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Target Vessel Cannulation with a Transfemoral Retrograde Approach Equals Antegrade Approach from the Upper Extremity in Complex Aortic Treatment with Off the Shelf Inner Branched Endografts in the Italian Branched Registry of E-nside Endograft (INBREED)☆

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WHAT THIS PAPER ADDS

In this multicentre experience involving 166 procedures, the retrograde transfemoral approach to target vessel (TV) cannulation in the endovascular treatment of aortic pathologies using the E-nside endograft showed satisfactory effectiveness in achieving TV cannulation and allowing bridging stent deployment compared with the antegrade approach from the upper extremity. Additionally, it ensured no post-operative neurological events by avoiding manipulation of the aortic arch.

Objective: The aim of this study was to assess the results of an off the shelf inner branched thoraco-abdominal endograft for treating aortic pathologies, with a specific focus on comparing outcomes between antegrade and retrograde approaches for target vessel (TV) cannulation.

Methods: This was a national, physician initiated, multicentre, observational study. Data from a registry on patients treated with the E-nside endograft were gathered prospectively. Patients were divided into two groups based on the type of endovascular approach for TV cannulation. The study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Results: From September 2020 to February 2024, 166 procedures were collected, of which 128 (77.1%) used an antegrade upper extremity approach to TV cannulation, while 38 (22.9%) employed a retrograde femoral approach. There were no statistically significant differences in terms of bridging stent choice (balloon expandable only, 69.4% *vs.* 73.7%; self expandable only, 12.9% *vs.* 7.9%; mixed configurations, 17.7% *vs.* 18.4%; $p = .68$). The mean operation time $\pm$ standard deviation was longer for the retrograde approach (282 $\pm$ 90 minutes *vs.* 313 $\pm$ 155 minutes; $p = .006$), but fluoroscopy time, dose area product, and the volume of contrast injected were similar. Six cases of post-operative stroke were reported in the antegrade group (4.7% *vs.* 0%; $p = .17$). The 30 day TV related technical success was 94.5% and 94.7%, respectively, for antegrade and retrograde approaches ($p = .96$). Mean follow up was 14.4 $\pm$ 11.3 months (median 12.5 months). Kaplan—Meier estimates (with 95% confidence interval [CI]) at twelve months revealed similar overall survival (87.7%, 95% CI 81 — 95% *vs.* 91.1%, 95% CI 82 — 100%; log rank = .009, $p = .92$). Competing risk analysis revealed similar one year estimates of TV instability and TV related re-intervention between groups both in patient centred and TV centred analyses.

† A complete list of the INBREED Investigators is included in Appendix A.

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Conclusion: A total transfemoral retrograde approach for TV cannulation of inner branches proved to be effective and was not associated with any neurological events.

Keywords: Aortic dissection, Branched endovascular aortic repair, Endoleak, Patency, Target vessel, Thoraco-abdominal aortic aneurysm
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INTRODUCTION

In recent years, considerable progress has been achieved in the field of endovascular treatment for extensive aortic pathologies, encompassing complex conditions such as aortic dissection and degenerative aneurysms. The outcomes of these advances have demonstrated immediate and short term effectiveness in reducing early deaths compared with open surgery.[1] However, in the long term, the frequent need for re-interventions remains a limitation, although these are most often endovascular.[2]

The minimally invasive nature of fenestrated and branched endovascular repair (FB-EVAR) also allows for a reduction in the systemic impact that open surgery may impose on patients.[3–5]

Despite this, endovascular intervention is not without significant risks of peri-operative systemic complications.[6] Therefore, in line with reducing periprocedural complications, another goal should be to adopt new materials and techniques aimed at further decreasing such occurrences.

A critical procedure related complication is the occurrence of cerebrovascular events that may result from aortic manipulation during the upper extremity target vessel (TV) approach.[7] In fact, data from the Vascular Quality Initiative (VQI) dataset indicated a 2.9% rate of post-operative cerebrovascular accidents among 837 upper extremity access FB-EVAR procedures.[8]

Implementation of steerable sheaths, facilitating the replication of an upper extremity approach through a complete transfemoral approach, has the potential to reduce cerebrovascular risks for the patient by minimising manipulation of the arch vessels.

The aim of this study was to evaluate the outcomes of an off the shelf inner branched thoraco-abdominal endograft (E-nside; Artivion, Kennesaw, GA, USA) for aortic pathologies by comparing the treatment results between antegrade (upper extremity) and retrograde (transfemoral) approaches for TV cannulation.

MATERIALS AND METHODS

Study design

Data from an ongoing national multicentre registry focusing on patients treated with the E-nside endograft were prospectively gathered in the ItaliaN Branched Registry of E-nside EnDograft (INBREED). The characteristics of the registry have previously been described.[9–11] It is a physician initiated, non-sponsored, prospective observational cohort registry involving 37 hospitals including both academic and community facilities across Italy. Patient recruitment began in September 2020 and is ongoing. For the purpose of this study, data were extracted on 11 October 2024. Data are collected on an online platform, with one centre appointed to be responsible for maintaining the raw data and organising regular meetings to improve data review and follow up updates. Institutional review board and ethics committee approval were obtained (Ethic Committee for Clinical Experimentation, Padova: study ID 21175), and each patient signed written consent for surgical treatment and pseudonymised data use. The checklist of items followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[12]

Demographics, clinical characteristics, and operative and follow up data were collected. The procedures were conducted in accordance with national and international guidelines, and definitions adhered to established reporting standards.[13–18] Disease extent and anatomical characteristics were assessed on pre-operative computed tomography angiography (CTA). Thrombosis involving $>50\%$ of the vessel wall circumference was documented across several anatomical regions on CTA images, including the subclavian artery, aortic arch, proximal and distal segments of the descending aorta, and perivisceral aorta. A post-operative CTA was obtained within one month of the index procedure. Follow up assessments were conducted at the discretion of each participating centre and were collected using imaging, in person consultations, medical records, and/or telephone interviews.

Target vessel approaches

The choice of approach type for TV cannulation was left to the discretion of each operator.

To facilitate an antegrade (upper extremity) approach, the E-nside endograft is equipped with a dedicated precannulated tube for each branch cuff. These tubes can be loaded with an 0.018" non-hydrophilic wire either before or after deployment of the proximal end of the main graft. Following deployment, each individual guidewire can be advanced over the tube, extending beyond the top of the graft and into the descending thoracic aorta, where it can be snared one at a time. Subsequently, the tube can be removed, and the respective branch and TV can be sequentially bridged. Once this process is complete, the wire can be removed.

For a retrograde (total transfemoral) approach, the precannulated system is unnecessary, and the tubes are removed beforehand. Instead, a steerable sheath is used to aid in the cannulation of branches and TVs (Fig. 1). A 16 F introducer DrySeal (Gore & Associates, Inc., Newark, DE,

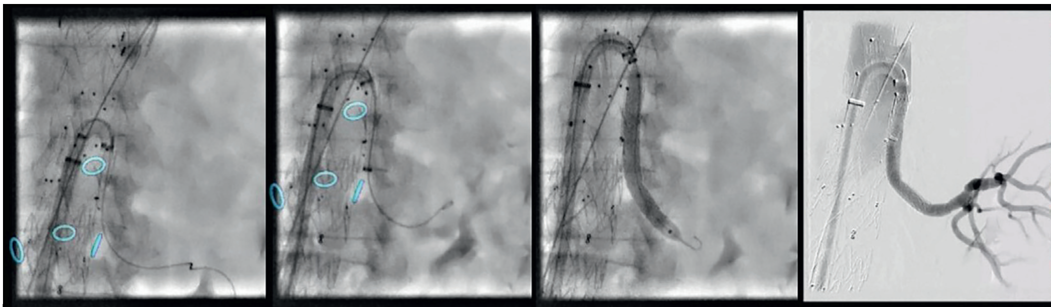


Figure 1. Intra-operative details of total transfemoral retrograde approach for target vessel cannulation with the E-nside endoprosthesis.

USA) is advanced into the branched endograft from the ipsilateral side, followed by the coaxial placement of a 22 mm Heli FX steerable sheath (Medtronic, Santa Rosa, CA, USA) and an 8 F, 90 cm introducer sheath: Destination (Terumo Corporation, Tokyo, Japan) or ANL (Cook Medical, Bloomington, IN, USA). The steerable sheath is rotated and tilted to reach the working position, and the inner branch is cannulated using a 125 cm long supporting catheter with a standard 260 cm Terumo wire. Once the TV is engaged, the introducer sheath is advanced to the origin of the TV to stabilise the system and increase support for the bridging stent. The Terumo wire is exchanged for a Rosen guidewire (Cook Medical, Bloomington, IN, USA), and the covered stent is advanced into the TV and inflated.

As an alternative, the pre-cannulated wires can be preserved and snared from the contralateral femoral access to facilitate access to TVs from below.

For a retrograde transfemoral TV approach, the patient is positioned with their arms elevated above their head to help minimise radiation exposure during the procedure. This position allows better access and visualisation, while reducing the radiation dose to critical areas of the body.

Endpoints and definitions

The primary endpoints were in hospital complications, in hospital death, intra-operative TV related technical success, and 30 day TV related technical success.

In hospital complications followed the definitions of the Society for Vascular Surgery (SVS) reporting standards.[17,18]

Target vessel related technical success was defined as successful catheterisation of the intended TV, placement of bridging stents, absence of TV related endoleaks (type Ic, IIIb, and IIIc), and patency of all intended side branch components.[17]

Secondary endpoints were estimated follow up overall survival, patient centred and TV centred follow up estimates of the incidence of TV instability, and patient centred and TV centred follow up estimates of the incidence of TV related re-intervention.

The follow up estimates of the incidence of TV instability and TV related re-intervention were also distinguished between renal and visceral (coeliac trunk and superior mesenteric artery) arteries cannulated with an antegrade or retrograde approach.

Target vessel instability was defined as a composite endpoint of any branch related complication leading to aneurysm rupture, death, occlusion, component separation, or re-intervention to maintain branch patency or to treat a branch related component separation or endoleak.[17,19]

Statistical analysis

Statistical analyses were performed with IBM SPSS Statistics Version 25.0 (IBM Corp., Armonk, NY, USA) and R statistical software (R Foundation for Statistical Computing, Vienna, Austria). Statistical and data reporting followed established guidelines and recommendations.[20] Continuous variables were tested for normality with the Shapiro—Wilk test and visual evaluation of quantile—quantile (Q-Q) plots; variables were presented as mean $\pm$ standard deviation if normally distributed, otherwise as median and interquartile range (IQR). Categorical variables were presented as frequencies and percentages. Quantitative variables were compared through one way analysis of variance (ANOVA), Mann—Whitney *U* test, or Student's *t* test, and qualitative variables through Pearson's χ^2 test.

The follow up index (FUI) was used to assess the completeness of follow up data. The FUI was defined as the proportion of potential follow up time actually achieved for each patient, relative to the time from surgery to the study endpoints. The overall FUI, representing the period from surgery to the data extraction date (11 October 2024), was calculated alongside the FUI for the specific one month and twelve month follow up points. Patients who did not undergo any follow up were included in the FUI calculation as contributing zero follow up time. Baseline characteristics of these patients were compared with those with follow up data to assess potential differences and bias. Patients who died during the follow up period were considered to have complete follow up to the time of death, as further follow up was not possible. Comparison of FUIs between groups was conducted to assess whether group allocation influenced the completeness of follow up data.

The rates of in hospital complications, in hospital death, intra-operative TV related technical success, and 30 day TV related technical success were compared using Pearson's χ^2 test.

The Kaplan–Meier method was used to evaluate overall survival, and the estimates were compared with the log rank test. To estimate the incidence of TV instability and TV related re-intervention during follow up, a cumulative incidence function via the proportional subdistribution hazards model was used, as death could have precluded the occurrence of TV related outcomes in the competing risks data, and the outcomes between groups were compared with the Gray's test. The 95% confidence interval (CI) was calculated for all estimates. A p value of $<.050$ was considered statistically significant.

RESULTS

Study group

From September 2020 to February 2024, a total of 166 procedures were collected from 37 Italian institutions. At 21 (57%) of the 37 institutions, three or more procedures were performed during the study period (range 1 – 19). Supplementary Figures S1 and S2 illustrate the distribution of procedures across centres and over the study period. Of the 166 procedures, 128 (77.1%) used a TV cannulation with an antegrade approach, while 38 (22.9%) employed a retrograde approach. The total number of cannulated TVs was 642, with 495 (77.1%) accessed via an antegrade approach and 147 (22.9%) via a retrograde transfemoral approach. The mean age at surgery was 73.4 ± 7.9 years and 71.7% of patients were male, with no differences between the two groups. Of the total cohort, 34 patients (20.5%) were treated in emergency or urgent situations (18.8% *vs.* 26.3%; $p = .31$). The decision not to use the preloaded system for TV cannulation was consistently based on surgeon preference and never due to unsuccessful attempts at cannulation from above. The two groups were similar in terms of demographics and anatomical characteristics. The mean minimum iliac artery diameter on the side of the main graft insertion was similar between groups (8.8 ± 1.9 mm *vs.* 8.9 ± 2 mm; $p = .60$). The proportion of patients with thrombosis affecting $>50\%$ of the vessel wall circumference in any of the analysed anatomical regions was similar between the two groups (50% *vs.* 63.2%; $p = .15$). However, patients in the antegrade group were more likely to present with chronic kidney disease ($p = .017$) and to be treated for degenerative rather than post-dissection aneurysm ($p = .007$) and for a complex abdominal aortic aneurysm (juxtarenal, pararenal, or extent IV thoraco-abdominal) rather than more extensive thoraco-abdominal pathology ($p = .011$). Regarding TV related anatomical characteristics, there were no differences between the two groups in terms of pre-operative visceral vessel stenosis; however, the coeliac trunk and the left renal artery had a wider mean diameter in the retrograde approach group. Details are shown in Supplementary Tables S1 and S2.

Prophylactic spinal drainage was positioned preoperatively in 53 cases, with 42 in the antegrade approach group and 11 in the retrograde approach group (32.8% *vs.* 28.9% of cases; $p = .65$), respectively. The endovascular procedure was predominantly performed via bilateral percutaneous femoral access in both groups (49.2% of cases in the antegrade approach group and 60.5% in the retrograde approach group; $p = .22$). For antegrade TV approach cases, a left upper arm approach was preferred over a right sided approach (92/128; 71.9%).

Intra-operative outcomes

No intra-operative conversion from either retrograde to antegrade or antegrade to retrograde to address potential difficulties in TV cannulation was registered. Balloon expandable stents were preferentially used in the entire cohort (475 cases out of 642 TVs; 73.9%). Of 642 TVs, 18 (2.8%) were intentionally occluded, including ten coeliac trunks (two in the retrograde TV approach group) and eight renal arteries (two in the retrograde TV approach group). There were no statistically significant differences observed in terms of bridging stent choice between the two groups. Specifically, the proportions of cases using balloon expandable stents alone (69.4% *vs.* 73.7%), self expandable stents alone (12.9% *vs.* 7.9%), or mixed configurations combining both types of stents (17.7% *vs.* 18.4%) were similar ($p = .68$). The specifics regarding bridging stent selection among TVs are outlined in Supplementary Table S3. On completion angiography, a type Ic , IIIb, or IIIc endoleak was observed in 15 procedures, necessitating the placement of an additional bridging stent. Of these, 11 were in the antegrade approach group and four in the retrograde group (8.6% *vs.* 10.5%; $p = .72$). The intra-operative TV related technical success was 97.6% (three cases of failure in the antegrade approach group and one in the retrograde approach group; 97.7% *vs.* 97.4%; $p = .92$); the reasons for TV related technical failure were three cases of failed attempts to cannulate a TV owing to endograft dislocation (one coeliac trunk and one left renal artery in the antegrade approach group; one coeliac trunk in the retrograde approach group) and one case of intra-operative TV dissection and occlusion in the antegrade approach group (intra-operative coeliac trunk dissection following cannulation and bridging stent deployment, which was found to be occluded on completion angiography). The mean operation time was longer for the retrograde approach (282 ± 90 minutes *vs.* 313 ± 155 minutes; $p = .006$), but the fluoroscopy time (96.8 ± 40.9 minutes *vs.* 104.6 ± 59.6 minutes; $p = .20$), dose area product (DAP) (424.1 ± 244.8 Gy cm^2 *vs.* 387.2 ± 245.2 Gy cm^2; $p = .64$), and contrast volume injected (196.7 ± 103.9 mL *vs.* 215.6 ± 148 mL; $p = .15$) were similar.

In hospital outcomes

The in hospital mortality rate was 5.4%, with seven deaths recorded in the antegrade approach group and two in the retrograde group (5.5% *vs.* 5.3%; $p = .96$). No statistically significant differences were observed between the two groups in terms of in hospital systemic complications (Table 1). However, six cases of post-operative stroke were reported in the antegrade group (4.7% *vs.* 0%; $p = .17$).

Table 1. Details of in hospital systemic complications in the total cohort (n = 166) and in patients undergoing an antegrade (n = 128) or retrograde (n = 38) approach for target vessel cannulation in the endovascular treatment of aortic pathologies using the E-nside endograft.

Complication	Total cohort (n = 166)	Antegrade approach (n = 128)	Retrograde approach (n = 38)	p value
Heart failure	2 (1.2)	2 (1.6)	0 (0)	.44
Respiratory failure	13 (7.8)	8 (6.3)	5 (13.2)	.16
Stroke	6 (3.6)	6 (4.7)	0 (0)	.17
Spinal cord ischaemia	16 (9.6)	14 (10.9)	2 (5.3)	.30
Acute kidney injury	18 (10.8)	13 (10.2)	5 (13.2)	.60
Mesenteric ischaemia	3 (1.8)	3 (2.3)	0 (0)	.34
Overall systemic complications	48 (28.9)	38 (29.7)	10 (26.3)	.69

Data are presented as n (%).

Among these, five were of ischaemic origin (four posterior and one anterior), while the remaining case was a haemorrhagic anterior stroke; in all cases except one, a left sided upper arm approach was used. Three of six patients had no significant thrombus load in any aortic region or subclavian artery, while one patient had thrombosis involving $>50\%$ of the vessel wall circumference in the paravisceral abdominal aortic segment and two in the distal region of the descending aorta. Supplementary Table S4 provides additional details on the six stroke cases recorded in the antegrade TV approach group. The spinal cord ischaemia rate was 9.6%; of the 16 spinal cord related events recorded, two were observed in the retrograde approach group (10.9% *vs.* 5.3%; $p = .30$). Partial or complete peri-operative recovery from symptoms related to spinal cord ischaemia was observed in 75% of cases. The median length of hospital stay did not differ between the two groups, being nine days (IQR 5, 16) in the antegrade group and eight (IQR 5, 17) in the retrograde group ($p = .83$).

Early outcomes and follow up

Thirty eight patients (22.9%) did not participate in any follow up, 32 (25.0%) in the antegrade group and six (15.8%) in the retrograde group ($p = .24$), while all remaining patients underwent at least the one month CTA. There were no statistically significant differences in baseline characteristics between patients who underwent follow up and those who did not (Supplementary Table S5). Mean follow up was 14.4 $\pm$ 11.3 months (median 12.5 months) and did not statistically significantly differ between groups (13.6 $\pm$ 11.6 months *vs.* 16.8 $\pm$ 10.4 months; $p = .26$). The mean overall FUI was 0.38 $\pm$ 0.37. In the antegrade group, the mean overall FUI was 0.34 $\pm$ 0.37, while in the retrograde group it was 0.52 $\pm$ 0.38, with no statistically significant differences between groups ($p = .80$).

At one month, the mean FUI was 0.76 $\pm$ 0.43, with no statistically significant differences between groups (antegrade 0.74 $\pm$ 0.44 *vs.* retrograde 0.83 $\pm$ 0.38; $p = .055$). The 30 day TV related technical success rate was 94.5% and 94.7% for the antegrade and retrograde approaches, respectively ($p = .96$); specifically, seven cases of branch occlusion were reported in the antegrade group (three of which occurred intra-operatively) and two in the retrograde one (one of which occurred intra-operatively).

The mean twelve month FUI was 0.55 $\pm$ 0.43, with no statistically significant differences between groups (antegrade 0.51 $\pm$ 0.43 *vs.* retrograde 0.69 $\pm$ 0.43; $p = .99$). Kaplan–Meier estimates at twelve months revealed similar overall survival (87.7%, 95% CI 81 – 95% *vs.* 91.1%, 95% CI 82 – 100%; log rank = .009, p = .92) between the two groups (Fig. 2).

In the patient centred analysis of the 166 procedures performed, the cumulative incidence using competing risk analysis of TV instability estimated at one year was 17% in both the antegrade (95% CI 10 – 25%) and retrograde (95% CI 5.9 – 33%) groups ($p = .80$), while the one year estimate of the cumulative incidence of TV related re-intervention was 7.4% (95% CI 3.2 – 14%) in the antegrade group and

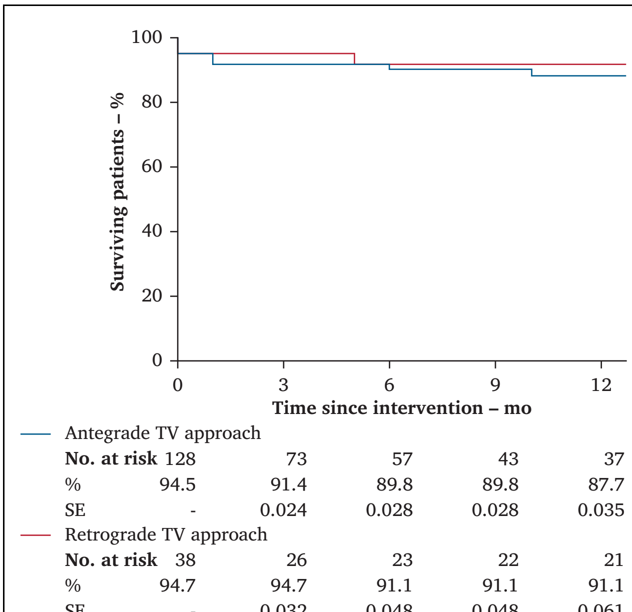


Figure 2. Cumulative Kaplan–Meier estimate of overall survival between patients undergoing an antegrade or retrograde approach for target vessel (TV) cannulation. Standard error (SE) $<$ 10%.

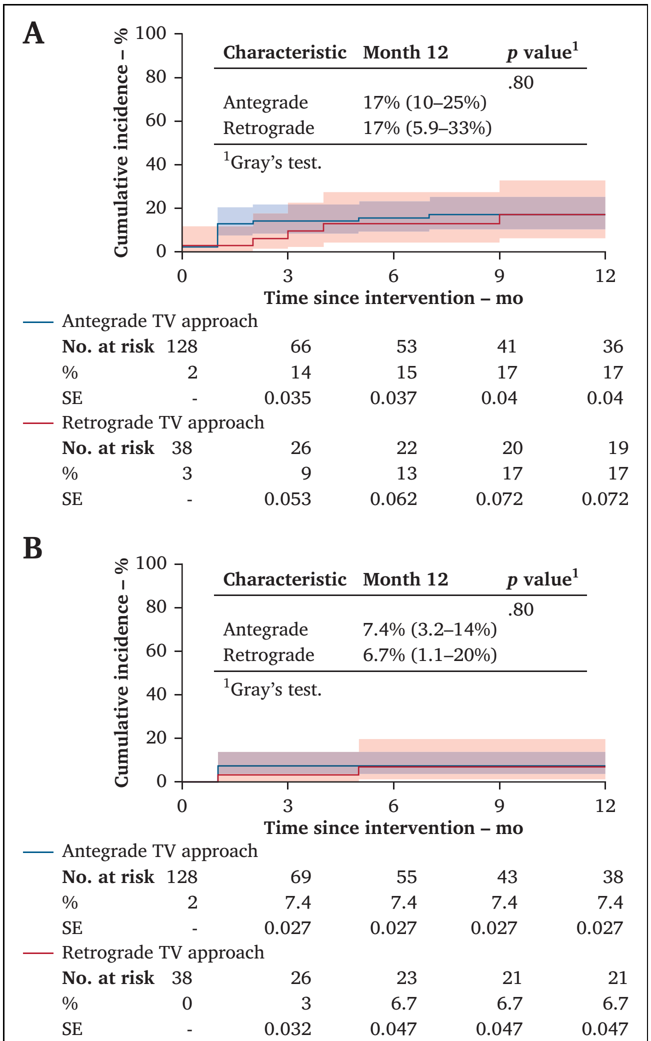


Figure 3. Estimates of the cumulative incidence of (A) target vessel (TV) instability (B) and TV related re-intervention at competing risk patient centred analysis between antegrade and retrograde approaches for TV cannulation. Standard error (SE) < 10%.

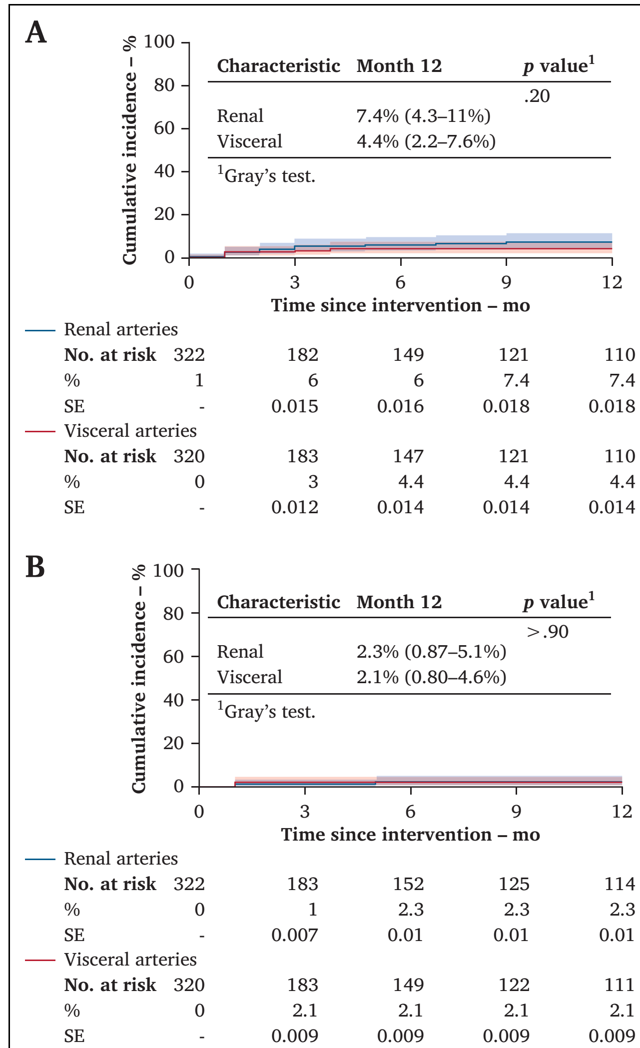
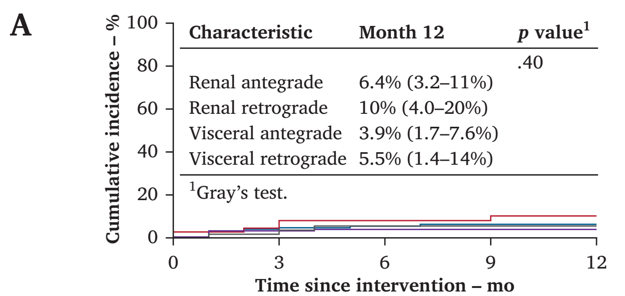


Figure 4. Estimates of the cumulative incidence of (A) target vessel (TV) instability and (B) TV related re-intervention at competing risk TV centred analysis between renal and visceral (coeliac trunk and superior mesenteric artery) arteries. Standard error (SE) < 10%.

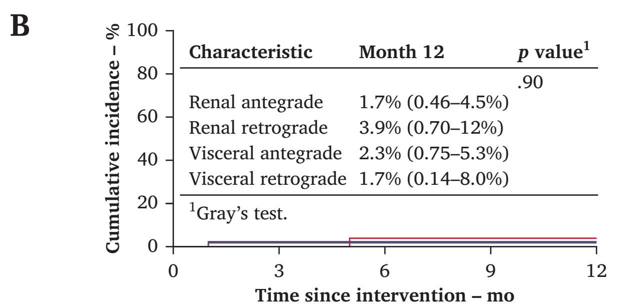
6.7% (95% CI 1.1 — 20%) in the retrograde group (p = .80) (Fig. 3). In the TV centred analysis of the 642 cannulated TVs, the cumulative incidence of TV instability estimated at one year was 5.1% (95% CI 3.1 — 8%) in the antegrade group and 7.9% (95% CI 3.8 — 14%) in the retrograde group (p = .30), while the one year estimate of the cumulative incidence of TV related re-intervention was 2% (95% CI 0.9 — 3.8%) in the antegrade group and 2.8% (95% CI 0.7 — 7.3%) in the retrograde group (p = .80) (Supplementary Fig. S3). When comparing the renal and visceral arteries, the estimates of one year cumulative incidence of TV instability (7.4%, 95% CI 4.3 — 11% *vs.* 4.4%, 95% CI 2.2 — 7.6%; p = .20) and TV related re-intervention (2.3%, 95% CI 0.9 — 5.1% *vs.* 2.1%, 95% CI 0.8 — 4.6%; p > .90) were similar (Fig. 4). The estimated one year cumulative incidence of TV instability and TV related re-intervention showed no statistically significant differences between groups when stratifying by antegrade and retrograde TV approaches, specifically comparing renal and visceral arteries (TV instability, renal arteries with antegrade approach 6.4%, 95% CI 3.2 — 11% *vs.* renal arteries with retrograde approach 10%, 95% CI 4 — 20% *vs.* visceral arteries with antegrade approach 3.9%, 95% CI 1.7 — 7.6% *vs.* visceral arteries with retrograde approach 5.5%, 95% CI 1.4 — 14%; p = .40; TV related re-intervention, renal arteries with antegrade approach 1.7%, 95% CI 0.5 — 4.5% *vs.* renal arteries with retrograde approach 3.9%, 95% CI 0.7 — 12% *vs.* visceral arteries with antegrade approach 2.3%, 95% CI 0.8 — 5.3% *vs.* visceral arteries with retrograde approach 1.7%, 95% CI 0.1 — 8%; p = .90) (Fig. 5).

DISCUSSION

This study demonstrated the effectiveness of the total transfemoral approach with retrograde cannulation of the TVs to achieve complete endovascular exclusion of complex thoraco-abdominal pathologies with an inner branched



	0	3	6	9	12
Renal artery antegrade approach					
No. at risk	249	132	105	81	71
%	0	5	5	6.4	6.4
SE	-	0.016	0.018	0.02	0.02
Renal artery retrograde approach					
No. at risk	73	50	44	40	39
%	3	8	8	10	10
SE	-	0.035	0.035	0.041	0.041
Visceral artery antegrade approach					
No. at risk	246	134	106	83	72
%	0	3	3.9	3.9	3.9
SE	-	0.013	0.015	0.015	0.015
Visceral artery retrograde approach					
No. at risk	74	49	41	38	38
%	0	4	5.5	5.5	5.5
SE	-	0.025	0.031	0.031	0.031



	0	3	6	9	12
Renal artery antegrade approach					
No. at risk	249	134	107	84	73
%	0	1.7	1.7	1.7	1.7
SE	-	0.01	0.01	0.01	0.01
Renal artery retrograde approach					
No. at risk	73	49	45	41	41
%	0	0	3.9	3.9	3.9
SE	-	-	0.027	0.027	0.027
Visceral artery antegrade approach					
No. at risk	246	135	107	83	72
%	0	2.3	2.3	2.3	2.3
SE	-	0.011	0.011	0.011	0.011
Visceral artery retrograde approach					
No. at risk	74	48	42	39	39
%	0	1.7	1.7	1.7	1.7
SE	-	0.017	0.017	0.017	0.017

Figure 5. Estimates of the cumulative incidence of (A) target vessel (TV) instability and (B) TV related re-intervention at competing risk TV centred analysis between antegrade and retrograde approaches for TV cannulation, stratified between renal and visceral (coeliac trunk and superior mesenteric artery) arteries. Standard error (SE) < 10%.

device. This method achieved high technical success rates both for device deployment and TV cannulation, while completely eliminating peri-operative neurological complications commonly linked to embolic events caused by aortic arch manipulation. Conversely, among the cohort of 128 patients treated by the antegrade approach, a neurological event rate of 4.7% consisting of six cases of stroke was observed, consistent with findings reported in the literature.[8,21,22] A direct correlation between thrombus burden in the aortic arch or descending thoracic aorta and stroke events was not consistently observed. However, it can be speculated that the manoeuvres required to gain access from the upper arm to the TVs, as well as the delivery of bridging stents towards branches from above, necessitated additional procedures that may have led to embolisation towards the supra-aortic trunks, ultimately resulting in stroke, an event not observed when targeting paravisceral vessels exclusively via retrograde femoral access.

The decision to use an upper extremity approach for treating TVs may hinge both on anatomical considerations and surgeon preference. Factors such as a narrow lumen in the visceral portion of the aorta and the downward orientation of TVs may sway towards an antegrade approach from the upper arm. The introduction of steerable catheters capable of bending the distal portion downward has addressed this challenge, although their application may not always be feasible.[23,24] Findings from this study revealed that although the E-nside is equipped with a pre-loaded system specifically designed to facilitate engagement of the visceral vessels, it was preferred not to use it in 22.9% of cases. Despite various anatomical factors, such as significant pre-operative TV stenosis, the aortic extent of the pathology, or the diameter of the paravisceral aorta, which might influence the choice of TV approach, this study found that the decision for primary use of a transfemoral retrograde approach was solely based on the surgeon's discretion, rather than being necessitated by an unsuccessful attempt of cannulation from above.[25–27] Moreover, the anatomical features both of aneurysms and TVs, along with the type of bridging stents used for TV treatment, were observed to be comparable across both groups. This finding not only reinforces the outcomes but also broadens the applicability of the retrograde approach via steerable catheters to nearly all anatomical scenarios and types of bridging stent. In addition, the retrograde approach has been found to be more prevalent in significantly challenging scenarios such as post-dissection aortic aneurysms, and yet the outcomes have proven to be no less effective than those achieved through the apparently simpler top down approaches.

In contrast to results from a recent meta-analysis involving eight previously published studies comparing outcomes between total transfemoral access and transfemoral access with adjunctive upper extremity access,[21] the current experience revealed longer operation times with a total transfemoral retrograde approach. This discrepancy could stem from the inclusion of a heterogeneous range of endografts in the meta-analysis or possibly due to a higher prevalence of larger diameter bridging stents in the current series, which might have impacted the ease of TV cannulation. Another possible explanation for this discrepancy could be that the longer operation times observed in the retrograde approach group compared with the antegrade approach group might be due to a slightly higher proportion of emergency procedures. This reflects limited time for thorough pre-operative planning, with the priority placed on endograft deployment to ensure proximal and distal sealing. Consequently, this may have led to increased difficulty in TV cannulation. Additionally, the retrograde group had a greater prevalence of thoraco-abdominal aneurysms, as opposed to juxtarenal and para-renal aneurysms, and a higher incidence of post-dissection aneurysms, which are inherently more complex due to the presence of both true and false lumens. These factors probably contributed to making the procedures more challenging in the retrograde approach group. Nonetheless, despite the increased peri-procedural difficulty due to anatomical complexity and extent in the retrograde approach group, fluoroscopy times, DAP, and contrast medium use were similar between the two groups.

Furthermore, despite a higher representation of patients with pre-operative chronic kidney disease in the retrograde approach group, the rates of renal and cumulative in hospital complications and hospitalisation times as well as in hospital and twelve month estimated survival were found to be similar to those of patients undergoing antegrade access. Indeed, pre-operative renal impairment has been observed not only to immediately affect post-operative renal function after standard and complex aortic repair, but also to correlate with heightened peri-operative mortality and one year survival post-surgery.[28,29]

Another noteworthy observation from the current analysis concerns the outcomes of TVs based on the approach type. It was interesting to note that balloon expandable bridging stents were generally preferred over self expandable ones and, although the literature suggests that in branched configurations overall TV instability and re-intervention rates seem more favourable for self expandable stents, the current analysis showed encouraging 30 day TV related technical success as well as very low estimates of one year incidence of TV instability and TV related re-intervention.[30] Nevertheless, it is important to mention that, regarding the follow up results, the analysis of this registry clearly demonstrated that adherence to the one year follow up was quite low, with 55% completing the twelve month follow up. This constraint is probably due to the observational, physician initiated nature of the study, which also involved a large number of centres, making it more challenging to monitor follow up adherence. Consequently, this significant gap in follow up data highlights the need to emphasise that the follow up information for patients who did not complete the follow up may not be comparable with the data presented in this analysis, potentially undermining its validity.

Study limitations

This study had several limitations. Primarily, the statistical power of the analyses may have been affected by the smaller sample size of the transfemoral retrograde approach group compared with the antegrade one. Additionally, the findings might reflect a potentially more complex anatomical profile of patients in the retrograde approach group. Moreover, the multicentre nature of the experience and the consequent varying levels of expertise at each centre may have influenced the results, although they reflect a real world scenario, providing valuable insights. A considerable number of participating centres (16 of 37) conducted fewer than three procedures during the study period (Supplementary Fig. S1). Despite this, all centres involved in the registry have demonstrated expertise in the endovascular treatment of complex abdominal and thoraco-abdominal aortic pathology, and during the same study period treated a limited number of cases using the endograft featured in this study. It is crucial to note that the findings from this study are limited to the use of a specific endograft, the inner branched E-nside endoprosthesis, and may not be generalisable to outcomes associated with all branched devices. Pre-operative, post-operative, and follow up CT findings were not assessed by a core lab, which introduced a significant risk of bias. Selection of the TV approach was not randomised but left entirely at the discretion of the operating surgeon at each centre, which may have introduced a selection bias. Nevertheless, the distribution of the type of TV approach chosen appeared to be relatively homogeneous during the study period (Supplementary Fig. S2). Additionally, a variety of bridging stents were used across the cohort, with selection influenced by their availability at each individual centre.

Lastly, it is essential to highlight that the follow up period was constrained, and a notable number of patients did not adhere to the scheduled checks. A comparative analysis of baseline characteristics between patients who participated in follow up and those who did not revealed no statistically significant differences. However, the incomplete follow up data may have introduced bias and limited the generalisability of the findings. These results should be interpreted with caution as the missing data may not be missing at random, which could affect the validity and reliability of the follow up outcomes. Nonetheless, the primary aim of this study, namely the impact of the approach type used for TV cannulation, is more directly and significantly reflected in the immediate intra-operative and peri-operative outcomes, as well as in the short and midterm results following the procedure. This variable is likely to have a more pronounced effect on peri-operative complications and midterm bridging stent stability, whereas long term outcomes may be influenced by a range of concurrent factors. Despite this, longer observation periods will be required to thoroughly validate and compare the long term outcomes of these approaches.

Conclusions

The current findings indicate that TV cannulation of inner branches via a total transfemoral retrograde approach offers comparable efficacy to the traditional antegrade approach from the upper extremity in both immediate procedural outcomes and early follow up. Additionally, the retrograde approach showcased a distinct advantage by significantly mitigating the risk of peri- and post-procedural neurological complications often linked to aortic arch manipulation. This highlights the potential clinical benefits and enhanced safety profile of adopting a retrograde approach in the endovascular management of complex thoraco-abdominal pathologies.

CONFLICTS OF INTEREST

G.S., M.P., and M.A. have consulting agreements with Artivion. G.P. receives fees for employment tutoring from Artivion. All other authors declare no conflicts of interest.

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APPENDIX A. SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejvs.2025.02.019.

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COUP D'OEIL

Open Repair of a Ruptured Juxtarenal Aortic Aneurysm with Left Sided Inferior Vena Cava

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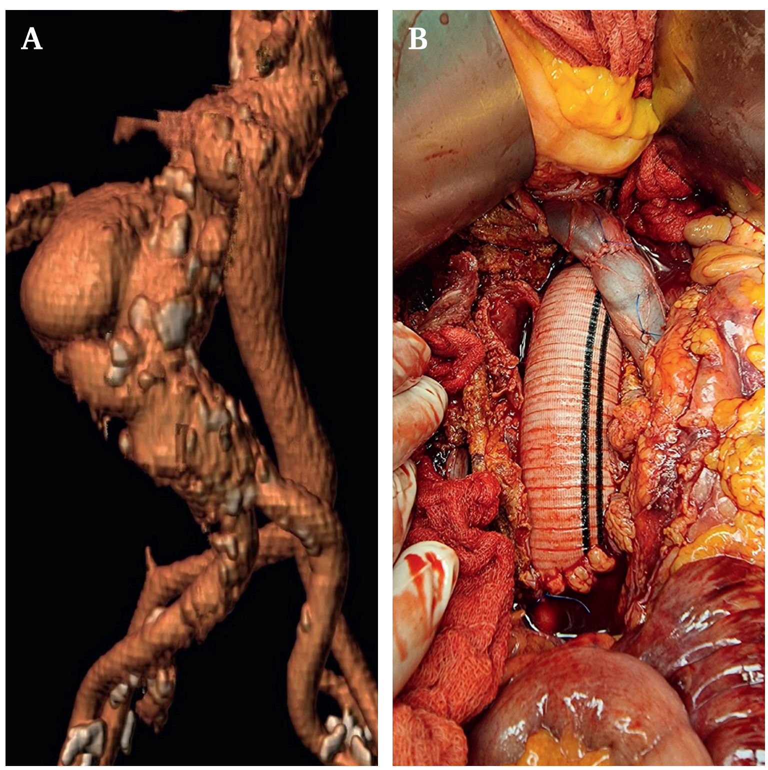

A 90 year old haemodynamically unstable male presented with a ruptured juxtarenal abdominal aortic aneurysm, unsuitable for endovascular repair due to a hostile proximal aorta. Pre-operative imaging demonstrated an intact left sided inferior vena cava (IVC) crossing the perirenal region of the aneurysm (A). IVC transection was first performed for adequate aortic neck exposure. A proximal aortic clamp was placed just below the renal arteries, followed by aneurysm repair and IVC reconstruction (B). Post-operative recovery was uneventful. Precise identification of this anomaly before open repair of ruptured abdominal aortic aneurysm is important for adequate pre-operative planning of the surgical procedure.

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