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Surgical Infrarenal "Neo-neck" Technique During Elective Conversion after EVAR with Suprarenal Fixation

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WHAT THIS PAPER ADDS

This study demonstrates that preservation of the first covered stent used as a "neo-neck" for proximal anastomosis during surgical conversion for EVAR with suprarenal fixation is feasible and durable. It may represent not only a valid and simple alternative to complete explantation in elective cases, but also as the eventual bailout maneuver in case of emergency.

Objectives: Conversion of a previous endovascular aneurysm repair (EVAR) with suprarenal fixation is a challenging situation even in the elective setting. The outcomes of a technique based on preservation of the first proximal covered stent of the endograft, used as a "neo-neck" for proximal anastomosis, are presented.

Methods: From 2001 to 2014, nine patients underwent elective conversion of a previous suprarenally fixed EVAR. After supraceliac clamping, the aneurysm sac was opened and the endograft identified; the fabric was cut beyond the first covered stent together with its native aortic wall in order to create a "neo-neck." An aortic balloon was inflated into the visceral aorta to avoid back bleeding. A Dacron bifurcated tube graft (Intergard, Maquet) was then sutured to the neo-neck mimicking endobanding, passing the stitches into the aortic wall and the first covered stent.

Results: The mean age was 68 years (range, 52–84 years). The stent grafts removed were four Zenith (Cook Medical), three Endurant (Medtronic), and two E-vita (Jotec). The indication for conversion was type 1A ($n = 2$), type 2 ($n = 2$), and type 3 ($n = 1$) endoleak, complete endograft thrombosis ($n = 2$), and abdominal pain with sac enlargement with no radiological sign of endoleak ($n = 2$). Blood loss was 1,428 mL (range 500–3,000 mL); the visceral ischemic time to perform the proximal anastomosis was 23.5 min $\pm$ 2.3 min). The post-operative complication rate was 11% ($n = 1/9$) related to a case of sac wall bleeding requiring re-intervention; mortality at 30 days was 0%. At 22 months (range, 8–41) the computed tomography angiogram demonstrated no signs of leaks or anastomotic pseudoaneurysm.

Conclusion: Preservation of the proximal covered stent of an endograft with suprarenal fixation used as an infrarenal "neo-neck" with incorporation of the aorta to the suture line during elective surgical explantation simplifies the procedure, and can be achieved with very low early morbidity and mortality; furthermore, it seems to be durable over mid-term follow up.

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INTRODUCTION

Nowadays, endovascular aneurysm repair (EVAR) is a well established technique for abdominal aortic aneurysm (AAA) treatment, and it has been proven to be safe and effective over two decades of experience.[1–6] However, the long-term outcomes may be limited by a higher rate of complications than open repair.

Although many of these complications are successfully addressed by endovascular means, the rate of late open conversion in both emergent and elective settings varies from 0% to 9% depending on different EVAR series.[3,6–8] The risk increases over time.

The overall average mortality rate associated with explantation of an endograft is about 22%,[9] ranging from 3.3% in elective cases to 25–67% in an urgent setting (rupture or infection).[10]

Even if conversion in an elective setting is considered to have low mortality, the procedure is challenging and outcomes are also determined by the reason for conversion,

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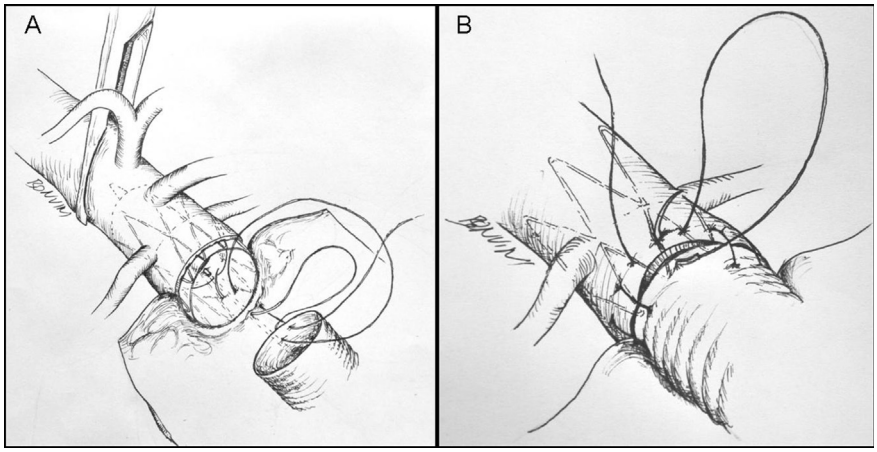

Figure 1. (A) The "neo-neck" (first covered stent and infrarenal aortic wall) used as the site for the proximal anastomosis with the Dacron graft, sutured in an end to end fashion, passing the stitches into the aortic wall and through the first covered stent; the aortic balloon is inflated at the level of the visceral aorta to avoid back bleeding. (B) In all the cases the stitches were passed as deeply as possible into the aorta at the level of the bottom of the fabric covered stent mimicking endobanding.

type of endograft to be explanted (suprarenal or infrarenal fixation), eventual visceral ischemia time, and risk of arterial wall damage after complete removal. Proximal[11] or distal endograft stent preservation where possible has already been described, with a reported peri-operative morbidity rate significantly lower than complete endograft removal (13% vs. 67%).[12]

In particular, in cases of conversion with suprarenal fixation, proximal endograft preservation may be necessary. The suprarenal uncovered stent is often totally incorporated into the aortic wall and attempts to completely remove it may turn the operation into a high risk procedure with increased peri- and post-operative complication rates.

Because of the low number of cases with proximal stent preservation, there are few data on peri-operative results and long-term follow up concerning residual proximal aortic wall neck aneurysmal progression. The early and mid-term outcomes with elective late conversion of AAA stent grafts with suprarenal fixation applying routine preservation of the proximal covered stent used as infrarenal "neo-neck" for proximal anastomosis were reviewed.

MATERIALS AND METHODS

A retrospective review was performed of all consecutive patients admitted to the Clinic of Vascular and Endovascular Surgery of Padova University who had undergone EVAR for infrarenal AAAs between January 2001 and January 2014. Informed consent requirements were waived for this study. Only patients treated for late elective open conversion of suprarenally fixed EVAR devices were included; exclusion criteria were emergent setting, suspicion or evidence of infection, or infrarenal fixation. Late conversion was defined as graft removal >1 month after implantation of an endograft.

From 543 standard EVARs 11 open conversions (2 early; 9 late) were identified; additionally, another seven late open conversions for EVAR cases previously treated at another institution were also performed. Of the 16 late conversions, 12 were elective and four were urgent (3 rupture, 1 infection); of the 12 late elective conversions, only nine were for endografts with suprarenal fixation, and these were included in this study.

Demographics, pre-operative medical and anatomical characteristics, and peri- and post-operative outcomes were analyzed; particular attention was given to the time between EVAR and conversion, intra-operative blood loss, operative time, and visceral ischemia time. Follow up data were obtained by review of the patients' medical records, computed tomography (CT) angiograms, and invasive diagnostic studies. The operative comorbidity risk was evaluated using the Society for Vascular Surgery (SVS) comorbidity grading system[13] and the American Society of Anesthesiologists (ASA) score. Pre-existing renal insufficiency was defined as serum creatinine concentration >1.5 mg/dL.

Surgical technique

Under general anesthesia all patients underwent a midline transperitoneal surgical approach; proximal supraceliac aortic and distal iliac control were identified by standard access. Subsequently, the infrarenal aortic neck up to the level of the lowest renal artery, often characterized by a wide inflammatory response, was identified but not completely dissected. Supraceliac and iliac cross-clamping were performed; the aneurysm sac was opened through a longitudinal arteriotomy with identification of the endograft. The arteriotomy was rapidly extended cranially until the first covered stent of the endograft was visualized; at this point both the aortic wall and the endograft were transected at the level of the fabric between the first and the second covered stents in order to create a "neo-neck." To avoid back bleeding from visceral arteries, a compliant Reliant balloon (Medtronic, Watford, UK) was pre-inserted through a limb of the Dacron graft to be sutured (Intergard Silver, Maquet, Sunderland, UK) coming out from the top of the graft body, and quickly advanced through the "neo-neck" into the visceral aorta and then inflated there.

All the bleeding lumbar arteries were oversewn from inside the sac. The "neo-neck" at this point was used as the site for the proximal anastomosis with the Dacron graft, sutured in an end-to-end fashion, passing the stitches into the aortic wall and through the first covered stent in order to minimize the risk of late dilatation of the residual aortic wall (Fig. 1A). In all cases the stitches were passed as deeply as possible as far as the juxtarenal aorta and through the covered stent mimicking endobanding (Fig. 1B). Once the proximal anastomosis was completed the Reliant balloon was deflated and removed, and the clamp moved from the supraceliac aorta to the infrarenal Dacron graft body. The bifurcated tube graft was sewn distally at iliac level according to the individual anatomic morphology and surgeon preference. The external and internal iliac vessels were dissected and controlled; when the graft was well incorporated into the vessel wall the distal portion of the stent was preserved.

Post-operatively the patient was routinely observed for the first 24 hours in the ICU (Intensive Care Unit) and when appropriate transferred to the Vascular Unit. Follow up consisted of a CT scan performed before discharge, at 6 months, and annually thereafter. Fig. 2A—C shows the results of the CT angiogram for the three different types of endograft.

RESULTS

Of the nine patients treated for late elective conversion after EVAR with suprarenal fixation, the stent-grafts were four (44%) Zenith (Cook Medical, Bloomington, IN, USA), three (33%) Endurant (Medtronic), and two E-vita (Jotec, Hechingen, Germany). The average time from EVAR to conversion was 57 months (range, 5—119 months) with five out of nine patients (56%) having already undergone a previous failed secondary endovascular re-interventions. The mean number of previous endovascular attempts was 2.2 (range 0—4).

The mean age was 68 years (range, 52—84), with eight men and one woman. Associated medical comorbidities included coronary artery disease ($n = 4$, 44%), hypertension ($n = 9$, 100%), hypercholesterolemia ($n = 4$, 44%), diabetes mellitus ($n = 2$; 22%), and mild renal insufficiency ($n = 1$, 11%); one patient had previously undergone heart transplantation. The mean SVS total score was 0.9 $\pm$ 0.4, while the mean ASA score was 2.8 $\pm$ 0.5.

Indications for conversion are described in Table 1. In particular two patients with type 1A endoleak and no graft migration were not fit for endovascular repair and underwent surgical conversion because of proximal aneurysmal development (1 case) and insufficient oversizing (1 case); both cases presented intra-operatively with an aneurysmal aortic neck wall (34 mm and 32 mm maximum diameter). Two cases were due to persistent type 2 endoleaks with sac enlargement after unsuccessful secondary endovascular re-intervention; in these cases the decision for a complete explantation was due, in one case to the young age of the patient (52 years), and in one case because safe suture of the lumbar arteries could not be guaranteed without endograft explantation. One patient had a type 3 endoleak and had already undergone an unsuccessful endovascular attempt at iliac relining. Complete endograft thrombosis occurred in two patients. Two patients were treated for continuous sac enlargement with no clear evidence of leakage.

Overall the intra-operative findings corresponded with the pre-operative CT angiogram imaging in six of the nine cases (67%), while in the remaining three other associated endoleak types were present.

The mean operative time was 232 minutes (range 165—330 minutes), with an estimated intra-operative blood loss of 1.4 L (range, 500—3000). The mean visceral ischemic time was 23.5 minutes (range, 21.2—25.8); in all cases hemostasis of the proximal anastomosis at the time of reperfusion was adequate with no need for additional stitches or anastomotic reinforcement maneuver. No peri- or post-operative deaths were registered; there were no observed cases of major cardiac, renal, or pulmonary complications. One patient underwent surgical revision at 24 hours because of chronic bleeding from the sac wall.

Minor complications included one case with slightly elevated pancreatic enzymes which resolved spontaneously with diet and medical therapy, three cases with ventilator dependence for more than 24 hours, and one case of bacteremia on blood culture with fever that resolved after 2 weeks of antibiotic therapy. Two cases (1 pre-existing moderate renal insufficiency; creatinine 1.58 mg/dL) developed post-operative worsening renal function (>2.0 mg/dL) that was resolved within 2 weeks after medical therapy.

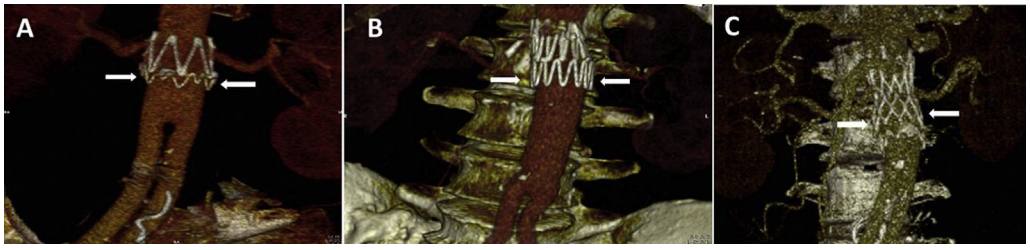

Figure 2. Three dimensional reconstruction of abdominal computed tomography angiogram performed during follow up after late open conversion for failed EVAR in three different endografts with suprarenal fixation. White arrows indicate the site of hybrid proximal anastomosis. (A) Endurant II; (B) Zenith Flex; (C) Zenith Low Profile.

Table 1. Indications and operative characteristics of the nine patients who underwent late elective open conversion for suprarenally fixed EVAR treated with the surgical infrarenal "neo-neck" technique.

Pts	Indication	Time to conversion (months)	Endograft explanted	Operative time (min)	Blood loss (mL)	Visceral ischemia time (min)	Follow up (months)/complications
1	E. type 1A	35	Zenith Flex	255 (PL)	1,000	26	(41)/—
2	E. type 1A	119	Endurant	165	2,000	23	(18)/—
3	E. type 2	29	E-vita	300 (RF)	3,000	26	(6)/—
4	E. type 2	110	E-vita	180	500	25	(13)/—
5	E. type 3	32	Zenith Flex	180	500	22	(8)/—
6	Thrombosis	5	Zenith LP	260 (RF)	1,500	25	(27)/—
7	Thrombosis	80	Endurant II	330 (PL)	2,300	20	(3)/—
8	Sac enlargement	58	Zenith Flex	190	800	21	(41)/—
9	Sac enlargement	56	Endurant	220	1,500	23	(41)/—

PL = previous laparotomy with lysis of adhesions; RF = retroperitoneal fibrosis.

ICU stay averaged 4 days (1—16) and hospital length of stay averaged 11 days (range, 7—23 days). The CT scan performed before discharge demonstrated complete aneurysm exclusion with no signs of leakage or pseudoaneurysm at the level of the proximal anastomosis with graft patency in all cases.

At an average follow up of 22 months (range, 8—41 months), the CT angiogram demonstrated that the proximal anastomosis was intact with no degeneration of the residual infrarenal aortic neck and no signs of anastomotic pseudoaneurysm. No residual type II endoleaks were identified.

DISCUSSION

Late open conversion after previous EVAR is primarily performed in an elective setting. Even if this type of intervention represents a challenging situation for the surgeon, the overall elective 30 day mortality is low in most of the reported series in the literature (0 to <10%). Recently, Scali et al.[14] published their experience comparing open elective conversion for type 1A endoleak and primary open repair of juxtarenal aneurysm; in their conclusions there were no differences in the 30 day mortality rates between the two groups (4% for both; $p = 1$). Mortality in this series at 30 days was 0% in line with that observed in the literature review,[12,15—25] where the overall 30 day mortality after explantation was very low (<2%), with no significant difference when comparing total versus partial explantation. However, of the 107 reported elective explantations with suprarenal fixation, the only two deaths occurred in those who had complete proximal explantation. Previous experiences with endograft removal have led to a wide variety of techniques helpful for stent graft explantation. May et al.[11] used metal cutters to remove suprarenally fixed stent grafts; Kong et al.[26] described a technique where the proximal fixation was compressed inside the barrel of a 20 mL syringe and subsequently removed; iced saline can be placed on nitinol elements to help collapse the metal to the pre-deployment state and facilitate removal from the arterial wall. All these maneuvers are valid but might be risky if the metal stent is completely incorporated in the reactive intimal tissue, and aortic wall damage may occur during any attempt at complete explantation. This aspect raises more concern in cases with suprarenal fixation.

Even if complete explantation is recommended, hybrid reconstruction is accepted as long as the endograft portion left in situ is not the cause of the failed EVAR. The preservation of the first proximal covered stent has already been reported for explantation of EVAR with both infrarenal[27] and suprarenal fixation[24]; however, its use is limited to cases with preserved proximal sealing by the endograft. Usually the hybrid repair of the aortic neck is based on two different approaches: one is to leave the incorporated uncovered stent only, cutting the graft between the uncovered and the covered stent and completing the surgical suture in the juxtarenal aortic wall; the second option, which is only possible in cases with no type IA endoleak, is to leave the first and/or the second covered stent and use the fabric alone or with the aortic wall as an attachment site for surgical anastomosis.

The concept of a "neo-neck" was useful in our experience, not only to reduce as much as possible the risk of complications related to aortic wall damage, blood loss, and visceral ischemia, but also as a simple solution for type 1A endoleak repair, using the proximal covered stent as the site for aortic wall fixation in an endobanding prosthetic reinforcement for a juxtarenal surgical anastomosis.

The overall operative time was high (232 minutes) in our experience, with a wide range (165—330 minutes). This is not based on proximal anastomosis management but primarily on the time needed for dissection in cases of relaparotomy or retroperitoneal fibrosis ($n = 4/9$; 44%) and distal iliac reconstruction. Similarly, the literature shows that open conversion after EVAR has significantly longer operative times than primary AAA open repair ($p = .03$).[14]

On the other hand, the time needed to complete the proximal anastomosis was a mean of 23 minutes, and no complications related to visceral ischemia were observed within 30 days. Clamp time in this experience was lower than the 43 minutes reported by the large Cleveland Clinic[10] report, where interventions for conversion with suprarenal fixation required significantly longer mean visceral ischemia than those with infrarenal fixation (43 vs. 28 min; $p = .039$).

Mean blood loss was lower than in the literature[10,15,19,23] (1,428 L vs. 4,078 L), which may also be due to the tactic

adopted; in a standard juxtarenal anastomosis, if required as is often the case, a balloon must be placed at the level of the visceral arteries but cannot prevent back bleeding from the renals because a minimum space is needed for stitching of the proximal anastomosis. In the approach reported here, the presence of the first covered stent, guarantees 1 or 2 cm (depending on the endograft type) of infrarenal free "neo-neck," and the balloon can be inflated from visceral level down to the level of the lowest renal artery with no back bleeding and no cumbersome maneuvers needed for the sutured anastomosis. Another option to avoid back bleeding could be to directly clamp the infrarenal neck and the stent graft together; this maneuver is avoided because of the needs completely dissect the infrarenal neck which may be involved in an inflammatory process; furthermore, with infrarenal clamping the stent may be crushed and the posterior suture may be difficult. Overall, the early complication rate was 11% (1 of 9 cases), and this was not related to proximal anastomosis management but to persistent sac bleeding; unfortunately, the literature does not provide clear data in this regard for comparison purposes.

The major concern regarding the use of a transected endograft as a part of the anastomosis concerns future pseudoaneurysm of the residual diseased aortic wall.

In 2003, Lipsitz et al.[12] reported a series of seven patients who underwent partial resection with hybrid reconstruction (proximal or distal iliac site) and no anastomotic complications at 22 months follow up. These findings are similar to our results where no mid-term (22 months) proximal anastomotic complications were identified in any of the nine cases, including those treated for type IA endoleak.

In the authors' view, this technique is simple, and, in addition to being routinely used for elective cases, may also represent a valid bailout approach in emergent cases presenting with rupture.

This study has some limitations that are worthy of mention. It was a retrospective observational study, with a small number of cases. The literature review is limited by the fact that the vast majority of reports do not clearly define the technique utilized in hybrid proximal stent preservation; furthermore, some fundamental information such as operative and post-operative outcomes and early mortality are not well stratified by the reason for conversion.

However, the accurate selection of the patients analyzed and the standardized technique validate the feasibility of this approach. Finally, an overview with sufficient baseline outcomes with which to compare the results is provided.

Preserving the proximal covered stent of an endograft with suprarenal fixation and incorporating the aorta to the suture line during elective surgical explantation simplifies the procedure, and can be achieved with very low early morbidity and mortality; furthermore, it seems to be durable over mid-term follow up.

CONFLICT OF INTEREST

None.

FUNDING

None.

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