report. J Vasc Surg 2006;43:896-902.
6. EVAR trial participants. Endovascular aneurysm repair versus open repair in patients with abdominal aortic aneurysm (EVAR trial 1): randomised controlled trial. Lancet 2005;365:2179-86.
7. EVAR trial participants. Endovascular aneurysm repair and outcome in patients unfit for open repair of abdominal aortic aneurysm (EVAR trial 2): randomised controlled trial. Lancet 2005;365:2187-92.
8. Prinssen M. Verhoeven EL, Buth J, Cuypers PW, van Sambeek MR, Balm R. et al. A randomized trial comparing conventional and endovascular repair of abdominal aortic aneurysms. N Engl J Med 2004;351:1607-18.
9. Ouriel K, Green RM, Donayre C, Shortell CK, Elliott J, DeWeese JA. An evaluation of new methods of expressing aortic aneurysm size: relationship to rupture. J Vasc Surg 1992;15:12-8.
10. Sivamurthy N, Schneider DB, Reilly LM, Rapp JH, Skovobogatyy H, Chuter TA. Adjunctive primary stenting of Zenith endograft limbs during endovascular abdominal aortic aneurysm repair: implications for limb patency. J Vasc Surg 2006;43:662-70.
11. Shin ES, Garcia-Garcia HM, Okamura T, Wykrzykowska JJ, Gonzalez N, Shen ZJ. et al. Comparison of acute vessel wall injury after self-expanding stent and conventional balloon-expandable stent implantation: a study with optical coherence tomography. J Invasive Cardiol 2010;22:435-9.
12. Dyet JF, Watts WG, Ettles DF, Nicholson AA. Mechanical properties of metallic stents: how do these properties influence the choice of stent for specific lesions? Cardiovasc Intervent Radiol 2000;23:47-54.
13. A comparison of balloon- and self-expanding stents. Minim Invasive Ther Allied Technol 2002;11:173-8.
14. Joh JH, Ahn HJ, Park HC. Reference diameters of the abdominal aorta and iliac arteries in the Korean population. Yonsei Med J 2013;54:48-54.
15. Carroccio A, Faries PL, Morrissey NJ, Teodorescu V, Burks JA, Gravereaux EC. et al. Predicting iliac limb occlusions after bifurcated aortic stent grafting: anatomic and device-related causes. J Vasc Surg
16. Woody JD, Makaroun MS. Endovascular graft limb occlusion. Semin Vasc Surg 2004;17:262-7.

17. Carpenter JP, Neschis DG, Fairman RM, Barker CF, Golden MA, Velazquez OC, et al. Failure of endovascular abdominal aortic aneurysm graft limbs. J Vasc Surg 2001;33:296-302.

18. Amesur NB, Zajko AB, Orons PD, Makaroun MS. Endovascular treatment of iliac limb stenoses or occlusions in 31 patients treated with the ancore endograft. J Vasc Interv Radiol 2000;11:421-8.

19. Nordon IM, Hinchliffe RJ, Malkawi AH, Taylor J, Holt PJ, Morgan R, et al. Validation of DynaCT in the morphological assessment of abdominal aortic aneurysm for endovascular repair. J Endovasc Ther 2010;17:183-9.